National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development & Ganga Rejuvenation
Government of India

Pollution Load
&
Pollution Mapping
Periyar

September 2025

IIT PALAKKAD

cGanga

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National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

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The Center for Periyar River Basin Management and Studies (cPeriyar) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by IIT Palakkad and NIT Calicut, under the supervision of cGanga at IIT Kanpur, the center serves as a knowledge wing of the National River Conservation Directorate (NRCD). cPeriyar is committed to restoring and conserving the Periyar River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

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Acknowledgment

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Preface

In the context of increasing anthropogenic pressures and rapid basin-level transformations, a clear understanding of pollution loads and treatment systems within river basins has become imperative. This report presents a systematic assessment of pollution load generation and treatment across the river basin, highlighting key sources, pathways, and management challenges that influence river water quality and ecological health.

The report brings together data on domestic, industrial, and solid waste pollution sources, along with an evaluation of existing treatment infrastructure and institutional arrangements. Through careful compilation and analysis of available datasets and stakeholder inputs, the study aims to provide a realistic representation of current pollution loads and the effectiveness of treatment mechanisms operating within the basin.

Beyond quantification, this report seeks to support informed decision-making by identifying critical gaps, uncertainties, and opportunities for improving pollution control and wastewater management. It underscores the importance of integrated planning, inter-agency coordination, and evidence-based interventions to reduce pollutant loads entering the river system.

This document is intended to serve as a technical reference for planners, regulators, and practitioners engaged in river basin management. We acknowledge the valuable contributions of various departments and institutions whose data, insights, and cooperation have strengthened this assessment. It is our hope that this report will act as a foundational resource to guide targeted actions, enhance treatment efficiency, and contribute meaningfully to the long-term restoration and protection of the river basin.

Centres for Periyar River Basin
Management and Studies (cPeriyar)
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List of Abbreviation

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ARWSS	Augmented Rural Water Supply Scheme
AS	Administrative Sanction
BDW	Biodegradable Waste
BOD	Biochemical Oxygen Demand
CAMP	Condition Assessment and Management Plan
CETP	Common Effluent Treatment Plant
COD	Chemical Oxygen Demand
DPR	Detailed Project Report
ETP	Effluent Treatment Plant
FSSM	Fecal Sludge and Septage Management
FSTP	Fecal Sludge Treatment Plant
GCDA	Greater Cochin Development Authority
GP	Grama Panchayath
HKS	Haritha Kerala Mission
IRTC	Integrated Rural Technology Centre
KILA	Kerala Institute of Local Administration
KINFRA	Kerala Industrial Infrastructure Development Corporation
KMRL	Kochi Metro Rail Limited
KLD	Kilo Liters per Day
KSCSTE	Kerala State Council for Science, Technology and Environment
KSPCB	Kerala State Pollution Control Board
KSWMP	Kerala Solid Waste Management Project

LB	Local Body
LSGs	Local Self Governments
LSGD	Local Self Government Department
LSGI	Local Self Government Institution
MBBR	Moving Bed Biofilm Reactor
MCF	Material Collection Facility
ME	Micro Enterprises
MLD	Million Litres per Day
MoEFCC	The Ministry of Environment, Forest and Climate Change
MSW	Municipal Solid Waste
MTU	Mechanical Treatment Unit
NBDW	Non-Biodegradable Waste
NGO	Non-Governmental Organization
PCC	Portland Cement Concrete
PRS	Project Review System
RRF	Resource Recovery Facility
RWSS	Rural Water Supply Scheme
SHPSC	State High Powered Steering Committee
SLTC	State Level Technical Committee
SOC	Soil Organic Carbon
STP	Sewage Treatment Plant
TPD	Tonnes per Day
TS	Technical Sanction
ULB	Urban Local Body

1. Introduction

The Periyar River, the longest river in Kerala with a length of 244 km, drains the second largest river basin in the state, covering an area of about 5216 km². The basin extends across the districts of Idukki, Ernakulam and Thrissur in Kerala and parts of Coimbatore district in Tamil Nadu, and supports a population of about 3.72 million as per the 2011 Census. Originating from the Sivagiri hills within the Periyar Tiger Reserve at an elevation of about 1830 m above Mean Sea Level, the river flows through forested highland regions before entering densely populated and economically active areas, finally draining into the Arabian Sea through the Cochin estuary. The basin has a well-developed tributary network including the Mullayar, Muthirapuzha and Idamalayar rivers, and contains several major hydraulic structures such as the Mullaperiyar, Idukki, Bhoothathankettu and Idamalayar dams which support hydropower generation, irrigation and water supply. Water from the Periyar River is extensively utilized for domestic water supply, agriculture, industry, fisheries and tourism, and major water supply schemes draw water from the river to serve urban centres including Kochi, Aluva and Perumbavoor. The boundary of the Periyar River Basin is shown in Fig. 1.

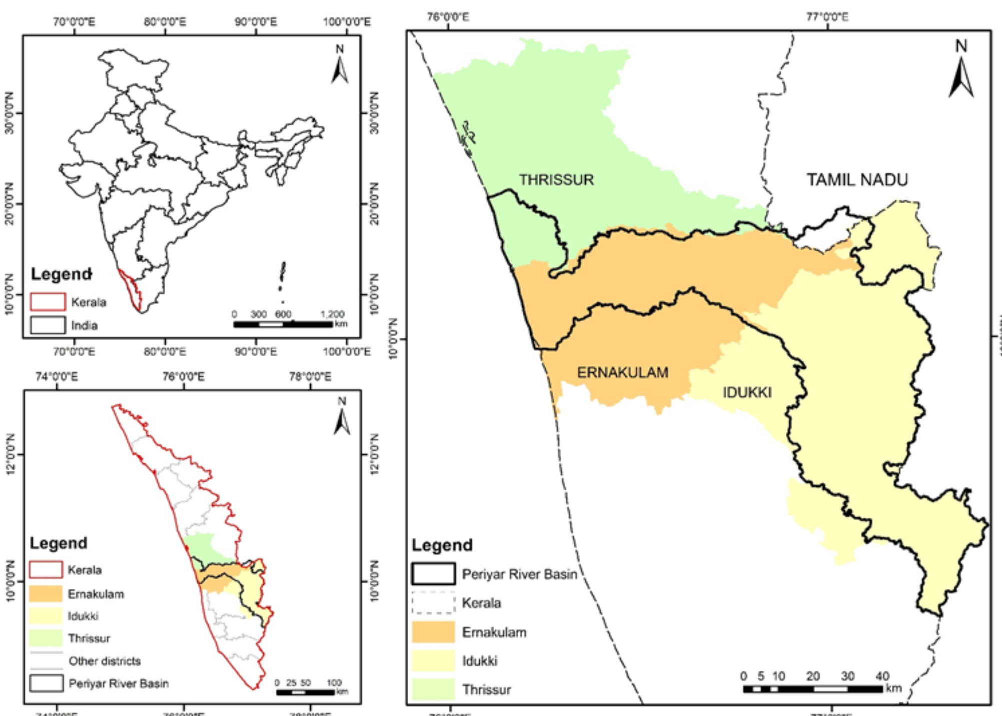

Fig. 1 Boundary of Periyar Basin *(Source: River Atlas - Periyar)*

At the same time, the basin accommodates significant urban settlements and industrial activity, particularly in the stretch between Angamaly and Kochi where numerous large, medium and small-scale industries operate in sectors such as fertilisers, chemicals, petroleum refining, rubber processing and metal processing. These activities, along with domestic wastewater generation and municipal solid waste management challenges in urban centres such as Kochi, contribute various pollutants including untreated sewage, industrial effluents, heavy metals, hydrocarbons, nutrients and other contaminants that may enter the river system. The presence of multiple drainage channels, tributaries and discharge points further facilitates the transport of these pollutants into the river and associated water bodies in this context, pollution load assessment is necessary to understand the magnitude and spatial distribution of pollutant inputs from domestic wastewater, industrial discharges, drains and solid waste management systems within the basin. Such an assessment provides the basis for understanding pollution pathways, identifying critical hotspots, evaluating existing treatment and waste management infrastructure, and supporting basin-level planning and management interventions for improving water quality in the Periyar River system.

Waste refers to materials that the generator no longer finds useful for production, processing, or consumption and therefore needs to dispose off. These wastes may exist as solid, liquid, or semi-solid forms and can significantly impact environmental components such as soil, water, and air if left unmanaged. Based on the characteristics and source, solid wastes are typically categorized as Municipal Solid Waste (MSW), Bio-medical Waste (BMW), Construction and Demolition (C&D) waste, E-waste, Plastic waste, and Hazardous waste. Depending on their characteristics, they can also be classified as biodegradable, non-biodegradable, combustible, dry, or inert (Comptroller and Auditor General of India, 2022).

Kerala is undergoing rapid urbanisation, with nearly half of its 3.34 crore population residing in urban areas. This has resulted in a rise in municipal solid waste, which is currently estimated at 3.70 million tonnes per year, of which Urban Local Bodies (ULBs) contribute around 59%. The waste stream comprises approximately 69% biodegradable and 31% non-biodegradable waste. The scientific handling of municipal solid waste including its collection, segregation, storage, transportation, processing, and disposal is an obligatory function of ULBs. To strengthen source-level waste management, Kerala promotes citizen responsibility through the campaign “My Waste, My Responsibility” (Comptroller and Auditor General of India, 2022).

Kerala, known for its clean environment, has made significant efforts to improve sanitation, hygiene, and health outcomes. The state has eliminated manual scavenging and is among the first open defecation-free states in India. The Suchitwa Padavi Padanam was introduced by the Local Self Government Department (LSGD), in collaboration with the Haritha Kerala Mission and Suchitwa Mission, to accelerate scientific solid waste management across Kerala's Local Self Government Institutions (LSGIs). A statewide assessment conducted in August 2020 evaluated all LSGIs on key criteria such as the functioning of Haritha Karma Sena (HKS), implementation of user fees, availability of Material Collection Facilities (MCF/Mini-MCF) and Resource Recovery Facilities (RRF), linkages with Clean Kerala Company Ltd., source-level treatment of biodegradable waste, sanitation infrastructure, condition of water bodies and public spaces, and adherence to green protocols. Based on compliance with the Solid Waste Management Rules, 2016, a total of 793 out of 1034 LSGIs were awarded *Suchitwa Padavi*. This assessment was carried out by multidisciplinary inspection teams at block and district levels, trained by the Kerala Institute of Local Administration (KILA) using a standardised evaluation framework. (LSGD, 2021). However, challenges such as increasing waste discharge, industrial pollution, and excessive use of chemical fertilizers and pesticides persist. Despite government support, awareness campaigns, behavioral change initiatives, and the promotion of appropriate technologies, maintaining environmental cleanliness remains an ongoing challenge (LSGD, 2018).

To address these issues, the LSGD, Kerala, notified the State Policy on Solid Waste Management on 13th September 2018, aiming to make the state garbage-free by adopting the principles of Reduce, Reuse, and Recycle. The policy mandates the segregation of waste at source into biodegradable, non-biodegradable, and domestic hazardous categories; promotes decentralised treatment methods such as on-site composting and biomethanation; and strictly prohibits open dumping. The policy further requires all waste generators to hand over residual and non-biodegradable waste to authorised collectors. Additionally, gated communities, large institutions, and commercial establishments are obligated to ensure source segregation, on-site processing, and responsible management of recyclable materials. Manufacturers and brand owners are also required to support waste management systems and undertake consumer awareness initiatives (KSWMP, 2020). In addition to solid waste management challenges, untreated sewage and domestic wastewater also represent significant sources of pollution affecting river systems in Kerala.

Beyond solid waste, sewage and domestic wastewater constitute a dominant and persistent source of pollution in Kerala's river systems due to limited sewerage coverage, inadequate treatment capacity, and the misuse of stormwater drains as wastewater conduits. In urban and peri-urban areas, limited sewerage coverage and inadequate treatment capacity result in a large proportion of domestic sewage being discharged untreated into nearby water bodies, often through open drains and canals (CPCB, 2009; Urban Wastewater Scenario in India, 2022). This pathway is clearly evident in the Periyar River, where water quality investigations by the Kerala State Pollution Control Board revealed that river decolouration and sediment settlement were caused primarily by sewage intrusion rather than industrial effluents (New Indian Express, 2020). In-depth sampling conducted at Pathalam and Manjummel recorded critically low dissolved oxygen concentrations (as low as 0.19 mg L^{-1} downstream of Pathalam), far below the levels required to sustain aquatic life, directly linking untreated sewage inflows to fish mortality events (New Indian Express, 2020). In parallel, hydrochemical studies have shown that the Periyar River exhibits metal concentrations exceeding regulatory thresholds in industrial stretches, while also confirming that wastewater outlets significantly aggravate overall riverine degradation (Chandni et al., 2026). These findings demonstrate that pollution in the Periyar arises from the cumulative interaction of industrial discharges, untreated domestic wastewater, and drain-mediated transport pathways. In this context, pollution load assessment is critical, as it enables quantification of contaminant inputs from sewage, wastewater outlets, and associated drainage networks, supports identification of dominant pollution sources, and provides a scientific basis for prioritising wastewater treatment infrastructure, regulating discharges, and restoring river water quality.

Pollution load assessment is crucial because water quality underpins both ecological integrity and human well-being, while understanding regional pollution patterns enables evaluation of how anthropogenic activities and policies shape water resources. Moreover, such assessment is vital for projecting the future condition of aquatic ecosystems and for determining the suitability of surface waters for various user needs (Williams *et al.,* 2012).

Water pollution in river basins such as the Periyar is typically the result of multiple interacting sources and pathways, including domestic sewage, industrial effluents, municipal solid waste mismanagement, and the conveyance of untreated wastewater through open drains and tributary channels. In many urban and peri-urban areas of the basin, limited sewerage networks and inadequate treatment capacity lead to the discharge of domestic wastewater into stormwater drains and natural streams, which ultimately transport these pollutants into the main river. Industrial clusters along the Angamaly–Eloor–Kochi stretch also generate effluents containing chemical contaminants and metals, while improperly managed solid waste can contribute leachate, plastics, and organic matter that enter drainage systems during runoff events. The availability and performance of treatment infrastructure such as Sewage Treatment Plants (STPs), Effluent Treatment Plants (ETPs), septage management facilities, and solid waste processing systems therefore play a critical role in determining the magnitude of pollutant loads entering the river. In this context, a comprehensive pollution load assessment is essential to quantify pollutant contributions from domestic wastewater, industrial discharges, drains, and solid waste systems, evaluate existing treatment and waste management infrastructure, identify critical pollution hotspots, and support evidence-based planning for improving water quality in the Periyar River Basin. The sources of data collected for this report are mentioned in Table 1.

Table 1: Source of Data for Pollution Load

Sl. No.	Source of Data
1	Kerala State Pollution Control Board (KSPCB)
2	Suchitwa Mission
3	Kerala Water Authority (KWA)
4	Local Self Government Institutions (LSGIs)
5	Kerala Solid Waste Management Project (KSWMP)
6	Central Pollution Control Board (CPCB)
7	Kerala Institute of Local Administration (KILA)

2. Methodology

A descriptive and analytical methodology has been adopted in this study to assess pollution load and existing treatment mechanisms within the Periyar River Basin, covering Thrissur, Ernakulam, and Idukki districts. These districts represent varying levels of urbanisation, industrial activity, and rural settlements, which help in understanding the spatial variation of pollution characteristics across the basin. This report mainly uses secondary data obtained from government sources. These government sources provide information on wastewater generation, sewage and industrial effluent loads, solid waste generation, existing treatment facilities, drainage systems, and overall waste management practices within the basin.

In addition to secondary data analysis, the study involved field visits and stakeholder interactions across the Periyar River Basin, covering the Idukki and Ernakulam districts. Field visits were conducted to relevant institutions and local bodies to validate available data, address existing data gaps, and develop a practical understanding of pollution monitoring, wastewater management, industrial activities, and solid waste management practices. Interactions with officials offered valuable insights into prevailing operational challenges and management issues. The institutions and offices visited included the Suchitwa Mission (Idukki), District Industries Centre, KSPCB regional and district offices, and the KSPCB office at Eloor, located within the industrial region of Ernakulam. The study also included visits to selected natural drains and major municipalities, such as Kalamassery, to assess on-ground conditions and existing waste management practices.

The combined use of secondary data analysis and field-level interactions strengthened the study by enabling validation of information and a better understanding of pollution sources, treatment infrastructure, and waste management practices within the basin. This integrated approach provides a clear overview of the current condition of the river and supports informed planning for improved pollution control and management measures.

3. Pollution Mapping

Pollution load mapping of the Periyar River Basin is undertaken to identify river stretches that are experiencing significant organic pollution and to prioritise areas requiring targeted management interventions. In India, polluted river stretches are identified and classified by the CPCB under the

National Water Quality Monitoring Programme (NWQMP). River water quality monitoring is carried out at designated locations through monthly analysis of physico-chemical and bacteriological parameters and biannual analysis of metals and pesticides in accordance with the Guidelines for Water Quality Monitoring (MoEF&CC, 2017). The monitoring data generated by State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) are compiled and uploaded through the Environmental Water Quality Data Entry System (EWQDES) and centrally maintained by CPCB.

The primary parameter used for identifying polluted river locations is Biochemical Oxygen Demand (BOD), which reflects the level of organic pollution in water. As per CPCB criteria, monitoring locations where BOD exceeds 3.0 mg/L, the Primary Water Quality Criteria limit for outdoor bathing (Class B water), are considered polluted locations. When a single monitoring location exceeds this threshold, it is classified as a Polluted River Location (PRL). If two or more such locations occur sequentially along a river, the segment is identified as a Polluted River Stretch (PRS). These polluted stretches are further categorized into five priority classes (I to V) based on the maximum observed BOD concentration, as follows:

- Priority I – BOD > 30 mg/L
- Priority II – BOD 20.1–30.0 mg/L
- Priority III – BOD 10.1–20.0 mg/L
- Priority IV – BOD 6.1–10.0 mg/L
- Priority V – BOD 3.1–6.0 mg/L

where higher priority classes correspond to higher levels of organic pollution and greater ecological risk.

Based on CPCB assessments, certain stretches of the Periyar River have been identified as polluted due to elevated BOD concentrations. In Ernakulam district, the stretch from Pathalam to Aluva–Eloor has been classified under Priority Class V, while another stretch from Aluva–Eloor to Kalamassery has also been identified under Priority Class V during earlier assessments. In Thrissur district, the Periyar River stretch at Kodungallur has been categorized under Priority Class IV, while no polluted river stretches were identified in Idukki district during the 2025 assessment.

Monitoring observations further indicate that during 2022–2023, the stretch from Pathalam to Aluva–Eloor recorded maximum BOD values ranging from 3.2 to 3.9 mg/L at the monitoring stations located at Pathalam and Aluva–Eloor, corresponding to Priority Class V conditions. A comparatively higher BOD value of 6.4 mg/L was recorded at Kodungallur, leading to its classification under Priority Class IV. More recent observations for 2024 indicate BOD concentrations of 3.4 mg/L at Pathalam, 3.4 mg/L at Aluva–Eloor, and 3.5 mg/L at Kodungallur, demonstrating the continued presence of organic pollution in these sections of the river.

The identification and mapping of these polluted stretches provide an important basis for understanding spatial patterns of pollution within the Periyar River Basin. This information supports the prioritisation of pollution control measures, targeted monitoring, and the planning of restoration interventions in river stretches that exhibit persistent water quality deterioration. The spatial identification of these polluted stretches, illustrated in Fig. 2, provides a clear representation of the distribution of pollution hotspots within the Periyar River Basin. Within the Periyar River Basin, pollution load mapping indicates that the identified polluted stretches are concentrated in the downstream districts. As shown in Fig. 2, two pollution hotspots occur within Ernakulam district, one hotspot occurs in Thrissur district, and no polluted river stretches have been identified within Idukki district based on the available monitoring assessments. The absence of polluted stretches in the upstream Idukki district indicates comparatively better water quality conditions in the upper catchment, which may be associated with relatively lower population density and limited industrial presence in this region. In contrast, the concentration of pollution hotspots in Ernakulam and Thrissur districts reflects the influence of higher population density and the presence of industrial activities in the downstream parts of the basin. Such mapping provides an important basis for prioritizing pollution control measures, strengthening monitoring programme's, and planning targeted river restoration interventions in the affected stretches of the Periyar River Basin.

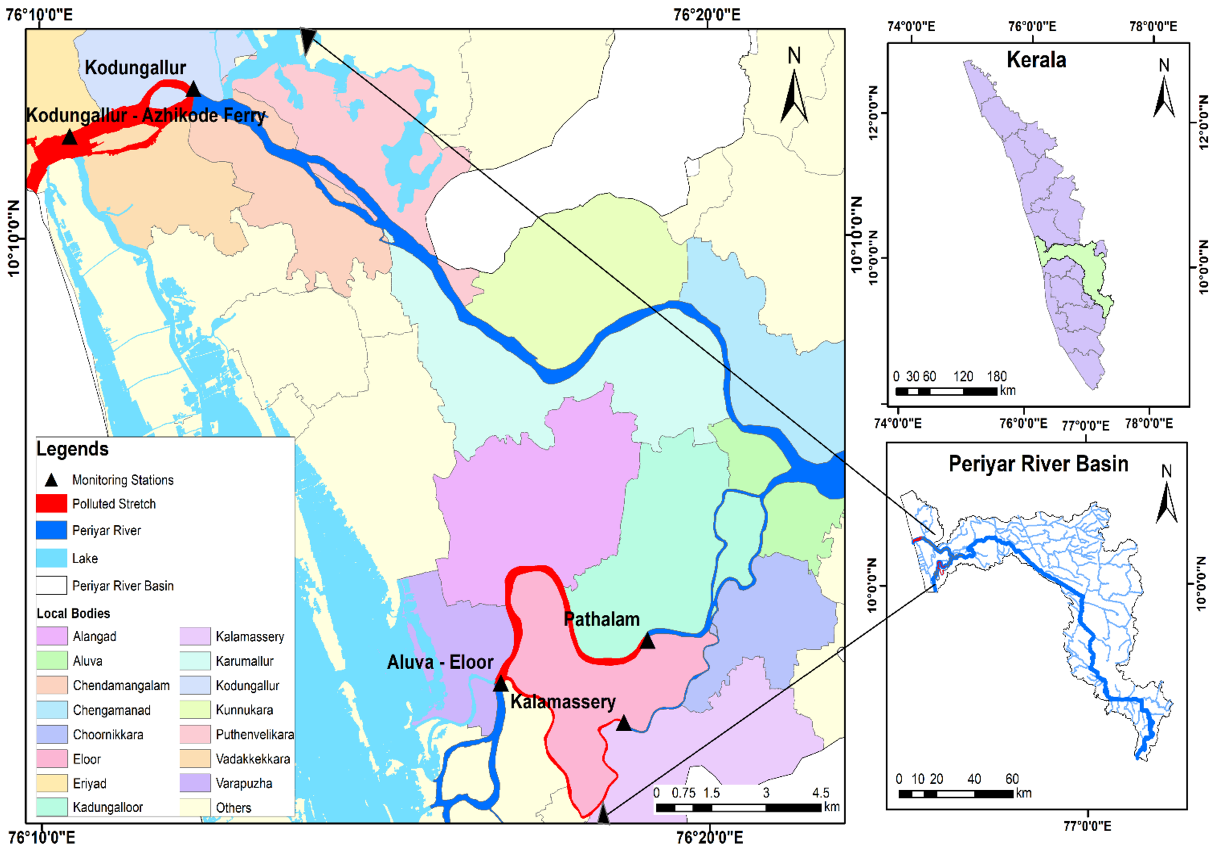

Fig. 2 Pollution load mapping of the Periyar River Basin showing identified polluted river stretches in Idukki, Ernakulam and Thrissur districts.

4. Pollution Load Assessment

4.1. Domestic wastewater load

Domestic wastewater load refers to the quantity of wastewater generated from households as a result of daily human activities such as cooking, bathing, washing, and sanitation. It generally includes two components: sewage (black water from toilets) and sullage (grey water from kitchens, bathrooms, and wash areas). Since domestic wastewater often contains organic matter, nutrients, and pathogens, its discharge into rivers without treatment can cause significant deterioration in water quality. Monitoring and estimating domestic wastewater load are therefore essential for pollution management and planning treatment infrastructure.

The estimation of water consumption and subsequent wastewater generation is carried out using the population projected for the year 2024, based on the 2011 Census data, as it is the latest official record available. According to the Bureau of Indian Standards (BIS), water consumption is assumed at 135 litres per capita per day (lpcd) for populations below 1 lakh and 180 lpcd for populations above 1 lakh. Of the total water consumed, 80% is considered as wastewater. This wastewater is further divided into two categories, with 30% classified as sewage and the remaining 70% as sullage.

As per the Census 2011, Kerala had a total population of 3,37,77,386, comprising 2,58,40,501 in rural areas and 79,36,885 in urban areas. The population projected for 2024 is 3,56,40,084. Based on this projected Figure, the estimated wastewater generation in Kerala is 3999 Million Litres per Day (MLD), of which 1018 MLD is generated from urban areas (six Corporations and 87 Municipalities) and 2981 MLD from rural areas (941 Panchayats). In urban areas, sewage accounts for 305.4 MLD and sullage for 712.6 MLD. In rural areas, sewage is estimated at 894.3 MLD and sullage at 2086.7 MLD. This highlights the significant contribution of rural settlements to the state's overall wastewater load. The district-wise sewage load in urban and rural region is as shown in Fig. 3.

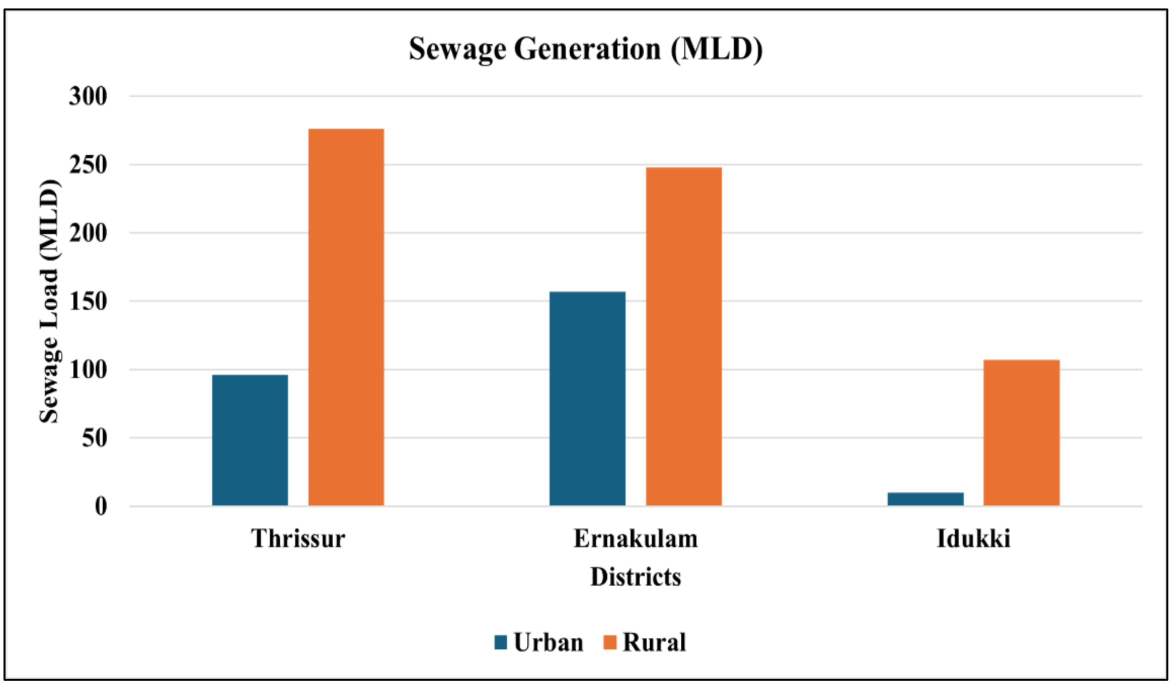

Fig. 3 Urban vs. Rural Sewage Generation

Ernakulam District

In 2024, Ernakulam district estimated the highest domestic wastewater generation among the three districts, with a total load of 405 MLD, according to data from the KSPCB. Of this, 157 MLD is generated in urban regions, while 248 MLD originates from rural areas. With a population of approximately 3,527,283, the data indicates a significant rural wastewater contribution in the district.

Thrissur District

In 2024, Thrissur district is estimated to generate a total domestic wastewater load of 372 MLD, according to data from the KSPCB. Of this, urban areas account for 96 MLD, while rural areas contribute 276 MLD, representing the predominant share. With a population of approximately 3,323,162, the district's rural regions emerge as the primary source of wastewater generation.

Idukki District

Based on the calculations for 2024, Idukki district's domestic wastewater generation is estimated at 117 MLD. Of this, the urban centres of Thodupuzha and Kattappana municipalities contribute around 10 MLD (9%), while the 52 grama panchayats in rural Idukki generate about 107 MLD (91%). The total projected population for Idukki in 2024 is 10,83,264. This means that the most of Idukki's wastewater originates from rural households, underlining the importance of rural wastewater management in the district. This clearly indicates that while Idukki is less urbanized, its rural settlements still make a substantial contribution to Kerala's overall wastewater generation. The domestic wastewater load in whole Periyar River Basin is given in Fig. 4.

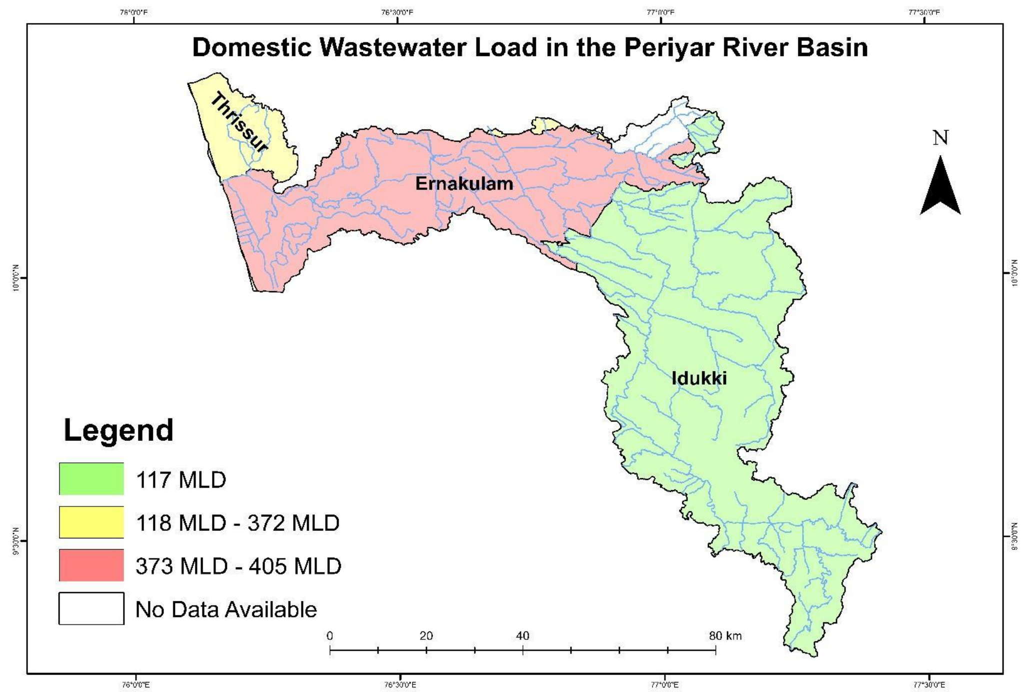

Fig. 4 Map Showing Domestic Wastewater Load in the Periyar River Basin

4.1.1. Sewage Generation by Local Bodies: Ernakulam District

Fig. 5 illustrates the projected sewage generation for the local bodies of Ernakulam District, estimated using the 2024 population projections provided by Suchitwa Mission. The source provides data on total sewage generation (in MLD), while the per capita sewage generation value of around 108 L/person/day has been assumed by the data source for most local bodies and is presented only as an indicative parameter.

Among rural local bodies, sewage generation ranges from 1.46 MLD in Keerambara to 5.12 MLD in Pallippuram. ULBs show considerably higher sewage loads, with Kochi Municipal Corporation generating 93.17 MLD, reflecting a higher assumed per capita value of 144 L/person/day. Kalamassery generates (8.25 MLD), while other municipalities such as Aluva, Perumbavoor, Angamaly, and Eloor generate between 2.61 MLD and 4.27 MLD. Overall, the data reflects the significant sewage load generated across both rural and urban regions of Ernakulam District, highlighting the growing need for improved wastewater collection and treatment infrastructure to keep pace with increasing population and urbanization. It may be noted that the Fig. 5 has been prepared based on the total sewage generation data received from Suchitwa Mission and therefore includes 41 local bodies for which data was available, although a total of 55 local bodies fall within the Ernakulam district portion of the Periyar River basin.

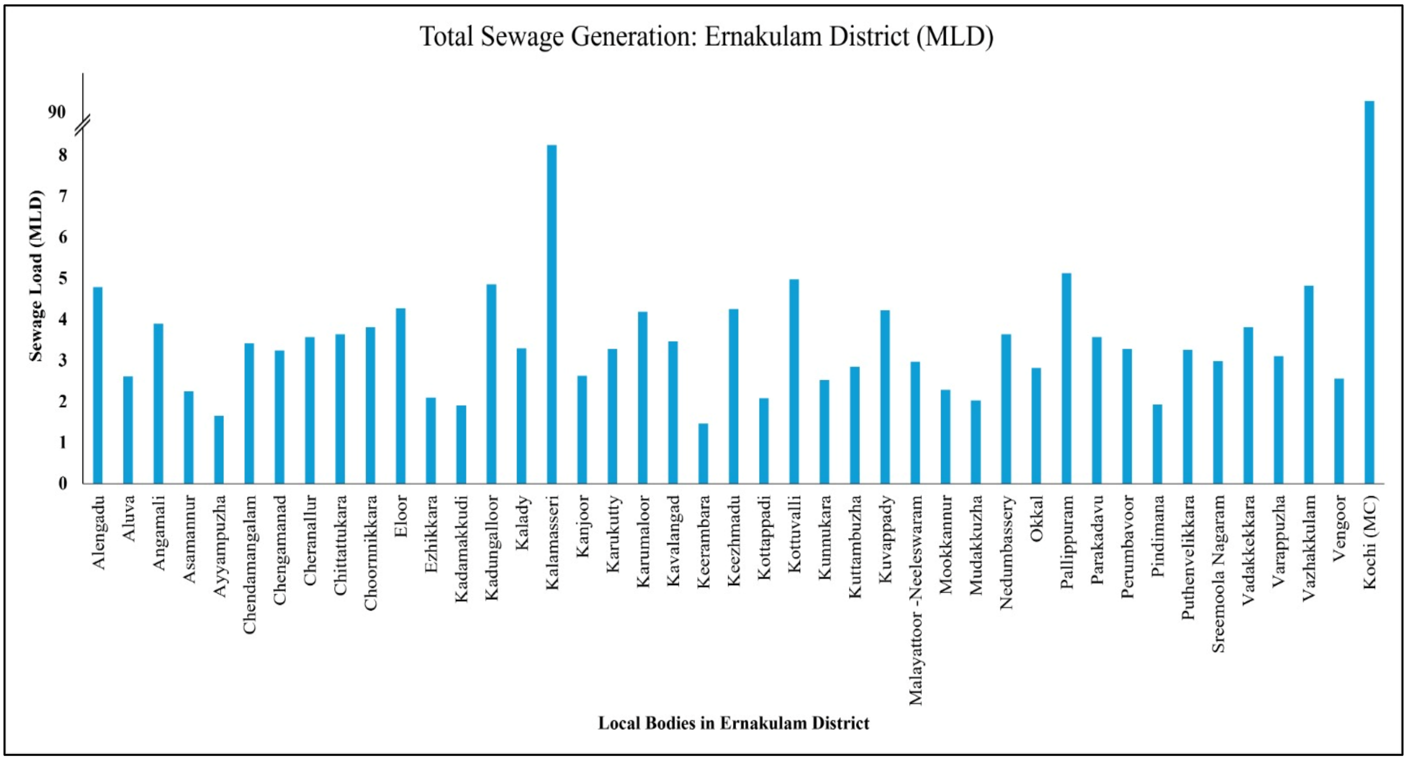

Fig. 5 Distribution of Sewage Generation Across Local Bodies - Ernakulam

4.1.2. Sewage Generation by Local Bodies: Thrissur District

The Fig. 6 below presents the estimated sewage generation within the Periyar River Basin in Thrissur District, based on 2024 population projections provided by Suchitwa Mission. The source provides data on total sewage generation (in MLD), while the per capita sewage generation value of around 108 L/person/day has been assumed by the data source for most local bodies and is presented only as an indicative parameter.

Among rural local bodies, sewage generation ranges from 1.45 MLD in Poomangalam to 5.32 MLD in Eriyad. The urban local body, Kodungallur Municipality, records the highest sewage generation at 8.22 MLD. Overall, the data highlights the sewage load across both rural and urban regions of Thrissur District, emphasizing the need for strengthened wastewater collection and treatment systems to keep pace with rising population and urban expansion. It may be noted that the Fig. 6 has been prepared based on the sewage generation dataset received from Suchitwa Mission and therefore includes 9 local bodies for which data was available, although a total of 23 local bodies fall within the Thrissur district portion of the Periyar River basin.

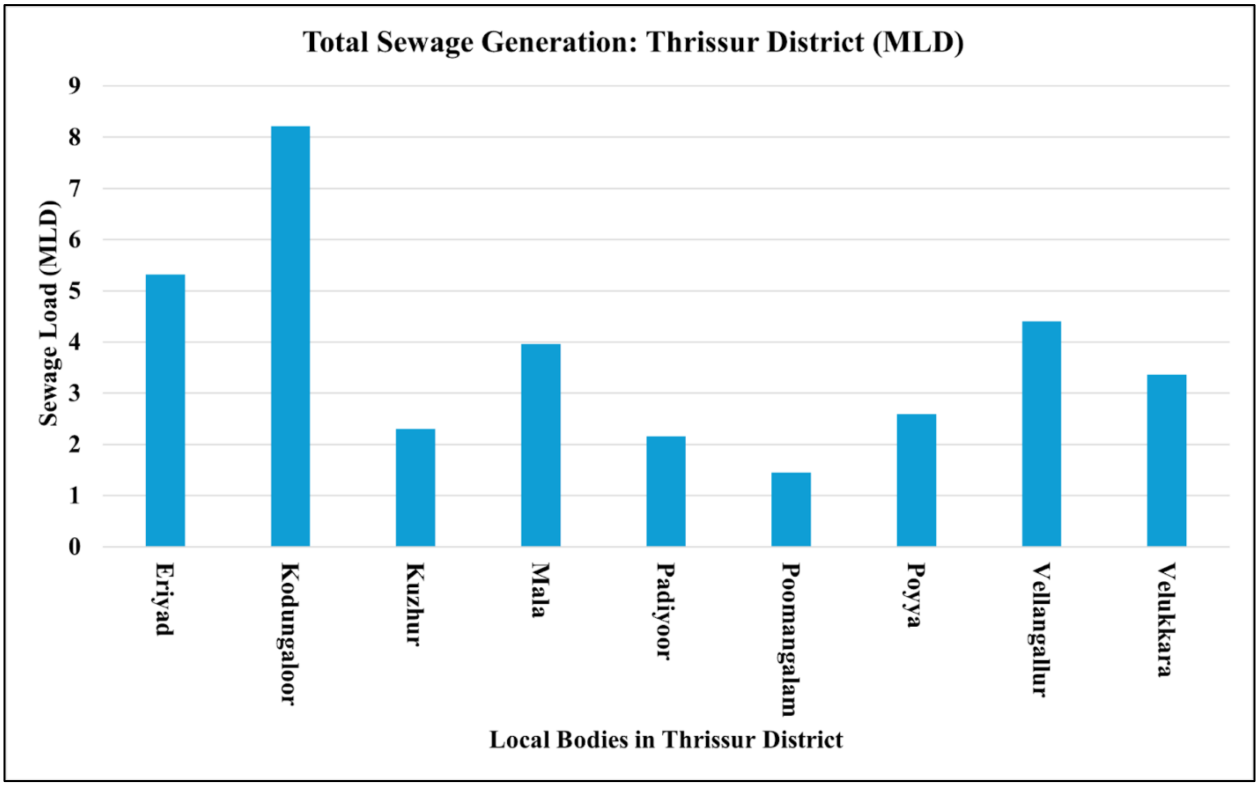

Fig. 6 Distribution of Sewage Generation Across Local Bodies - Thrissur

4.1.3. Projected Sewage Generation by Local Bodies: Idukki District

For effective sewage management, it is crucial to anticipate future population growth, as wastewater generation directly depends on population size and water usage patterns. Planning ahead ensures that infrastructure such as STPs are designed with adequate capacity to meet both current and future demands. Only by forecasting wastewater loads can authorities implement sustainable and cost-effective treatment systems. Failure to do so may result in under-capacity systems, leading to untreated discharges into rivers and associated environmental and public health impacts. Thus, forward planning is essential for ensuring efficient management of domestic wastewater in both urban and rural areas.

To address this, the KWA has projected the population for 2053 using 2011 as the base year. In calculating sewage load, a return ratio of 80% of the total water consumption is assumed. In addition, allowances are made for various other demands: 15% for non-domestic and floating population requirements, another 15% for unaccounted water and infiltration, and, in the case of municipalities and corporations, 20% is adopted for these additional components. Faecal sludge is also considered, with its quantity estimated at 1% of the sewage load. KWA has computed these sewage load values specifically for the 54 municipalities and grama panchayats of Idukki district, providing a framework for future wastewater management planning.

From the Expected Sewage Load in 2053 (MLD) as projected by the KWA, it has been identified that, only 34 grama panchayats and one municipality falls under the Periyar River Basin in Idukki district. Among these, Kattappana Municipality has been found to be the largest contributor, with an expected sewage load of 7.8 MLD by 2053, followed by Adimaly Grama Panchayat with 5.14 MLD and Nedumkandam Grama Panchayat with 4.88 MLD. This clearly indicates that these three local bodies must be prioritized for detailed study and targeted wastewater management interventions, as they are projected to generate the highest wastewater load within the basin. The high sewage generation in these regions can be primarily attributed to factors such as higher population density, rapid urbanization, and commercial activity. Given these dynamics, it becomes essential to focus sewage treatment and management strategies in these regions. Establishing adequate STPs, promoting decentralized wastewater treatment systems, and implementing proper sewage networks in these regions would ensure effective pollution abatement in the Periyar River Basin. By addressing the largest contributors first, it would be possible to make significant progress in reducing the overall domestic pollution load. The Fig. 7 below presents the projected sewage generation within the Periyar River Basin in Idukki District, based on 2053 population projections provided by KWA.

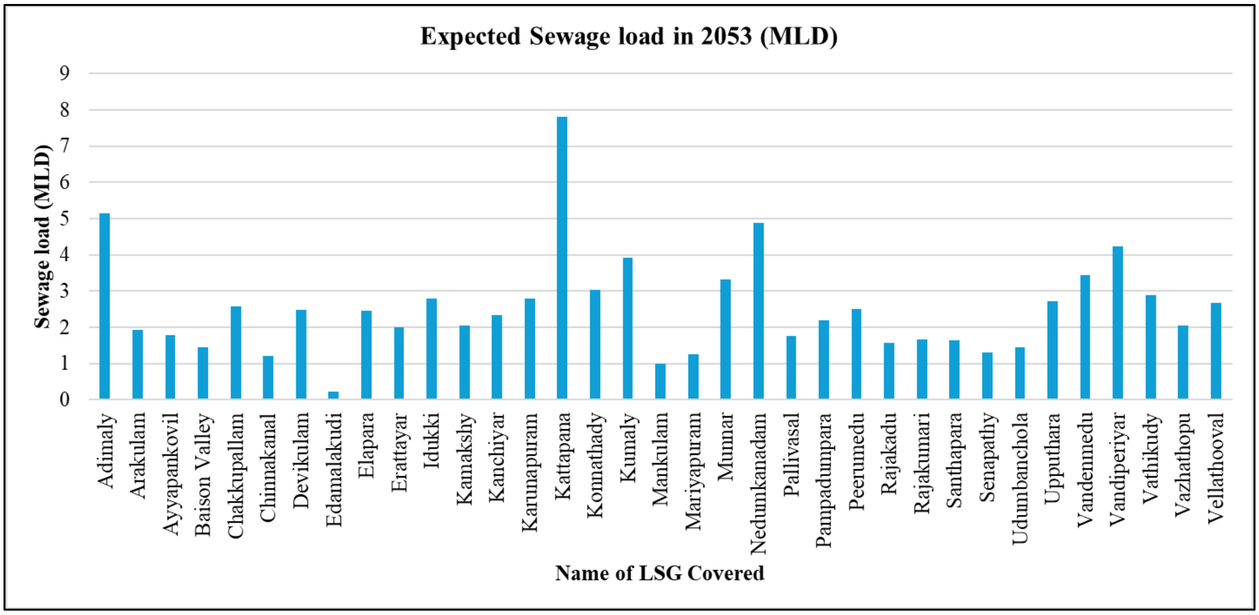

Fig. 7 Projected Sewage Generation by Local Bodies: Idukki

4.2.Status of sewerage network and household connections

Although India had advanced sewer systems during the Indus Valley Civilization over 4,500 years ago, today providing safe sanitation remains a major challenge. Only a small fraction of cities and towns in the country have proper sewerage networks, and in many cases untreated sewage is discharged directly into rivers, lakes, and other water bodies, leading to widespread contamination. This has contributed to the spread of waterborne diseases such as gastroenteritis, typhoid, and cholera, while also posing serious threats to sustainable development and public health.

In Kerala, despite its reputation as the most literate state, sewerage infrastructure remains limited. Out of five municipal corporations, only Thiruvananthapuram and Kochi have nominal sewerage systems, while many urban and rural households still depend on pit toilets or shared sanitation facilities. According to Census 2011, around 93,046 urban households lacked access to sanitary toilets, with a significant number practicing open defecation or using shared facilities, adding to the fecal load in the environment. (Preliminary Proposed Sewerage Scheme for Idukki District Report, 2020)

Table 2: Status of sewerage network and household connections in Ernakulam District

Division	Sub division	Section	Domestic Connections (no.)	Non-Domestic Connections (no.)	Industrial Connections (no.)	Special Connections (no.)	Total Connections (no.)
W.S Kochi-18	Paravoor Sub - division	Muppathadom Section	25,748	750	85	0	26,583
		Njarakkal Section	50,896	2114	56	1	53,067
		Paravoor Section	37,078	1054	17	0	38,149
P.H Muvattupuzha	Kothamangalam Sub-division	ARWSS to Kuttamangalam-Neriyamangalam	3536	176	0	4	3716
		RWSS to Pindimana	3551	111	0	8	3670
		RWSS to Kottappady	3779	116	101	176	4172
		RWSS to Keerampara	2073	101	0	4	2178

Table 2 outlines the status of sewerage networks and household connections in Ernakulam district, as reported by the KSPCB, focusing on the Kochi-18 Paravoor subdivision and the Muvattupuzha Kothamangalam subdivision. Within the Kochi-18 Paravoor subdivision, the Njarakkal Section records the highest number of total connections (53,067), followed by the Paravoor Section (38,149) and the Muppathadom Section (26,583). Across all three sections, domestic connections form the predominant share, while non-domestic connections are comparatively lower, and industrial and special connections remain marginal. In the Muvattupuzha division under the Kothamangalam subdivision, the scale of connectivity is notably smaller, with total connections ranging from 2,178 to 4,172 across the Area-wide Rural Water Supply and Services (ARWSS) to Kuttamangalam–Neriyamangalam, Rural Water Supply and Sanitation (RWSS) to Pindimana, RWSS to Kottappady, and RWSS to Keerampara sections. Here again, domestic connections account for the majority, with non-domestic connections remaining below 200 in each section. Industrial and special connections are minimal in most areas, except in the RWSS to Kottappady section, where 101 industrial and 176 special connections are reported significantly higher compared to other sections.

For Idukki district, the situation is critical as there is no organized sewerage network, and most households rely on pit toilets. During the monsoon season, these systems often overflow, contaminating nearby drinking water sources and increasing health risks. Recognizing this urgent need, the Sewerage Circle, Kochi of the KWA has prepared a Preliminary Proposed Sewerage Scheme for Idukki District (Fig. 8), highlighting the necessity of establishing a structured sewerage system to address public health concerns and prevent pollution of the Periyar River Basin.

The proposal highlights the Proposed STP and Fecal Sludge and Septage Management (FSSM) scheme for Idukki district. The scheme covers Thodupuzha and Kattapana municipalities along with 52 panchayats, spanning a total area of 4356 sq.km. As per Census 2011, the population of Idukki was 11,08,974 with 2,79,011 households, giving a population density of 255 persons per sq.km. With a design period of 30 years, the population of the district is projected to rise to 11,68,475 by 2053, generating an estimated sewage load of 128 MLD, considering per capita water supply norms of 150 lpcd for municipalities and 100 lpcd for panchayats.

The proposed scheme divides the district into 21 sewerage zones, incorporating both network-based and non-network approaches depending on population density and settlement patterns. Four STPs have been planned with a combined treatment capacity of 25.80 MLD, supported by 875 km of sewerage network pipelines. These will cover a land area of 226.12 sq.km, connecting around 47,338 households and a population of 1,87,934 by 2053. The cost of implementing the STP and sewerage network is estimated at ₹1142.02 crores, translating to approximately ₹2.41 lakh per household. In addition, 17 septage treatment plants (FSSM) have been proposed to handle areas where sewerage networks are not feasible, with a combined capacity of 1022 Kilo Litres per Day (KLD). This arrangement will cover the vast non-networked area of 4129.88 sq.km, serving a population of 9,80,541 across scattered settlements, forests, and plantation-dominated landscapes. The estimated cost of FSSM is ₹51.10 crores, bringing the total project cost for Idukki district to ₹1193.14 crores (excluding land cost).

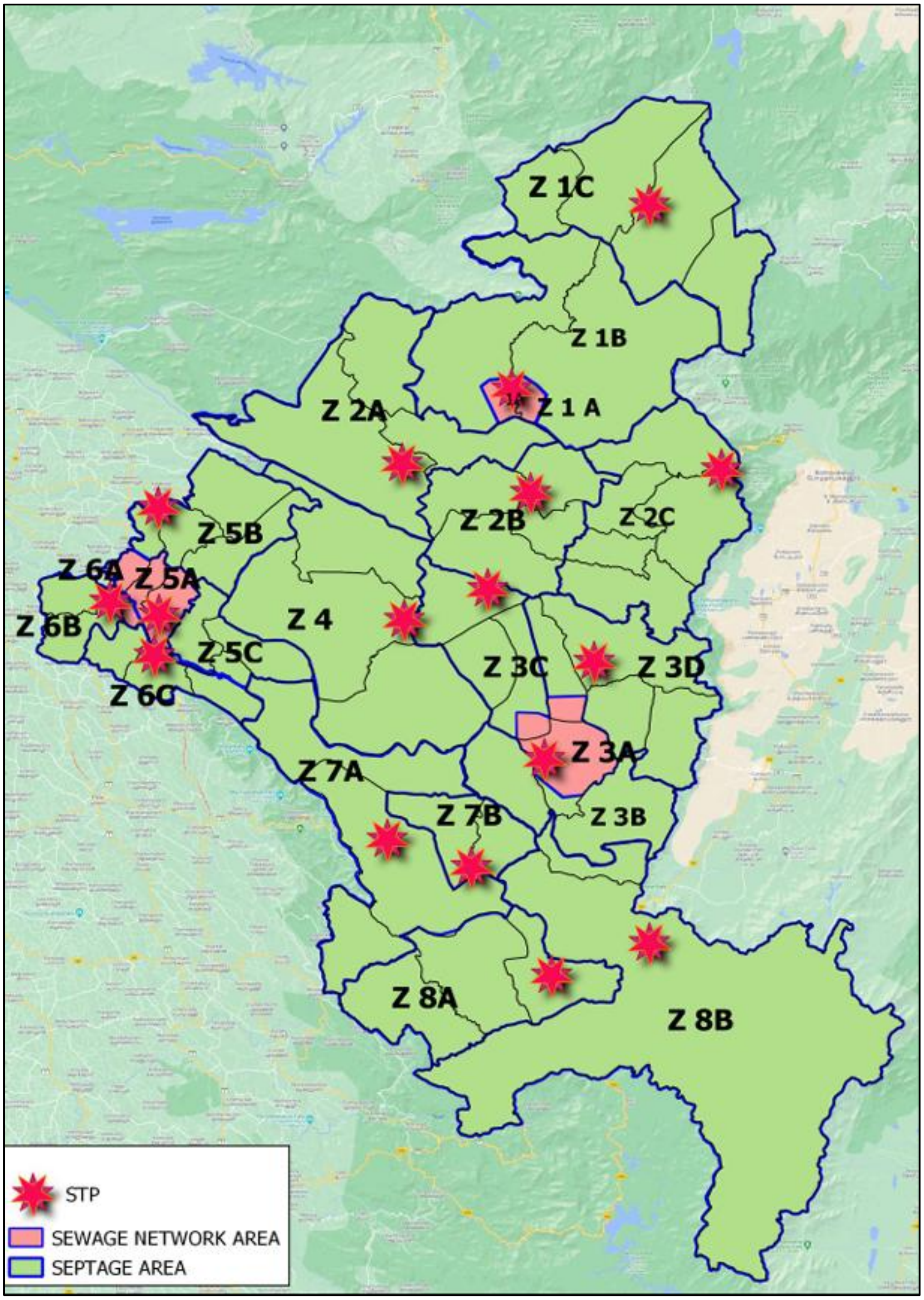

Fig. 8 Map of Proposed Sewerage Scheme for Idukki District *(source: KWA)*

While the sewerage network is concentrated in higher density areas, special focus has been given to Kattapana municipality, which lies within the Periyar River Basin. Although the population density here is slightly less than 1000 persons per sq.km, one STP network has been planned, covering adjoining panchayats such as Erattayar and Kamakshy, due to its regional importance and growing wastewater load. Similarly, the tourist hub of Munnar/Devikulam, also falling within the basin, has been included with one STP and network owing to high floating population, rapid growth of hotel infrastructure, and significant wastewater generation risks. Thodupuzha municipality and parts of adjoining panchayats such as Edavetty and Kumaramangalam also qualify for networked sewerage, though they do not fall within the Periyar Basin and hence are not the direct focus of this study. For the remaining panchayats, given their low population density, scattered households, and dominance of forest and plantation areas, providing an extensive sewerage network is uneconomical. Instead, de-sludging of existing septic tanks and treatment in strategically located septage plants has been proposed by combining multiple panchayats based on topography and natural drainage patterns.

This integrated approach, combining centralized STPs in urban and high-density regions with decentralized FSSM for rural and scattered areas, aims to ensure that by 2053, Idukki district will have an effective sewage management system, addressing both environmental protection and public health, while significantly reducing the pollution load entering the Periyar River Basin.

4.3.Information of interception and diversions

Rivers and lakes have historically been the lifeline of civilizations, providing drinking water, irrigation, transportation, and shaping cultural traditions. However, rapid urbanization, industrial growth, and increasing population pressures have severely degraded their quality. In most Indian cities, centralized sewerage systems are either incomplete or inadequate, and as a result, a large share of sewage, including septic tank overflows, never reaches treatment facilities. Instead, wastewater directly enters open drains, streams, and lakes, leading to heavy pollution loads. Drains in India typically carry a mixture of untreated domestic wastewater, industrial effluents, and even solid waste, making wastewater management complex and multidimensional. The situation worsens during the monsoon season when stormwater runoff combines with untreated sewage, overflowing drains and drastically increasing organic and hydraulic loads in rivers.

As per the CPCB, in 2021 India generated nearly 72,368 MLD of sewage but had treatment capacity for only 20,236 MLD, revealing a substantial gap in wastewater management. To bridge this, Swachh Bharat Mission (SBM) 2.0 emphasizes the role of Interception and Diversion (I&D)

projects, especially in regions lacking underground sewerage networks. I&D provides an effective intermediate strategy by capturing untreated wastewater from critical drains before it reaches natural water bodies and diverting it to treatment plants. This not only prevents contamination but also enhances the efficiency of existing wastewater management systems.

Key steps in implementing I&D projects include mapping and monitoring drains to identify major outfalls and quantify pollution loads; constructing interception structures such as weirs or chambers to capture sewage; installing diversion systems like pipelines or channels to carry intercepted flows to treatment units; and ensuring proper treatment and reuse of the wastewater for agriculture, landscaping, or industrial purposes. Beyond reducing non-point source pollution, they provide economic and ecological benefits, such as sustaining fisheries, improving biodiversity, and reducing incidences of waterborne diseases, ultimately safeguarding both public health and environmental sustainability.

Several shining examples across India highlight the success of I&D projects. The Sabarmati Riverfront Development Project in Ahmedabad has greatly improved river water quality by integrating extensive interception and diversion systems along with treatment infrastructure. Similarly, the Mahadevapura Lake I&D project in Bengaluru employs hydraulic diversion structures to capture wastewater before it enters the lake, redirecting it to a 1 MLD decentralized wastewater treatment system (DEWATS) equipped with screened intake structures, diversion channels, culverts, sedimentation, and balancing tanks. In Varanasi, the Assi River I&D project intercepts wastewater using screening units, diversion channels, and interceptor pipelines, channeling it to treatment plants, thereby preventing direct pollution of the river. These initiatives demonstrate that I&D can be effectively tailored to diverse geographic and urban contexts to achieve rapid water quality improvements (Downtoearth, 2025).

4.3.1. Information on Interception and Diversion Projects in Ernakulam District

In the case of Ernakulam district, interception and diversion measures are contextually significant due to higher urbanisation levels, dense settlements, and substantial wastewater generation, particularly in municipal areas such as Kochi. The district functions under the institutional and policy framework of Suchitwa Mission, the nodal agency under the LSGD responsible for planning, technical support, and approval of solid and liquid waste management projects across

ULBs and Panchayats. Through programmes such as *Malinya Mukta Keralam*, *Swachh Bharat Mission* (Urban and Rural), city sanitation initiatives, and liquid waste management projects, the focus has been on ensuring safe disposal of human excreta and preventing untreated sewage from entering water bodies. Despite these efforts, significant gaps persist between sewage generation and treatment capacity; for instance, in Kochi, less than 30% of generated sewage is currently treated before discharge into local water bodies (Earth5R). In this context, interception and diversion of sewage lines, along with upgrading existing sewage treatment plants, are identified as critical interventions to achieve the objective of zero untreated sewage discharge. However, detailed district-wise data on implemented interception and diversion projects were not available at the time of assessment, indicating that while the need and policy backing for such measures are well established, their extent and coverage remain inadequately documented (Suchitwa Mission, Ernakulam district).

4.3.2. Information on Interception and Diversion Projects in Thrissur District

In the case of Thrissur district, limited information is currently available regarding large-scale interception and diversion projects specifically implemented for wastewater management. However, certain initiatives have been proposed under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0 programme to improve sewerage and septage management infrastructure in the district. As per the agenda of the 9th State Level High Powered Steering Committee (SHPSC) of AMRUT 2.0, a proposal has been placed for the augmentation of the existing 3 MLD STP at Chakkamkandam in Guruvayur to 5 MLD, along with 20 KLD septage co-treatment facilities. The project also includes interception and diversion works for the purification of the polluted Valiyathodu canal, in addition to the development of 2.75 km of sewer network. The proposal has been placed before the SHPSC for approval, with land availability and council approval already obtained, and the KWA designated as the implementing agency (Government of Kerala, 2024) Apart from the above proposal, detailed information on other interception and diversion projects within Thrissur district has not been received at present.

4.3.3. Information on Interception and Diversion Projects in Idukki District

In the case of Idukki district, interception and diversion projects have not yet been implemented. This is primarily due to the region’s low urbanization and scattered settlements, where conventional drains carrying large volumes of untreated sewage, common in plains and urban centers, are largely absent. Wastewater here is mostly managed through onsite sanitation systems such as septic tanks and pit latrines. Moreover, a large portion of land in Idukki is covered by forests and plantations, making centralized drain interception systems technically challenging and economically unfeasible. Instead, the focus in Idukki has been on septage management solutions and localized treatment plants, which are more suitable to the district's settlement pattern and ecological sensitivity.

4.4.Location of pumping stations and their status

Sewage pumping stations play a crucial role in urban wastewater management, particularly in areas where gravity flow is not sufficient to carry sewage to treatment plants. These stations lift and transfer wastewater from lower elevations to higher levels, ensuring smooth conveyance to sewer networks and treatment facilities. Without functional pumping stations, untreated sewage often stagnates or overflows into nearby drains and rivers, causing significant pollution.

Ernakulam District

In Ernakulam District, sewerage pumping stations are provided as collection well–based structures to lift sewage against gradients and to limit excessive depth of sewer excavation where gravity flow is not feasible. In Aluva Municipality, which is divided into zones for sewerage planning based on natural and man-made features such as River Periyar, National Highway, railway line, and boundaries of adjacent Panchayaths, pumping stations and lift stations are proposed as part of the sewerage system for Phase-I implementation covering Zone-1 (Thottakkattukara West) and Zone-2 (Thottakkattukara East) (KWA, 2021). The locations and number of pumping stations are finalised based on ground level contours obtained from topographical surveys, and such stations are generally located at lower points of the sewerage network, with overflow not permitted (KWA, 2021). Pumping stations handle greater flows with arrangements for removal of floating material and grit prior to pumping sewage through force mains, while lift stations consist of enlarged manholes functioning as wet wells with submersible pumps and minimal superstructure, without screens or grit wells, and are generally proposed where the depth of cutting exceeds 5.0 m (KWA, 2021).

In the Aluva sewerage scheme, three collection wells functioning as pumping stations are proposed, of which one is located within the sewage treatment plant premises and the remaining two are located near Old Desam Road and Paravoor Kavala, with separate pumping mains provided from each collection well to convey sewage under pressure to the treatment plant (KWA, 2021). In the Elamkulam area of Ernakulam District, pumping stations form an integral part of the existing sewerage system conveying sewage to the Elamkulam STP, where sewage is received from Pump House No.1 near Maharaja's College Ground and Pump House No.7 at Muttathil Lane, with sewage quantities determined based on pumping hours and discharge capacities (KWA, 2022).

Under the project for utilisation of unutilised capacity of the Elamkulam STP, additional collection wells and pumping arrangements are proposed, wherein sewage collected by gravity through underground sewer lines is conveyed to collection wells and then pumped to the treatment plant. The pump houses in these schemes are proposed as circular structures with submerged wet-well submersible pumps, provision for detention of sewage in the collection wells, and multiple pump sets including standby capacity to meet varying flow conditions (KWA, 2022).

Thrissur District

Thrissur district has limited centralized sewerage infrastructure, and sewage pumping stations are not widely developed across the district. Most areas rely primarily on onsite sanitation systems such as septic tanks, as settlements are distributed across municipalities, small towns, and rural areas rather than large, densely concentrated urban centres. In the absence of an extensive underground sewer network, the requirement for large-scale sewage pumping infrastructure is relatively limited. Sewerage systems have been implemented or proposed only in a few municipalities to manage wastewater generated in localized urban areas, where pumping or lifting arrangements may be provided as part of the sewer network. Consequently, sewage pumping facilities in Thrissur district remain limited and are generally associated with specific municipal sewerage projects rather than forming part of a comprehensive district-wide sewerage system

Idukki District

Idukki district does not have sewage pumping stations, as a centralized sewerage system has not been developed in the district. The population is distributed in small and dispersed settlements, and there are no major urban agglomerations generating concentrated sewage flows that require collection through sewers and lift arrangements. In the absence of a structured sewer network, the need for pumping infrastructure does not arise. Wastewater is predominantly managed through individual septic tanks and other onsite sanitation systems. Consequently, sewage pumping stations have not been planned or implemented in the district.

4.5. Drains - Domestic and Industrial

4.5.1. Details of Drains: Ernakulam District

The Eloor–Aluva region of Ernakulam district contains several drains that convey wastewater from nearby urban settlements and industrial areas into the river system. These drains function as important channels through which untreated or partially treated domestic and industrial effluents enter the aquatic environment. Assessing the discharge quantity and pollution load from these drains is essential for understanding their contribution to river pollution and for identifying priority locations for pollution management.

Information on major drains discharging wastewater in the Eloor–Aluva stretch was compiled from the Action Plan for Rejuvenation of River Periyar (Alwaye–Eloor to Kalamassery Stretch Priority V, 2019). The dataset provides details on discharge quantity and associated pollution load, including BOD and Chemical Oxygen Demand (COD), which are commonly used indicators of organic and chemical pollution in wastewater (Table 3).

The volume of wastewater discharged by the identified drains varies significantly, ranging from 315,977 L/day at the Hotel Periyar drain to 9,953,280 L/day at Edapally Thodu. Larger discharge volumes are typically associated with more densely populated or industrial areas, indicating that these drains are likely carrying a mixture of domestic and industrial effluents. The BOD and COD values provide an indication of organic and chemical pollution in the wastewater. Among the drains, Thoombungal Thodu records a BOD of 300 mg/L and a COD of 960 mg/L, suggesting considerable contamination in this location.

Table 3: Drains (Domestic & Industrial) (Source: Action plan for rejuvenation of stretch of River Periyar-Alwaye-Eloor to Kalamassery (Priority-V), 2019)

Sl. No.	Location of drains	Area of Flow (Sqm)	Discharge quantity (L/Day)	Discharge quality			
				BOD (mg/l)	BOD (Tonne/Day)	COD (mg/l)	COD (Tonne/Day)
1	Amrutha Sag Pharma, Eloor	0.2	1382400	100	0.138	320	0.442
2	Pathalam Bridge	0.075	617143	360	0.222	1120	0.691
3	Aluva Thoittumugham	0.6	5456842	160	0.873	480	2.619
4	Asramam Road	0.05	1944000	280	0.544	880	1.711
5	Aluva Market/Jewel River woods flat	0.1	1024000	420	0.43	1280	1.311
6	Hotel Periyar	0.03	315977	340	0.107	1040	0.329
7	Puthalam Kadavu Drain	0.04	348365	120	0.042	400	0.139
8	Thoombungal Thodu	1	6912000	300	2.074	960	6.636
9	Edapally Thodu	1.2	9953280	180	1.792	560	5.574

The pollution load, expressed as BOD and COD in tonnes per day (TPD), represents the total quantity of organic and chemical pollutants discharged through the drains. Thoombungal Thodu discharges approximately 2.074 tonnes/day of BOD and 6.636 tonnes/day of COD, making it a major contributor of both organic and chemical pollution in the area. Edapally Thodu contributes about 1.792 tonnes/day of BOD and 5.574 tonnes/day of COD, indicating a substantial pollution load, though slightly lower than that of Thoombungal Thodu. In both cases, COD values are considerably higher than BOD values, indicating the presence of chemical contaminants in addition to organic pollutants. In addition to the discharge estimates, water quality monitoring has been carried out at selected drain outfalls in the Ernakulam district by the KSPCB. Monitoring parameters include temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), BOD, COD, nutrients, and microbial indicators.

Monitoring observations further indicate that Pathalam Bridge (sewerage pipe) and Edayattu Chaal exhibit the highest BOD (305 mg/L), reflecting strong organic pollution (Table 4). The drains near Aluva Market and Onji Thodu show low dissolved oxygen levels and high microbial counts, signifying degraded water quality. Overall, Pathalam Bridge and Edayattu Chaal represent the most polluted discharge points, while the drain near SCMS School shows comparatively lower contamination levels among the sites studied (KSPCB).

Further monitoring carried out by the KSPCB has identified additional drains, streams, and channels discharging wastewater into the river system in the Ernakulam district. These locations include drains within the Edayar industrial area as well as other nearby channels and streams that contribute wastewater inflow to the river. Water quality measurements were conducted at these sites to assess parameters such as pH, EC, DO, BOD, COD, chloride, phosphate, and microbial indicators. The monitoring results for these additional drains and channels are presented in Table 5. Detailed analytical results including heavy metal concentrations for the monitored drains are provided in Annexure 1

Table 4: Drains - Discharge quality

Drains	Stretch	Latitude	Longitude	Discharge quality									
				Temperature (°C)	pH	EC (µS)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	NO_3^- (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)	TC MPN/ 100mL
Pathalam bridge - sewerage pipe	Edayar Stretch	10.0413° N	76.3185° E	25	6.59	161	9.1	305	-	5	170	-	800
Edayattu Chaal	Muttar River Stretch	10.0531° N	76.3181° E	27.4	5.8	309	7.9	120	-	0	34	-	300
SCMS School (Thumbungal thodu)	Muttar River Stretch	10.0661° N	76.3242° E	30.9	6	53.2	7.4	5	-	5	4	-	200
Drain near Aluva Market	Kalady Stretch	10.1116841 N	76.3493685 E	-	6.93	-	6.1	4.2	56	BDL	-	0.3	>100
Onji Thodu	Kalady Stretch	10.1012377 N	76.3186315 E	-	6.51	-	7	4	120	BDL	-	0.2	>100

Table 5: Water Quality of Additional Drains and Channels in Ernakulam District *(Source: KSPCB)*

Name of Chal / Drain / Stream	Latitude (N)	Longitude (E)	pH	EC (µS/cm)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Cl^- (mg/L)	PO_4^{3-} (mg/L)	TC (CFU/100 ml)	FC (CFU/100 ml)
Drain between Alpha Crumb Rubber & Malaya Rubtech, Edayar	10.07989	76.31517	6.9	13790	0	420	1680	3500	1.512	7000	1000
Drain inside CMRL (East side), IDA Edayar	10.07803	76.31364	–	–	–	–	–	–	–	–	–
Drain inside Srisakthi Paper Mill compound (East side)	10.07933	76.31492	–	–	–	–	–	–	–	–	–
Drain joining upstream near Navigation Channel, Pathalam Bund	10.07703	76.30903	6.1	14330	0.9	180	720	4200	BDL	2400	700
Drain near Marksmen Marine Products (D/S Pathalam Bund)	10.07706	76.30858	6.7	17340	–	–	–	4800	0.673	3000	800
Storm water drain of Indogerman, IDA Edayar	10.07811	76.30197	6.3	3594	0	440	1760	750	0.685	–	–
Edayattuchal	10.09186	76.30133	6.5	2433	3.6	500	1840	920	BDL	1700	300
Onjithodu	10.09947	76.29017	6.4	3902	4.2	220	880	980	BDL	1700	200
Stream near Pallathunadupalam (Adichilikadavu)	10.09364	76.27986	6.5	21050	2.6	420	1600	5800	BDL	3500	400
D-Drain, FACT UD	10.07633	76.30214	6.8	4897	1.9	420	1680	1500	2.555	–	–

C-Drain, FACT UD	10.07828	76.30017	5.1	3281	2.3	320	1040	890	0.452	3800	600
O4-Drain, TCC	10.0755	76.30639	6.2	14340	2.8	540	1840	3400	BDL	–	–
Drain at Pathalam Bridge – Eloor side	10.08097	76.31786	6.2	10930	0	240	880	3100	2.491	4100	700
E-Drain, FACT PD	10.07006	76.29072	5.1	11100	1.3	640	2160	3600	BDL	2600	400
Unthithodu	10.07292	76.28697	6	6022	3	80	224	1800	BDL	1900	300
Drain at eloor-ferry road	10.07292	76.28697	6.2	7883	2.7	140	336	3300	0.023	4300	700
Stream at Palliyattukarakadavu	10.07661	76.28447	6.3	20590	2	120	360	5800	BDL	4700	700
Drain at Periyar Road, Varapoli	10.07825	76.28614	6.3	19620	2.1	180	408	5200	BDL	3600	500
Drain near Methanamkadavu	10.09547	76.28947	6.4	19560	2.9	500	1680	6100	BDL	3600	500
Drain near Popular Lime Shell	10.06506	76.29453	6.9	3423	1.2	160	368	910	0.195	3200	600
Drain at Amrutha Sag Pharma	10.07461	76.312	6.3	2564	1.2	120	320	750	2.314	5000	900
B-Drain FACT PD	10.06914	76.29056	6	4030	2	120	560	1100	0.36	1900	300
Storm water drain of IRE	10.08258	76.2985	6.9	35470	3.1	560	1840	6500	0.157	–	–
Drain at Manjali Bridge	10.28455	76.46156	5.5	2121	3.9	200	720	790	BDL	900	100
Drain at Pazhampillythuruth Bridge	10.07989	76.31517	6	53310	4.2	360	1280	13900	BDL	2100	200
Drain at Ryan School	10.07803	76.31364	6.3	1736	4.4	160	640	350	BDL	200	NIL

(Note: TC - Total Coliform; FC - Faecal Coliform)

The monitoring programme covered 26 drains, streams, and channels discharging into the river system. The listed water bodies include drains, storm water drains, small streams, medium streams, an irrigation canal, and stream–drain systems. Several locations are identified within the Edayar industrial area, including drains near Alpha Crumb Rubber and Malaya Rubtech, drains inside CMRL and Srisakthi Paper Mill compounds, the storm water drain of Indogerman, and drains associated with FACT units and TCC. Remarks provided in the dataset indicate specific field observations such as industrial drains joining the Periyar upstream of Pathalam Bund, storm water drains of the IDA area, authorised discharge points, delay pond sampling locations, and drains influenced by domestic sewage or urban runoff. Some streams and channels, including Edayattuchal, Ongithodu, Unthithodu, and the stream near Pallathunadupalam, are noted with remarks describing their connection to paddy fields, residential flow paths, tributary status, or tidal influence. Additional drains at locations such as Periyar Road (Varapoli), Methanamkadavu, Popular Lime Shell, Amrutha Sag Pharma, Manjali Bridge, Pazhampillythuruth Bridge, and Ryan School are described in the remarks column as storm water drains, branches of streams, or locations with industrial or domestic influence.

Overall, the monitoring results indicate considerable variability in the physicochemical and microbiological characteristics of the drains in the study area. The pH values range from 5.1 to 6.9, reflecting slightly acidic to near-neutral conditions. The lowest pH value (5.1) was recorded at C-Drain, FACT UD and E-Drain, FACT PD, while the highest value (6.9) was observed at the drain between Alpha Crumb Rubber & Malaya Rubtech, the drain near Popular Lime Shell, and the storm water drain of IRE. Electrical conductivity (EC) values also show substantial variation, ranging from 1736 µS/cm at the drain near Ryan School to 53,310 µS/cm at the drain at Pazhampillythuruth Bridge, indicating considerable differences in dissolved ionic content among the drains. Dissolved oxygen (DO) concentrations range between 0 mg/L and 4.4 mg/L. The lowest DO (0 mg/L) was observed at the drain between Alpha Crumb Rubber & Malaya Rubtech, the storm water drain of Indogerman, and the drain at Pathalam Bridge – Eloor side, whereas the highest value (4.4 mg/L) was recorded at the drain near Ryan School. BOD values vary from 80 mg/L at Unthithodu to 640 mg/L at E-Drain, FACT PD. Similarly, COD ranges from 224 mg/L at Unthithodu to 2160 mg/L at E-Drain, FACT PD, indicating variation in organic and chemical pollution levels among the monitored drains. Chloride concentrations range from 350 mg/L at the drain near Ryan School to 13,900 mg/L at the drain at Pazhampillythuruth Bridge, reflecting high dissolved salt content in certain locations. Phosphate concentrations are generally low or below detectable levels; however, the highest value (2.555 mg/L) was recorded at D-Drain, FACT UD, followed by the drain at Pathalam Bridge – Eloor side (2.491 mg/L) and the drain at Amrutha Sag Pharma (2.314 mg/L). Microbiological analysis indicates that total coliform counts range from 200 to 7000 CFU/100 mL, while fecal coliform counts vary from not detected (NIL) to 1000 CFU/100 mL, indicating varying levels of microbial contamination across the monitored drains.

4.5.2. Details of Drains: Idukki District

Idukki district exhibits a drainage profile that is distinctly different from the heavily industrialized downstream stretches of the Periyar River. The district is predominantly a highland region characterized by agricultural land use, forest cover, and hydropower reservoirs, with limited industrial activity. As per records from the KSPCB, three identified drains are present within the Idukki district. Of these, two drains are located within Munnar Grama Panchayat, while one drain is situated in Vandiperiyar Grama Panchayat. These areas are major tourist destinations with high visitor inflow, resulting in the presence of several resorts and related facilities to accommodate tourism activities, which influences the nature of wastewater discharge in these regions.

For Idukki district, the availability of drain-related data is limited. KSPCB provided only the locations and names of the drain outfalls (Fig. 9), while additional information on drain water quality was obtained from the Room for Periyar report prepared by the Irrigation Department, Kerala. The available water quality parameters for these drains are restricted to BOD (mg/L) and coliform count (CFU/100 ml). All three drains are located in proximity to resort establishments, indicating tourism-related wastewater as a key contributor to the observed pollution load.

The first drain, Nadayar Drain near Silver Spoon Restaurant in Munnar Grama Panchayat, records a BOD concentration of 6.6 mg/L and a coliform count of 1,600 CFU/100 ml. The second drain, located behind Broad Bean Resort in Munnar Grama Panchayat, shows a comparatively lower BOD of 1.8 mg/L but a significantly higher coliform concentration of 8,400 CFU/100 ml, indicating microbiological contamination. The third drain, situated at the Periyar River near Springdale Resort in Vandiperiyar Grama Panchayat, has a BOD value of 5.4 mg/L and a coliform count of 4,200 CFU/100 ml, reflecting moderate organic and bacterial pollution.

Overall, although the number of identified drains in Idukki district is limited, the observed organic and microbial contamination highlights the contribution of localized, tourism-related domestic wastewater discharges to the pollution load of the Periyar River in the upstream reaches.

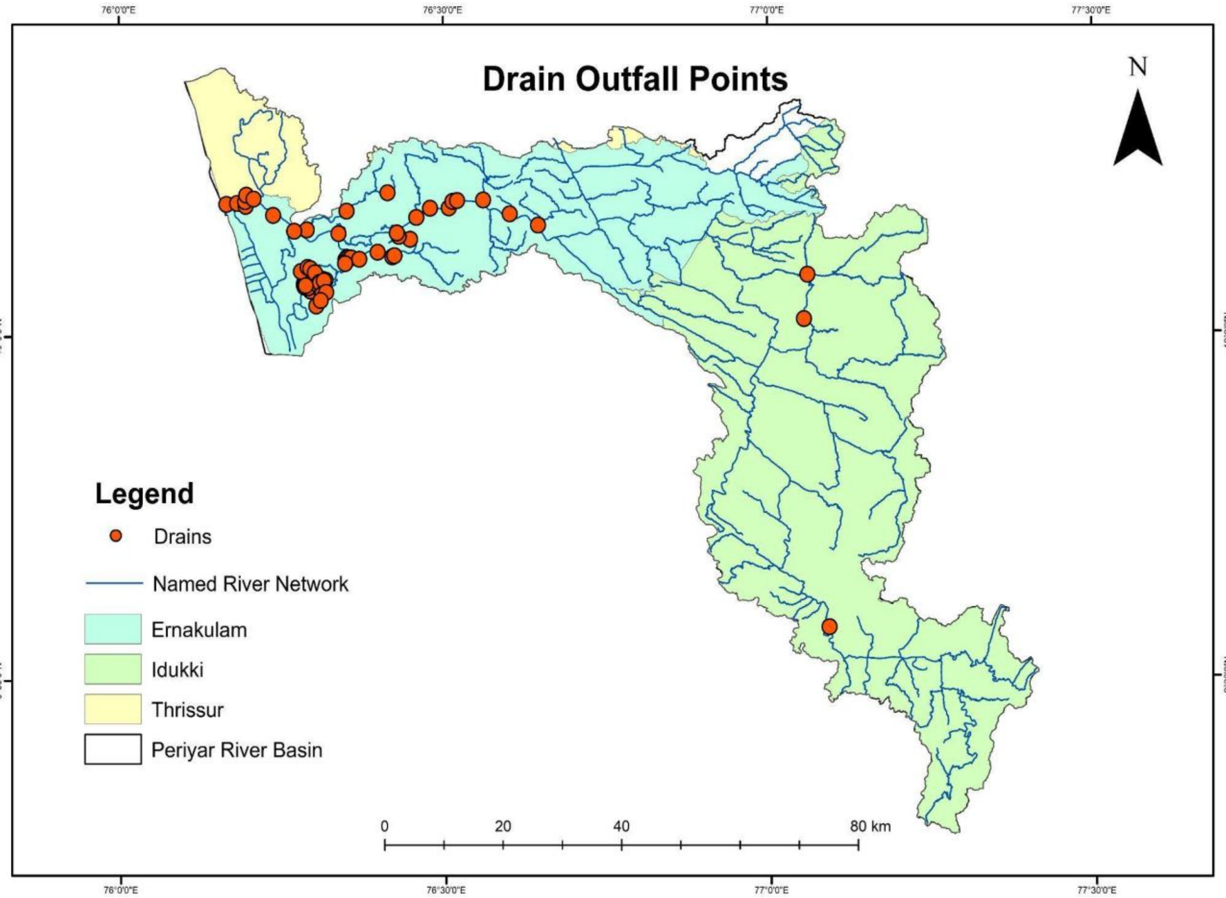

Fig. 9 Drain Outfall Points in the Periyar River Basin

4.6.Industrial Wastewater Load

The rapid pace of industrial growth, urban expansion, and population increase has led to a substantial rise in water demand. Most of this water is extracted from groundwater sources and rivers, and after use, it generates effluents from industrial units. To regulate this discharge, the KSPCB issues a combined 'Consent to Operate' under the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, and the Environment Protection Act, 1986. This consent specifies the maximum permissible discharge, quality standards for treated effluent or sewage, location of disposal outlets, and the mode of disposal to ensure compliance and pollution control.

The Periyar River Basin's industrial landscape is influenced by various establishments, including large-scale chemical, fertilizer, and metal-processing units, which rely on the river for water, transportation, and effluent disposal. The Eloor-Edayar belt is a major industrial hub, contributing to the region's economy. However, this concentration has led to environmental challenges, including pollution, disrupting aquatic biodiversity, and undermining traditional livelihoods. Sustainable strategies are needed to ensure a resilient riverine ecosystem.

The industrial estate accommodates around 280 industries, of which 112 belong to the Red Category and 46 to the Orange Category, indicating their high potential for environmental impact. According to CPCB guidelines, Red category units are those with the highest pollution potential (e.g., chemical industries, tanneries), Orange units have moderate pollution potential (e.g., food processing, textile washing units), Green units represent low pollution potential (e.g., small workshops, bakeries), while White units are virtually non-polluting (e.g., educational institutions, offices).

The assessment of industrial wastewater loads in the Periyar basin, based on KSPCB data, reveals a highly uneven pollution profile shaped by the wide diversity of industrial activities operating along the river. Large red-category industries particularly chemical, petrochemical, fertilizer, mining, and leather units generate the highest wastewater volumes and routinely discharge treated effluent into the Periyar, especially downstream of the Pathalam bund. Medium and small-scale units, including activated carbon, rubber, rendering, bone meal, tallow, electroplating, and chemical manufacturers, display significant variation in wastewater management, ranging from structured effluent treatment systems to rudimentary mechanisms such as soak pits, septic tanks, neutralisation tanks, or simple settling arrangements. A considerable number of small bone meal and tallow units operate without ETPs, disposing of effluent mixed with lime, indicating persistent gaps in environmental compliance. In contrast, sectors such as fish processing, oleoresin extraction, resin production, and ready-mix concrete demonstrate comparatively robust treatment processes with partial or full reuse of treated effluent. Tables 6 and 7 present a detailed classification of industries, outlining their wastewater generation levels and corresponding treatment or disposal practices. Table 6 focuses on industries equipped with fully functional ETPs and authorized discharge outlets to the Periyar River, while Table 7 summarizes the sector-wise industrial wastewater load.

Table 6: Industrial wastewater load: Industries with Operational ETPs and Permitted Periyar Outlets

Sl. No.	Name and Address of the unit	Latitude	Longitude	Type of unit	Category	Scale	Water Consumption (L/day)	Sewage/ Effluent (L/day)	ETP Details	Sewage disposal details
				Industries Having Full Fledged ETP and Permitted Outlet to River Periyar						
1	Sud Chemie India Private Limited, Edayar Industrial Development Area, Binanipuram P.O., Pin – 683 502	10.07894 479N	76.3038147 E	Chemical catalyst industry	Red	Large	450000	450000	Oil traps, Equalization tank, Flash mixer, Clarifier, Filter press, Delay tank	To river periyar (Downstream of Pathlam bund)
2	Cochin Minerals and Rutile Ltd., Industrial Development Area, Edayar, Muppathadom P.O.	10.08150 540N	76.31107811 E	Mining and ore beneficiation (ore - Ilmenite)	Red	Large	1995000	659000	Neutralisation, Equalisation, Flash mixer, Secondary clarifier, vacuum belt filter, filter press	To River periyar (Downstream of pathalam bund)
3	TMS Leathers Industrial Development Area, Edayar, Muppathadom P.O.	10.08082 N	76.31335E	Leather	Red	Large	123600	101000	Solar evaporation beds, Chrome recovery plant collection tank, Effluent collection tank, Equalisation tank, Chemical precipitation tank, Primary settling tank, Aeration tank, Secondary settling tank, Sludge drying bed.	To river Periyar (upstream side of pathalam bund) and reuse
4	FACT Ltd., Udyogamandal, Division, Eloor, Udyogamandal	10.07468 N	76.29784E	Chemical Fertilizer	Red	Large	19075000	1680000 0	-	-
5	FACT Ltd., Petrochemical, Division, Eloor, Udyogamandal	10.07373 N	76.29362E	Petrochemical unit	Red	Large	13970000	5040000	-	--
6	Indian Rare Earths Ltd, Eloor,Udyogamandal P.O.	10.08053 N	76.29667E	Chemical	Red	Large	422000	400000	-	-

Table 7: Sector-wise Distribution of Industrial Wastewater load

Sl. No.	Name and Address of the unit	Type of unit	Category	Scale	Water Consumption (L/day)	Sewage/ Effluent generation (L/day)	ETP Details	Sewage disposal details
				Activated carbon units				
1	Active Char Product Pvt. Ltd., Industrial Development Area, Edayar	Activated carbon	Red	Medium	1,00,000	4500	No trade effluent generated (only boiler blow down/back wash return after the process) STP (10 KLD) with MBR system for domestic effluent.	Percolation pit
2	Cochin Surfactants Pvt. Ltd., Industrial Development Area, Edayar, Muppathadom P.O.	Activated Carbon production unit	Red	Small	30400 (Process: 400 L/day, Domestic: 5,000 L/day, Boiler feed: 25,000 L/day)	6500 (domestic - 5000 L/day & boiler blow down:1500 L/day)	No ETP	Septic tank soak pit system provided for domestic effluent and boiler blow down disposed through percolation pit
3	Indo German Carbon Ltd, Industrial Development Area, Edayar, Binanipuram P.O.	Activated carbon	Red	Large	139300	8600	Collection tank, neutralisation, sand filter, and carbon filter and ultrafiltration system	For irrigation and percolation pit.
				Bone meal/rendering units/fish processing units				
1	Alliance Marine Products, Industrial Development Area, Edayar	Rendering unit	Red	Medium	53,750	45,000	ETP of 100 KLD capacity -Screen chamber, grit chamber,fat & oil removal with DAF, fat & oil trap, High-Rate Anaerobic Digester,Nitrification, equalisation tank, Anoxic tank, aeration tank, secondary settling tank, PSF, ACF, Ultrafiltration, treated water tank, filter press.	Reuse & Soak Pit
2	Ashan Exports & Furnishers, Industrial Development Area, Edayar, Muppathadom P.O.	Bone Meal and Rendering unit	Red	Small	13,000	12,000	Multiple Effect Evaporator and Agitated Thin Film Drier	Reuse

3	Biocon Industries, Industrial Development Area, Edayar, Muppathadom P.O	Bone Meal Unit	Red	Small	2500	Not Available	No ETP	Effluent mixed with Lime and sell as manure
4	Marksmen marine products Pvt Ltd, SyNo.61/6-10, IDA, Edayar	Fish meal & Fish oil Manufacturing	Orange	Medium	35000	52000	Screen chamber, oil trap, collection tank, anaerobic system, equalisation tank, aeration tank, secondary clarifier, flash mixer, flocculation and settling tank, pressure sand filter, activated carbon filter, filter press, sludge drying bed, treated water tank	Reuse
5	National Industries, Industrial Development Area, Edayar, Muppathadom P.O.	Bone Meal Unit	Red	Small	900	Not Available	No ETP	Effluent mixed with Lime and sell as manure
6	Nelkadhir Bone Industries, Industrial Development Area, Edayar, Muppathadom P.O	Bone Meal Unit	Red	Small	1400	Not Available	No ETP	Effluent mixed with Lime and sell as manure
7	Organo Fertilizers (India) Pvt. Ltd., Industrial Development Area, Edayar, Muppathadom P.O.	Bone meal	Red	Medium	5000	20000		
8	Panchami Agro Industries Industrial Development Area, Edayar, Muppathadom P.O.	Bone Meal Unit	Red	Small	1000	Not Available	No ETP	Effluent mixed with Lime and sell as manure
9	Parakkal Industries Vi, 592 A,Ida Binanipuram P.O Edayar - 683502	Bone meal	RED	Small	8000	7000	Screen chamber, oil trap ,equalisation tank, flash mixer, primary settling tank, recirculation tank, anaerobic tank, plain settling tank, aerobic tank, flocculation tank, secondary settling tank, filter feed tank, pressure sand filter, activated carbon filter, treated water tank, sludge digester	Soak pit
10	Sigma Fertilizers	Bone Meal Unit	Red	Small	2000 (Domestic -1000, Boiler - 1000)	Not Available	No ETP	Effluent mixed with Lime and sell as manure
11	Varkey's Industries Industrial Development Area, Edayar, Muppathadom P.O.	Bone Meal Unit	Red	Small	Domestic -500	Domestic - 300	No ETP	Effluent mixed with Lime and sell as manure

12	Yeoman Bone and Allied Products, Industrial Development Area,	Bone Meal Unit	Red	Small	8900	2000	No ETP, Provided shell and tube water condenser	Reuse in boiler
13	Five Star Industries Industrial Development Area, Edayar, Muppathadom P.O.	Manufacturing of animal tallow	Red	Small	Domestic -200	Not Available	No ETP	Effluent mixed with Lime and sell as manure
14	Formal Trade Links Llp, Industrial Development Area Edayar,	Tallow unit	Red	Small	1200	200	Screen chamber, collection tank, oil removal, aeration tank, clarifier, filter feed tank, pressure sand filter, activated carbon filter, treated water tank, sludge digester	Reuse
15	Jks Industries, V/597 Industral Developement Area Edayar Muppathadam Aluva	Tallow unit	Red	Small	200	600	Screen & Oil Separator, Anaerobic Digestor 1, Anaerobic Digestor 2, Aeration Tank 1, Aeration Tank 2, settling tank, filter feed tank, pressure sand filter, activated carbon filter	Soak pit
16	Siya Enterprises Industrial Development Area, Edayar, Muppathadom P.O.	Tallow unit	Red	Small	620	Not Available	No ETP	Effluent mixed with Lime and sell as manure
					Paint unit/thinner Unit			
1	Allied Coating Industries Building No. 253, Industrial Development Area, Edayar, Binanipuram P. O.	Water based paints	Orange	Small	1000	750	Settling tank - soak pit	Soak pit
2	Amcos Xl Paints (India) Pvt. Ltd, Unit 1, Industrial Development Area, Bund Road, Edayar, Muppathadom P.O.	Water based & solvent based paints	Orange	Small	1000	500	Collection tank, mixing channel, settling tanks, sand filter, filter press	Reused for floor cleaning
3	Cochin Petromins, Industrial Development Area, Edayar	Manufacturing of Thinner, Turpentine, Wall primer	Red	Small	500	100	collection tank, settling tank, chemical precipitation tank, aeration tank and filtration	Reuse

				Rubber Industries Units (crumb/crepe/centrifuged latex)				
1	Alpharub Crumb Rubber P Ltd	Crumb rubber	Orange	Medium	100000	85000	Rubber trap (2 nos.), collection tank, lime mixing tank, parallel plate settler, aeration tank, secondary clarifier, alum mixing tank, settling tank, aeration tank, treated water tank, sand filter, carbon filter and sludge drying bed.	Reused in the process
2	Essar Enterprises, Industrial Development Area	Crepe rubber	Orange	Small	10000	5000	rubber trap, chemical treatment, primary settling tank, aeration tank, secondary settling tank, disinfection, pressure sand filter and activated carbon filter, activated carbon filter	Treated water reused in the process
3	Malaya Rub Tech Industries	Rubber	Orange	Large	720800	710000	bar screen, rubber trap, oil & grease trap, primary settling tank, aeration tank, secondary settling tank, pressure sand filter, activated carbon filter, treated water tank, filter press, sludge drying bed	Reuse
4	Sunrise TSR Factory	Crumb rubber unit	Orange	Small	302000	45000	rubber trap, collection tank, chemical treatment tank, primary settling tank, aeration tank (2 nos.), secondary settling tank, filter feed tank, Pressure sand filter, activated carbon filter	Reuse
				Compound Rubber units				
1	JBS Intermix and Rubber Products Pvt. Ltd., Industrial Development Area, Near KSEB Substation, Edayar, Muppathadom P.O.	Rubber unit	Orange	Medium	2500	2500	collection tank, aeration tank, settling tank, filter feed tank, filtration, and treated water tank	Soak pit
2	Rubber O Malabar Products Pvt. Ltd., IDA, Edayar, Muppathadom P.O.	Rubber	Orange	Medium	6250	1000	Collection tank, Settling tank, Aeration tank, filtration, final tank *waste water from bath rooms not connected to STP and directly disposed to the nearby land	reuse
				Electroplating/powder coating units				
1	Aristo Steel Fabricators, Door V/688D, Edayar, Industrial Development Area, Muppathadom P.O.	Engineering fabrication, powder coating	Red	Small	850	780	Collection tank, equalisation tank, aeration tank, settling tank and filtration and treated water tank	Reuse
2	Bright Coats, Edayar, Industrial Development Area, Binanipuram P.O., Pin - 683502	Anodising unit	Red	Small	500	50	collection tank, lime addition and settling tank	Soak pit

3	Bright Powder Coatings, Door No. 6/575, Edayar, Aluva -Edayar Road.	Powder coating unit	Orange	Small	1300	200	No ETP	Directly disposed to drain
4	Exelon Hi-Fabs and Contractors Pvt. Ltd. (Matson Electro coats Pvt. Ltd), Industrial Development Area, Edayar, Muppathadom P.O.	Powder coating unit	Red	Small	4000	3000	collection cum equalisation tank, reduction and precipitation tank, alkali addition tank, settling tank, pressure sand filter, activated carbon filter, treated water tank, sludge drying bed	Reuse
5	New Aluminium And Allied Industries,V/807 ,Ida, Edayar, Muppathadam 683110	Aluminium powder coating	Red	Small	250	250	Waste water is collected in a collection tank and after chemical mixing and disposed to the drain	disposed to the drain
6	Poly-Coat industries (Ramanand Electrocoats), Industrial Development Area, Edayar, Muppathadom P.O.	Powder coating unit	Red	Small	4000	2000	collection cum neutralisation tank, oil trap, settling tank, filter feed tank, pressure sand filter, activated carbon filter, treated water tank, sludge drying bed	Reuse
7	Popular Industries, Industrial Development Area	Electroplating unit	Red	Small	200	150	Provided a system to neutralise the effluent and after that the effluent was disposed of to the treatment system of nearby service stations. But the treatment system of service station is also not adequate	Soak pit
8	Success Spinning Pv.t Ltd., V/752, (B. No. 21, 21A, 21B), Industrial Development Area, Edayar, Muppathadom P. O.	Powder coating unit	Red	Small	350	250	Some tanks provided for the treatment of effluent which is not adequate	Reuse
9	Kemo Gravures Ida, Edayar, Binanipuram	Printing Rollers	Red	Small	940	250	Neutralisation and precipitation tank, settling tank, filter, treated water tank *Provided an ETP in the unit. But it was not properly operated. An augmentation is directed.	Soak pit
10	St. George Industries, Industrial Development Area, Edayar, Binanipuram P.O.	Engineering unit	Red	Small	1000	250	Waste water generated during the pre-treatment is collected in the tank and neutralised and settled sludge is recovered using filter press and water reused in the process	reuse
11	Wisdom Associates & Co	Aluminium powder coating	Red	Small	1700	1000	collection tank, coagulation and settling tank, filter feed tank, pressure sand filter, activated carbon filter and treated water tank	Reuse

				Oleo resins Units				
1	Arjuna Natural Limited, Industrial	Oleo resins manufacturing unit	Orange	Medium	51,000	20,000	Collection tank, neutralisation tank, flocculation tank, aeration tank, settling tank, filtration, triple effect evaporator, filtration, and agitated thin film dryer	Land percolation and reuse
2	TMV Natural Oils and Extracts (P), Industrial Development Area, Edayar, Muppathadom P.O.	Herbal extracts	Orange	Small	1700	1000	screen chamber, oil trap, equalisation, flocculation tank, primary settling tank, anaerobic tank, aeration tank, flocculation tank, secondary settling tank, filter feed tank, pressure sand filter, activated carbon filter, treated water tank	Soak pit
				Nitrous oxide Units				
1	Atchuth Nitrous Company, VI/549C, Industrial Development Area, Edayar, Binanipuram P.O.	Nitrous Oxide manufacturing	Green	Small	1400	1200	Waste water generated is the condensed steam and scrubbed water which is collected in a settling tank	Reuse - recirculated in the process
				Oil recycler units				
1	Cee Jee Lubricants, Industrial Development Area, Edayar, Binanipuram P.O.	Oil re-refining	Orange	Small	11,000	No effluent generation	Provided oil trap in the storm water drain and disposed of to public drain after settling tank/collection tank.	Cooling water is completely recirculated
				Ware house/ go down Units				
1	Cella Space Ltd, Industrial Development Area, Mupathadam	Ware House/ Godown	Orange	Medium	20000	20000	ETP of 25 KLD capacity - screen chamber, septic tank, up flow anaerobic reactor, collection/ equalisation tank, primary settling tank, secondary settling tank, filter feed tank, pressure sand filter, activated carbon filter, disinfection, treated water tank and sludge bio reactor is provided for the treatment of domestic effluent	Soakpit
				Gold purification Units				
1	CGR Metalloys Pvt. Ltd., (Chemmanur Gold Refinery (P) Ltd., Century Gaskets & Rubber Works) No. Industrial Development Area, Edayar, Muppathadom, Aluva - Ernakulam	Gold purification	Red	Small	100	50	equalisation tank, chemical treatment tank, collection tank, final pH correction tank and filtration	Treated water reused for gold washing
				Dyeing units				
1	Classic Concepts Home India Pvt. Ltd., VI/565, Industrial Development Area, Edayar,	Dyeing unit	Red	Small	37000	34000	oil& grease trap, flash mixer, clarifier, aeration tank, clarifier ,pressure sand filter, activated carbon filter, treated water tank, filter press	soak pit

				Formaldehyde Resin units				
1	Cloud Chemicals, Door No. 18/770, Industrial Development Area, Edayar, Binanipuram P. O., Ernakulam - 683 502.	Formalin & Urea formaldehyde Resin	Red	Medium	3500	2000	screening, equalisation, anaerobic system, aerobic system, flocculation, settling and filtration	Treated effluent reused in the process
2	Deccan Industries Industrial Development Area, Edayar, Binanipuram P.O., Ernakulam - 683 502	Urea formaldehyde Resin	Red	Small	2000	2000	collection tank, electro coagulation, settling cum clarifier, sand filter, carbon filter, treated water tank	Treated effluent reused in the process
3	Industrial Development Area, Edayar, Binanipuram P.O., Ernakulam - 683 502	Urea formaldehyde Resin	Red	Small	2000	2000	collection tank, electrocoagulation, poly dosing system, clarifier, pressure sand filter, activated carbon filter, treated water tank, sludge drying bed (ETP was not operational)	Soak pit
4	Vinayaka Industries, V/685, Industrial Development Area, Edayar, Muppathadom P.O.	Urea formaldehyde Resin	Red	Small	2400	350	collection tank, electro coagulation, settling cum clarifier, sand filter, carbon filter, treated water tank	Treated effluent reused in the process
5	Euro Polymers, Industrial Development Area, Edayar, Binanipuram P.O.	Chemical	Red	Small	2000	1000	Collection tank, electrocoagulation, poly dosing system, clarifier, pressure sand filter, activated carbon filter, treated water tank, sludge drying bed	Reuse
6	Gayathri Industries, V/822, Industrial Development Area, Edayar, Muppathadom P.O.	Chemical	Red	Small	1750	1035	collection tank, electro coagulation, settling cum clarifier, sand filter, carbon filter, treated water tank & sludge drying bed	Reuse
7	Hi Power Industries, VI/652, Industrial Development Area, Edayar, Binanipuram P.O.	Chemical	Red	Small	2000	1000	Collection tank, Electro coagulation, Settling cum clarifier, Sludge drying bed, Sludge storage tank, Sand filter and Carbon filter	Reuse
8	KVS Polymers (Fai's Chemicals), V/716A, Industrial Development Area, Edayar, Muppathadom P.O.	Chemical	Red	Small	1100	1100	collection tank, electro coagulation, settling cum clarifier, sand filter, carbon filter, treated water tank	Reuse
9	Ridha Polymers,VI/599, Development Area, Edayar, Binanipuram P.O.	Chemical	Red	Small	15.8 KL	2.5 KL	screen chamber, oil separator, equalisation, anaerobic tank, aeration tank, flocculation tank, settling, filter feed tank, filtration and treated water tank	Reuse

10	Inter Decore Industries, Industrial Development Area, Edayar	Fabrication unit	Orange	Medium	250	150	collection tank, chemical treatment facility & filter provided	Reuse
				Ready mix/concrete allied/ sand unit				
1	Duratech Concrete And Products, 63/2 C,Edayar Kara,Kadungaloor	Readymix	GREEN	Small	27000	5000	Settling tanks	clear water reused in the process
2	Neptune Readymix Concrete Pvt. Ltd., Plot No. VI/58 & 59, Industrial Development Area, Edayar, Muppathadom P.O., Ernakulam - 683 110.	Concrete product unit	Green	Small	16000	5000	Neutralisation, Settling and filtration	Reuse
3	Prism Cement Ltd., Industrial Development Area, Edayar, Binanipuram P.O.	Readymix	Green	Small	15000	5000	Settling tank	soak pit
4	S.M. Industries, Industrial Development Area, Edayar, Muppathadom P.O.	Concrete allied products	Green	Small	1200	800	Waste water generated is collected in settling tank and reused in the process	Reuse
5	Ultra Tech Cement Ltd., RMC Division, VI/61B, Industrial Development Area, Edayar, Binanipuram P.O.	Readymix	Green	Small	10300	7000	Settling tank	overflow is disposed to the drain nearby
6	Unipack (India) P Ltd., Bldg. No. V/577, Industrial Development Area, Edayar, Binanipuram P.O.	M-Sand unit	Red	Small	13500	12800	Settling tanks	Reuse
				Service station units				
1	Popular Industries, Industrial Development Area, Edayar, Binanipuram P.O.	Service station	Orange	Small	1000	1000	Oil trap, 3 chambered settling tank and soak pit	Soak pit
2	The Edayar Industries Centre, 5/818B, Industrial Development Area, Edayar, Muppathadom P.O.	Service Station	Orange	Small	900	500	No treatment system provided for the treatment of waste water generated. Only a collection tank provided	Collection tank

				Battery units				
1	National battery Industries, Industrial Development Area, Edayar, Muppathadom P.O.	Battery unit	Red	Small	500	500	Waste water generated during the battery case is disposed to an underground tank covered with concrete slab	disposed to an underground tank
				Steel units				
1	Premium Ferro Alloys Limited, Industrial Development Area, Edayar, Binanipuram P.O.	Steel industry	Red	Medium	21500	20000	Scrubber water collected in the settling tank and recirculated	recirculated
				Cleaning materials units				
1	Jonarin Jaliz & Company, Plot NO. 91/7A, NO. V/684A, IDA, Edayar, Muppathadom P.O.	Cleaning materials	Green	Small	5340	1500	collection tank, neutralisation and equalisation tank and sludge settling tank	soak pit
				Barrel cleaning units				
1	Global Traders Old Mosque Road, Edayar Industrial Area, Binanipuram P.O.	Cleaning and Storage of Plastic barrels and Cans	Green	Small	2300	2000	ETP of 2KLD with the units such as grit chamber, three chambered collection tank, chemical addition and settling tank, disinfection, filter feed tank, pressure sand filter, activated carbon filter	Soak pit
				Cattle field units				
1	Prima Agro Ltd., Industrial Development Area, Edayar, Muppathadom P.O.	Cattle feed	Orange	Medium	20000	2000	Collection tank, settling tank, filtration	Reuse
				Copper oxy chloride units				
1	Chemical Manufacturing Corporation	Chemical	Red	Small	300	300	Collection tank, reaction cum settling tank, filter feed tank, pressure sand filter, pressure carbon filter, sludge drying bed	Reuse
				Distillation of solvents/chemical packing units				
1	Sterling Industrial Chemical & Allied Industries, Industrial Development Area, Edayar, Binanipuram P.O.	Chemical	Red	Small	4000	NA	Cooling water completely recirculated	reuse

4.7.Quantity of solid waste generation

Solid waste management is a crucial component of both rural and urban environmental systems, directly influencing public health, ecological sustainability, and the overall quality of life. As urbanization accelerates and rural settlements expand, the quantity of solid waste being generated continues to rise. Proper management of this waste is not only necessary for pollution control but also for achieving sustainable development. Globally, the issue has been prioritized within the Sustainable Development Goals (SDGs), particularly under SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production). These goals emphasize the importance of reducing, recycling, and reusing materials, alongside establishing efficient waste collection and disposal systems by 2030.

The quantity of solid waste generated refers to the total volume of waste produced within a given area on a daily basis, expressed in TPD. It serves as a key indicator of the waste management burden and pollution load in a region, as it reflects the combined effect of population size, settlement type, and lifestyle patterns. For the Periyar River basin, this assessment helps in understanding the scale and sources of solid waste that contribute to environmental stress on the river system.

In the context of Kerala, waste management poses both unique challenges and opportunities owing to its geography, terrain, and high population density. With a population of around 35.6 million, Kerala is characterized by densely packed settlements and a rural-urban continuum, where villages and towns are closely interspersed. As of recent estimates, the state generates over 10,076.17 TPD of solid waste, of which 3,011.23 TPD originates from urban areas and 6,561.12 TPD from rural areas (KSPCB, Monthly Progress Report, May 2025). The waste composition in Kerala is distinct, with nearly 73% being biodegradable, largely due to its hot-humid climate and the prevalence of food and organic waste. The remaining fraction includes 22% inorganic material and around 5% inert waste. In absolute terms, this corresponds to 7,398.64 TPD of biodegradable waste, 2,173.72 TPD of non-biodegradable waste, and 503.81 TPD of inert material.

To estimate the quantity of solid waste generated in Kerala, the government follows a population-based calculation method, which relies on the most recent Census data of 2011 and projects the population for the year 2024. Based on this projected population, the Per Capita Waste Generation (gpcd) is applied according to the category of the local body—Corporations are generally assigned higher values, followed by Municipalities and then Grama Panchayats. For instance, in the case of Kattapana Municipality in Idukki district, the per capita waste generation value prescribed for municipalities (350gpcd) is multiplied by its projected 2024 population to determine the total daily waste generation (TPD). Similarly, for Adimaly Grama Panchayat, the lower per capita value applicable to panchayats (250 gpcd) is multiplied with its projected population to arrive at the total daily waste produced. This methodology ensures that waste generation is estimated accurately by reflecting the population density, settlement type, and administrative category of each local body, thereby providing realistic Fig.ures for planning waste management interventions in the Periyar River basin.

4.7.1. Solid Waste Generation in Ernakulam District

Solid waste generation in Ernakulam District varies according to the population and urbanization of its municipalities and grama panchayats. Based on the 2011 Census and projected 2024 population, waste quantities have been estimated under three categories: Biodegradable Waste (BDW), Non-Biodegradable Waste (NBDW), and Inert Waste (in TPD). Kochi Corporation generates the highest amount of waste, with approximately 204.16 TPD of biodegradable waste, 72.91 TPD of non-biodegradable waste, and 14.58 TPD of inert waste. Significant contributions are also observed from the municipalities of Kalamassery, Eloor, and Angamaly. Among the grama panchayats, Vengola, Elamkunnappuzha, Edathala, Pallippuram, and Vazhakkulam record higher waste quantities. Biodegradable waste constitutes the largest fraction, highlighting the predominance of organic materials and the importance of efficient segregation, composting, and decentralized waste management strategies across the district.

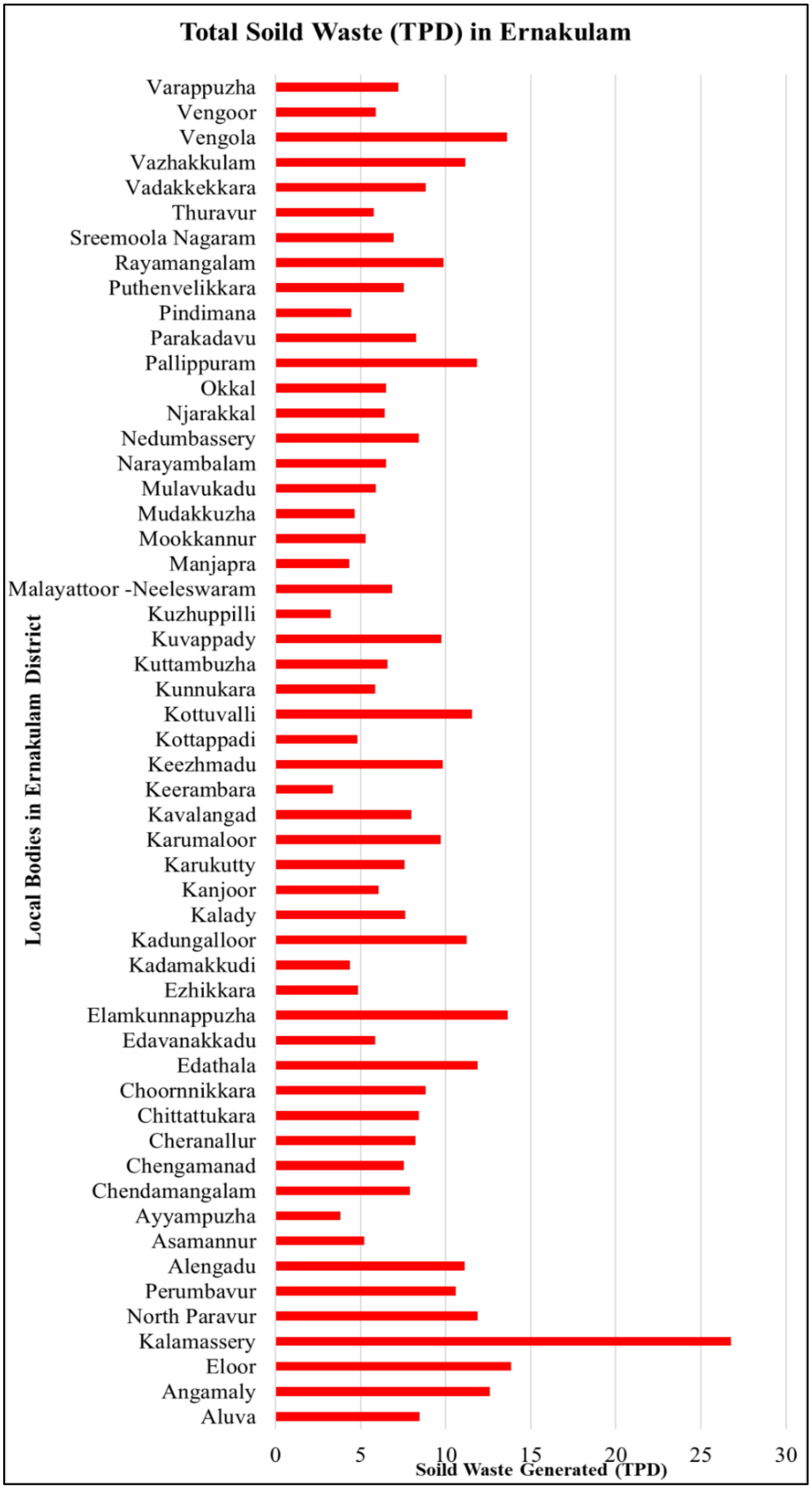

Fig. 10 Local Body-wise Solid Waste Generation in Ernakulam

Based on LSGI local body data and the projected 2024 population, municipal solid waste generation in Ernakulam District is estimated at 440.01 TPD. With a total projected population of 1,813,620, this translates to a per capita waste generation of 0.24 kg/capita/day. Analysis by type of local body shows that ULBs contribute 19.12% of the district's total waste generation, whereas grama panchayats account for 80.88%, indicating the dispersed nature of population and waste generation across rural areas of the district. The Fig. 10 shows solid waste generation within the Periyar River Basin in Ernakulam District.

4.7.2. Solid Waste Generation in Thrissur District

Solid waste generation in Thrissur District varies across municipalities and grama panchayats according to their population and urbanization levels. Based on the 2011 Census and projected 2024 population, all municipalities in Thrissur District, including Kodungallur (26.64 TPD), and Irinjalakkuda (23.33 TPD) contribute substantially to waste generation, while among the grama panchayats, Aloor (11.59 TPD), Eriyad (12.32 TPD), Sreenarayanapuram (10.12 TPD), and Vellangallur (10.19 TPD) record comparatively higher waste quantities. Overall, biodegradable waste forms the largest fraction, reflecting the predominance of organic material and highlighting the need for effective segregation, composting, and decentralized waste management strategies throughout the district. The Fig. 11 below shows solid waste generation within the Periyar River Basin in Thrissur District.

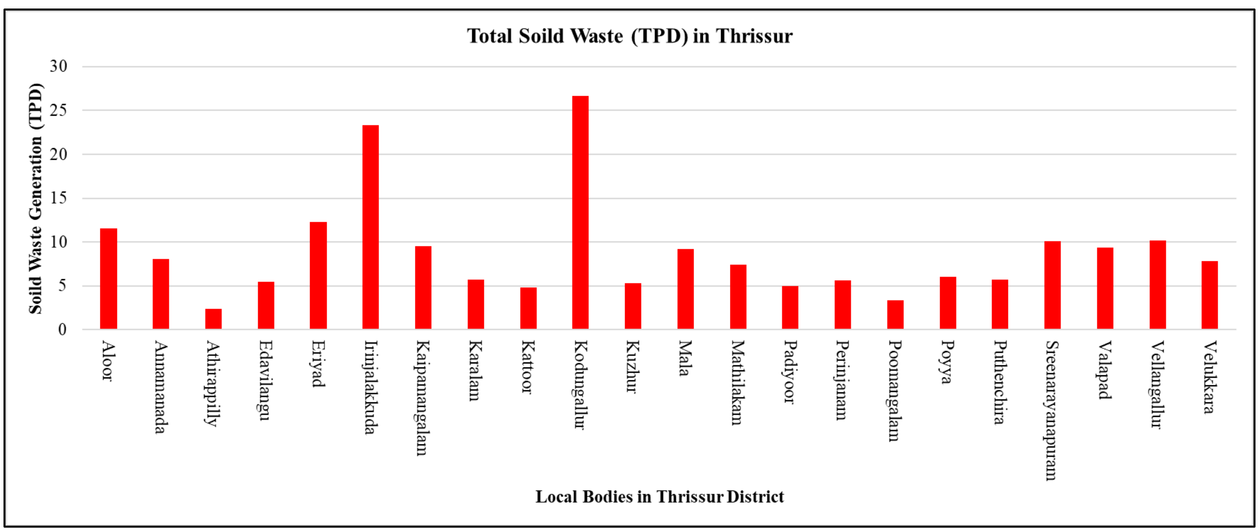

Fig. 11 Local Body-wise Solid Waste Generation in Thrissur

4.7.3. Solid Waste Generation in Idukki District

The overall solid waste generation in Idukki district is estimated at 197.63 TPD. On average, daily waste generation per local body stands at 5.68 TPD, with values ranging from 0.55 TPD to 14.52 TPD. Most gram panchayats are observed to fall within the 3–7 TPD range, whereas municipalities and high population density panchayats generate significantly higher amounts. This variation is strongly linked to both settlement type and population size, as municipalities and urbanizing gram panchayats tend to exhibit higher per capita generation compared to rural areas. According to the Kerala Suchitwa Mission, greater population density and lifestyle changes in semi-urban and urbanizing areas result in higher waste volumes, particularly the biodegradable fraction such as food residues and organic matter.

Within the Periyar River basin portion of Idukki district, Kattappana Municipality stands out prominently, producing 14.52 TPD of solid waste from a population of 41,482. This is due to its elevated per capita generation rate of 350 g, which is higher than the 250 g considered for gram panchayats. Following Kattappana, Nedumkandam GP (10.23 TPD), Vandiperiyar GP (9.95 TPD), and Adimaly GP (9.87 TPD) emerge as the next largest contributors. These local bodies also have projected populations exceeding 39,000–41,000, which directly explains the higher waste volumes. Moreover, these centres act as commercial and service hubs, catering not just to permanent residents but also to significant floating populations, including tourists, thereby amplifying the waste generation load.

On the other end of the spectrum, remote and sparsely populated panchayats such as Edamalakudy (0.55 TPD), Mankulam (2.34 TPD), Chinnakanal (2.82 TPD), Mariyapuram (2.94 TPD), and Senapathy (3.05 TPD) contribute the least to solid waste generation. These areas typically have projected populations below 12,000 and are situated in ecologically sensitive and less urbanized zones of Idukki. The relatively low levels of waste generation can be attributed to low population density, minimal commercial establishments, and subsistence-based lifestyles, which limit both the volume and diversity of waste streams produced. Fig. 12 and Fig. 13 below shows local body-wise solid waste generation in Idukki district and solid waste generation in the Periyar River Basin.

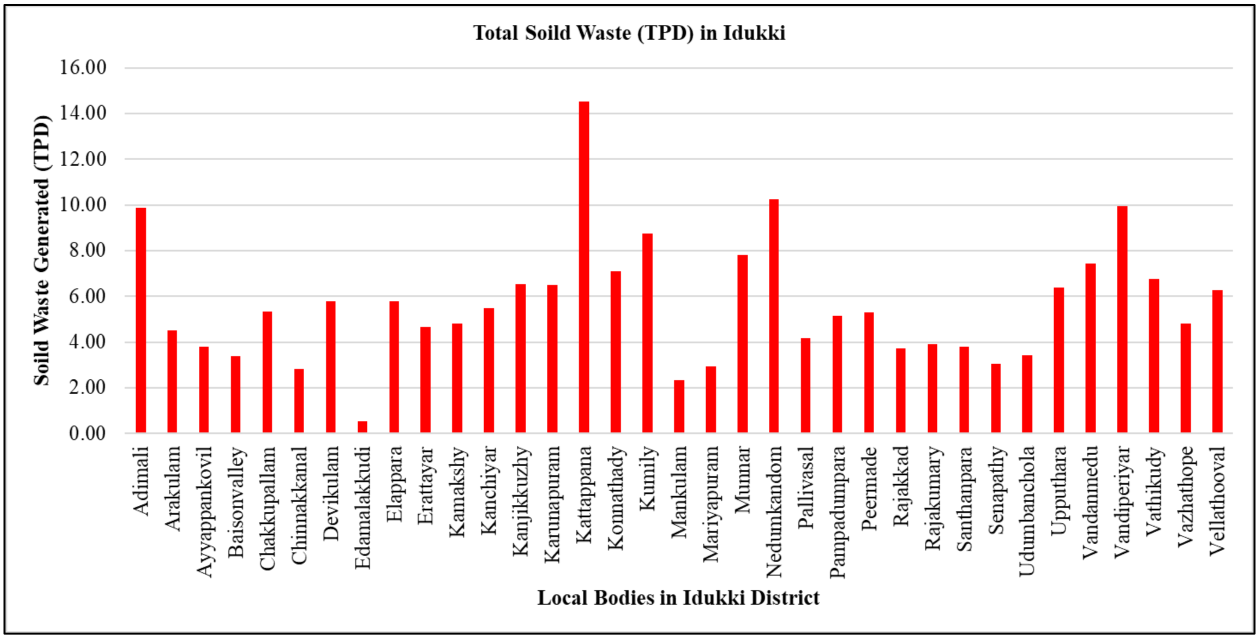

Fig. 12 Local Body-wise Solid Waste Generation in Idukki

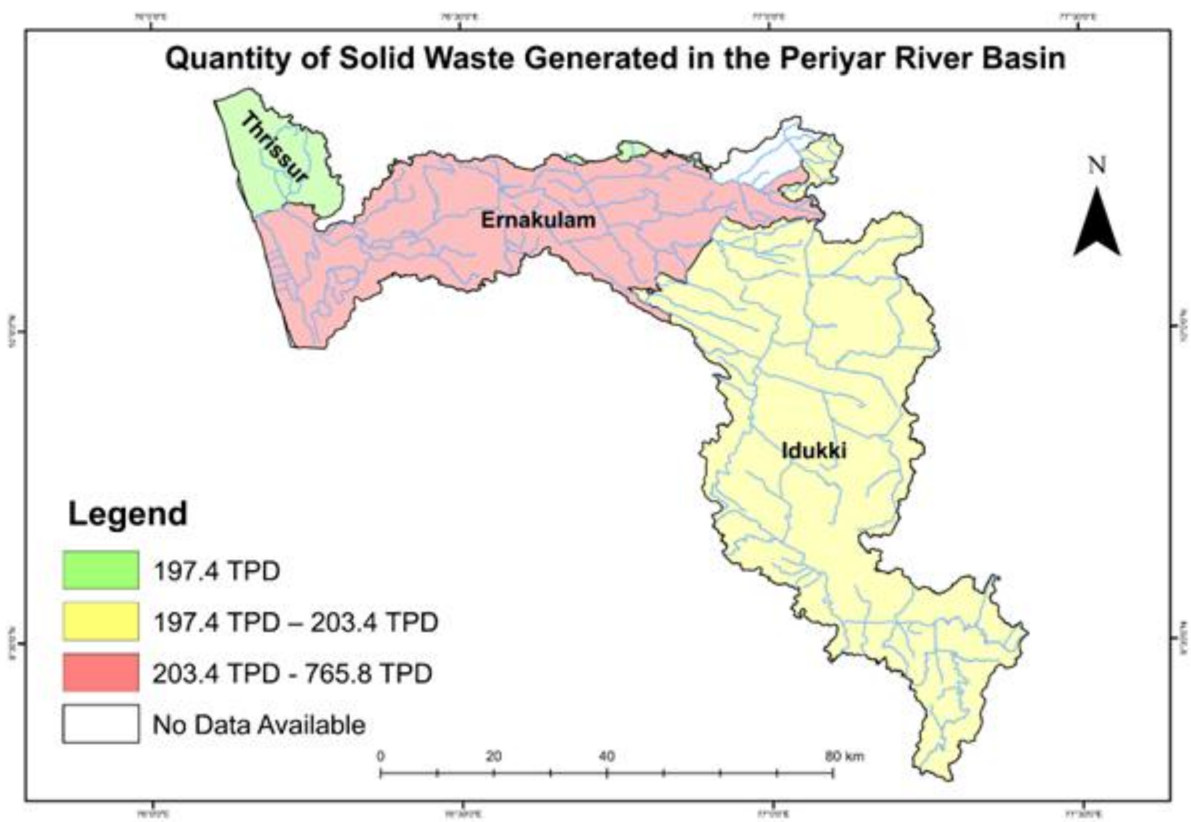

Fig. 13 Map Showing the Quantity of Solid Waste Generated in the Periyar River Basin

4.8.Composition of solid waste

The composition of solid waste refers to the relative proportion of different waste fractions—biodegradable waste, non-biodegradable waste, inert waste, recyclable waste, non-recyclable waste, and domestic hazardous waste—within the total municipal solid waste stream. Understanding waste composition is essential for pollution load assessment, as each fraction contributes differently to environmental stress. In the context of the Periyar River basin, this analysis helps identify dominant waste fractions that may enter the river system through direct dumping, runoff, or drain connectivity, thereby influencing organic load, plastic pollution, and long-term contamination.

For estimating solid waste composition, a population-based methodology prescribed by Suchitwa Mission and commonly adopted in Kerala was followed. As per the guidelines, biodegradable waste constitutes approximately 70% of total waste generated in urban areas and 75% in rural areas, reflecting the dominance of food waste and organic residues. The non-biodegradable fraction accounts for about 25% in urban areas and 20% in rural areas, owing to higher usage of plastics in urban settlements. The remaining portion is categorized as inert waste, which includes construction debris, silt, ash, and other non-reactive materials.

The non-biodegradable fraction is further classified into recyclable, non-recyclable, and domestic hazardous waste. Recyclable waste includes materials such as plastics, paper, metals, and glass that can be recovered and reprocessed. Non-recyclable waste consists of low-value or contaminated materials that cannot be economically recycled and usually require disposal. Domestic hazardous waste includes small quantities of household-generated hazardous materials such as batteries (Fig. 14), paints, pesticides, and electronic discards, which pose environmental and health risks if improperly managed. As per standard assumptions, recyclable waste constitutes 12% of non-biodegradable waste in urban areas and 10% in rural areas, non-recyclable waste accounts for 10% in urban and 7% in rural areas, while domestic hazardous waste forms about 1% of the non-biodegradable fraction.

Using these standard ratios, Suchitwa Mission estimated waste composition for each local body in the Periyar River basin by applying the projected population data of panchayats and municipalities. This approach enables a consistent assessment of biodegradable, non-biodegradable, inert, recyclable, non-recyclable, and domestic hazardous waste fractions, which is essential for understanding the pollution load associated with solid waste.

Fig. 14 Domestic hazardous waste (Source: Technical Manual for Solid Waste Management, 2024)

4.8.1. Solid Waste Composition: Ernakulam & Thrissur Districts

Solid waste generation assessments from Local Self Governments (LSGs) located within the Periyar River Basin in Ernakulam and Thrissur districts indicate that biodegradable waste forms the dominant portion of municipal solid waste in the region. Urban centres such as Kochi Corporation, Irinjalakkuda, and Kodungallur, along with surrounding municipalities and grama panchayats, generate waste largely composed of organic materials from households, markets, and commercial establishments. Non-biodegradable and inert components constitute a comparatively smaller share of the waste stream. This composition pattern highlights that biodegradable waste streams are predominant in the basin, while non-biodegradable and inert components form a relatively smaller share (LSGI).

The composition data of solid waste from selected local bodies in Ernakulam District shows notable variation in waste fractions (Fig. 15). Biodegradable waste was not reported, as data for this category was unavailable from several local bodies according to KSPCB records. The plastic fraction shows the highest quantities, ranging from 750 kg in Alangad to 28,442 kg in Paravoor, followed by Eloor (16,000 kg) and Kottuvally (8,330 kg), indicating the dominance of non-biodegradable materials in the municipal solid waste stream. Moderate quantities were also reported in Varapuzha (7,500 kg) and Puthenvelikkara (3,500 kg), while several other local bodies lacked data.

Glass waste was comparatively lower, ranging from 50 to 1,881 kg, with Karumalloor (1,881 kg), Eloor (1,200 kg), and Chennamangalam (1,000 kg) showing notable quantities. E-waste generation was limited, with Eloor (300 kg), Paravoor (205 kg), Alangad (2 kg), and Karumalloor (10 kg) reporting small amounts. Biomedical waste (medicine strips) appeared in trace quantities, mainly in Eloor (150 kg) and Paravoor (81 kg).

Overall, the data reveal gaps in waste characterization, particularly for biodegradable and paper fractions, and highlight the increasing share of plastic in the solid waste composition. Strengthening waste segregation, material recovery, and data reporting mechanisms at the local level is essential for improving solid waste management efficiency in the district (KSPCB).

With respect to recyclable and non-recyclable waste generation in Ernakulam district, Kochi Municipal Corporation records the highest quantities, with 34.90 TPD of recyclable waste and 29.08 TPD of non-recyclable waste, reflecting the significantly larger population and urban activities within the city (Fig. 16). Among the other local bodies, Kalamassery Municipality shows comparatively higher waste generation with 3.20 TPD of recyclable waste and 2.67 TPD of non-recyclable waste, followed by Eloor Municipality with 1.66 TPD recyclable waste and 1.38 TPD non-recyclable waste, and Angamaly Municipality generating 1.51 TPD of recyclable waste and 1.26 TPD of non-recyclable waste. North Paravur Municipality also contributes notable quantities, producing 1.42 TPD of recyclable waste and 1.18 TPD of non-recyclable waste.

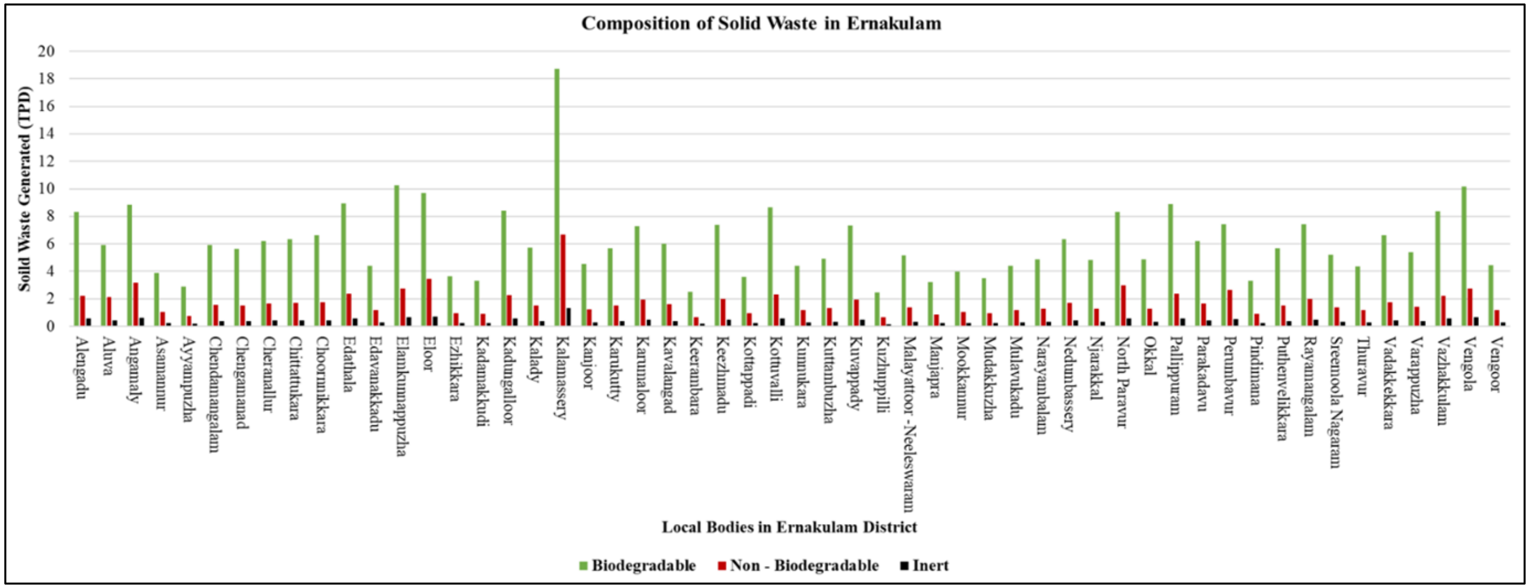

Fig. 15 Characterization of Solid Waste: Biodegradable, Non-Biodegradable, and Inert (Ernakulam)

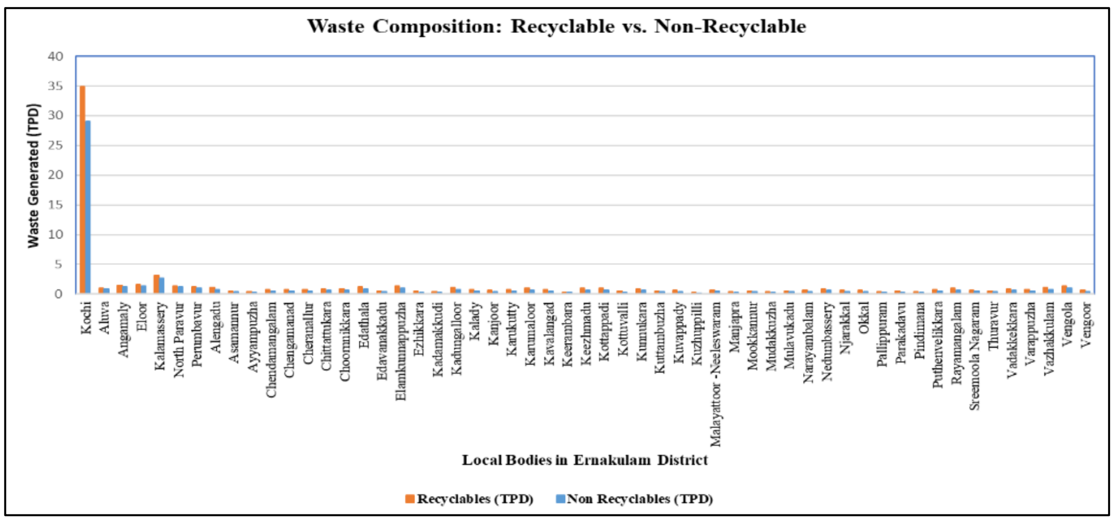

Fig. 16 Distribution of Recyclable vs. Non-Recyclable Waste: Ernakulam District

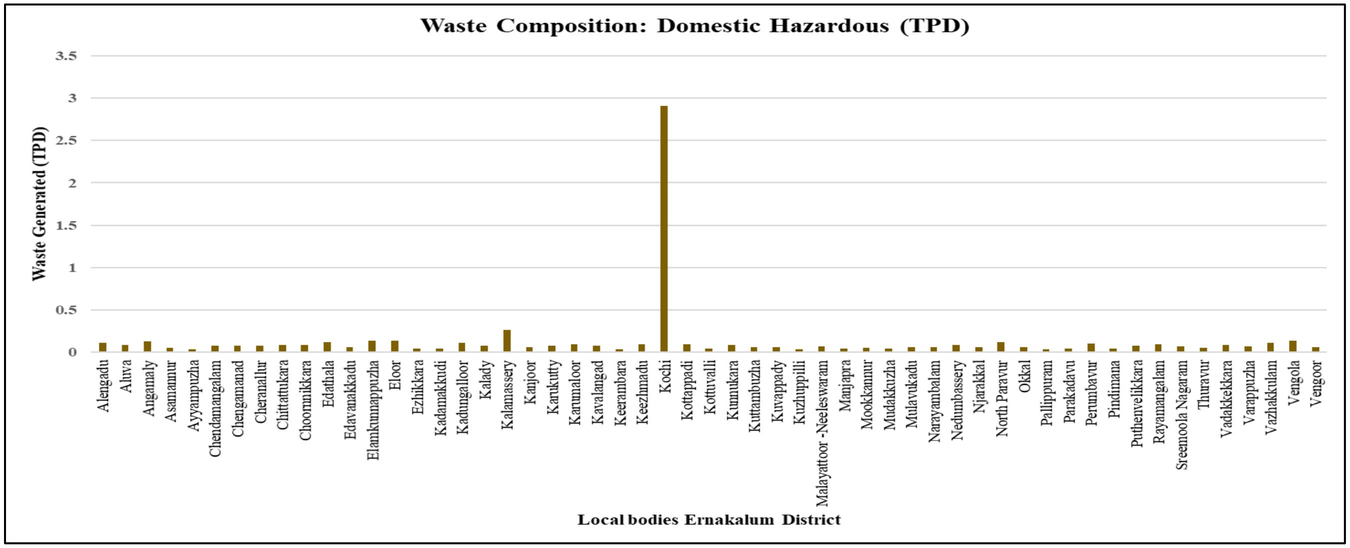

Fig. 17 Domestic Hazardous Waste Profile: Ernakulam District

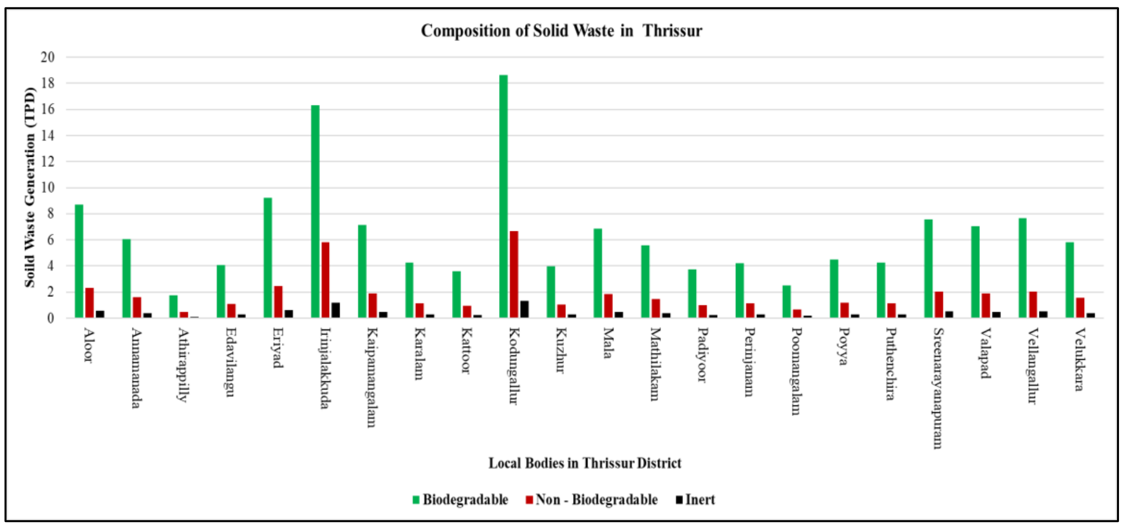

Fig. 18 Characterization of Solid Waste: Biodegradable, Non-Biodegradable, and Inert (Thrissur)

With respect to domestic hazardous waste generation in Ernakulam district, Kochi Municipal Corporation records the highest quantity at 2.91 TPD, which is significantly higher than other local bodies due to its large population, dense urban settlements, and higher consumption of household products such as cleaning agents, batteries, and electronic items (Fig. 17). Among the other local bodies, Kalamassery Municipality generates 0.27 TPD, followed by Eloor Municipality (0.14 TPD) and Elamkunnappuzha Grama Panchayat (0.14 TPD). Relatively higher quantities are also observed in Vengola Grama Panchayat (0.14 TPD), Angamaly Municipality (0.13 TPD), and North Paravur Municipality (0.12 TPD).

Fig. 18 and Fig. 19 shows characterization of solid waste as Biodegradable, Non-Biodegradable, and Inert and distribution of recyclable vs. non-recyclable waste in Thrissur district. With respect to recyclable and non-recyclable waste generation in Thrissur district, Kodungallur Municipality records the highest quantities, generating 3.17 TPD of recyclable waste and 2.64 TPD of non-recyclable waste. This is followed by Irinjalakkuda Municipality, which produces 2.78 TPD of recyclable waste and 2.32 TPD of non-recyclable waste. Among the Grama Panchayats, Eriyad shows comparatively higher waste generation with 1.22 TPD of recyclable waste and 0.86 TPD of non-recyclable waste, followed by Aloor Grama Panchayat (1.15 TPD recyclable and 0.81 TPD non-recyclable). Other local bodies such as Vellangallur (1.01 TPD recyclable; 0.71 TPD non-recyclable) and Sreenarayanapuram (1.01 TPD recyclable; 0.70 TPD non-recyclable) also contribute notable quantities.

With respect to domestic hazardous waste generation in Thrissur district (Fig. 20), Kodungallur Municipality records the highest quantity at 0.26 TPD, followed by Irinjalakkuda Municipality with 0.23 TPD. Among the Grama Panchayats, Aloor and Eriyad generate comparatively higher quantities, each producing 0.12 TPD of domestic hazardous waste. Other local bodies such as Sreenarayanapuram and Vellangallur also contribute notable quantities at approximately 0.10 TPD, while several panchayats including Annamanada, Edathiruthy, and Valapad generate around 0.08 TPD.

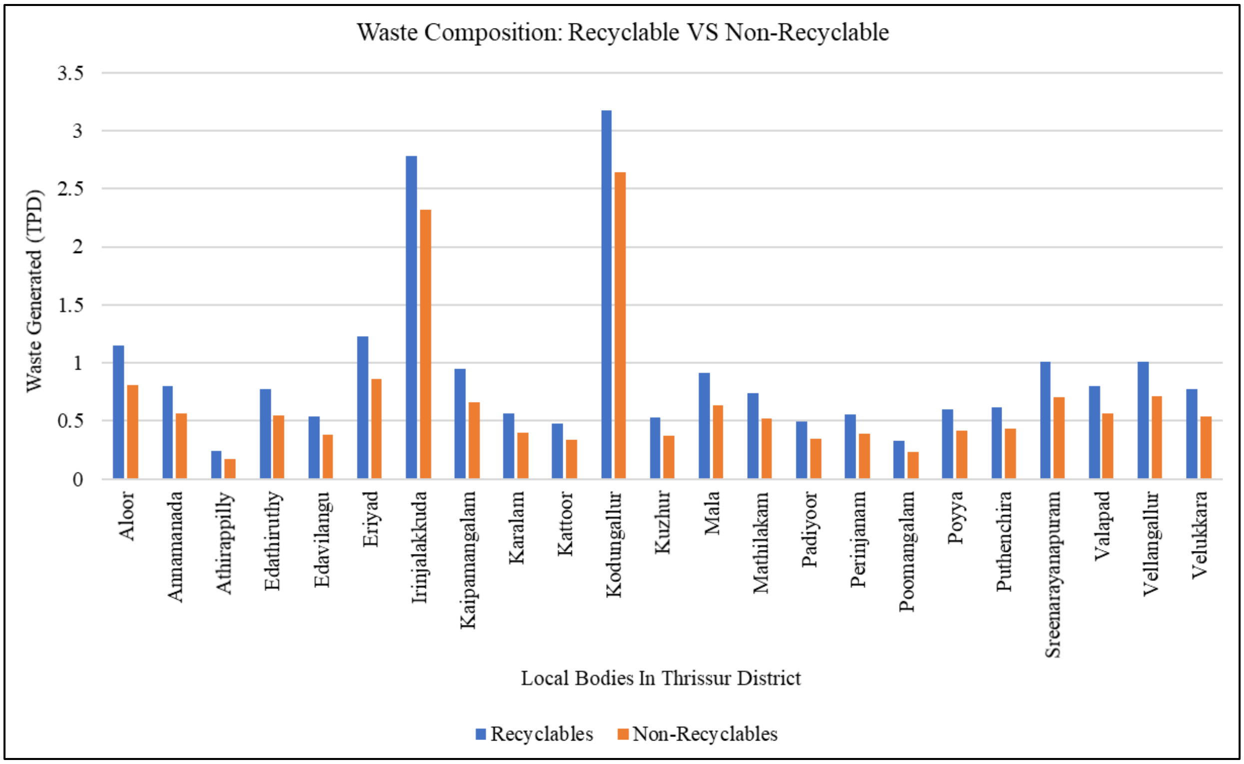

Fig. 19 Distribution of Recyclable vs. Non-Recyclable Waste: Thrissur District

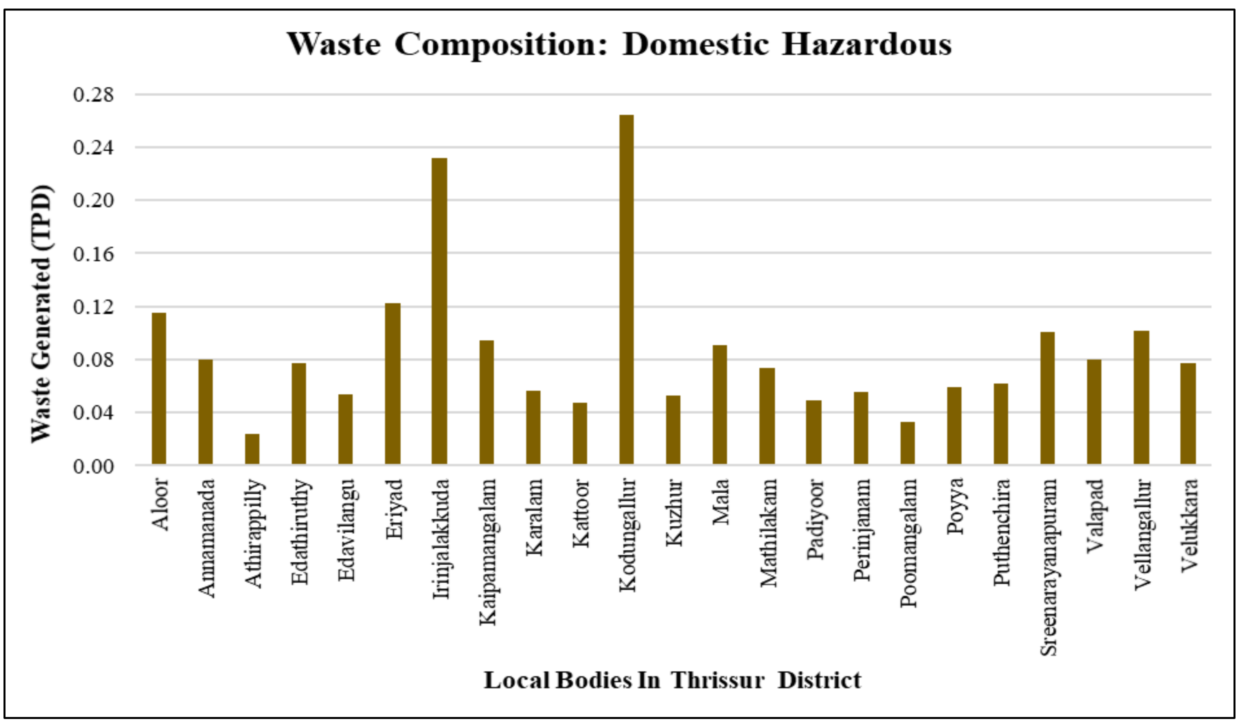

Fig. 20 Domestic Hazardous Waste Profile: Thrissur District

4.8.2. Solid Waste Composition: Idukki District

In Idukki district, biodegradable waste is the dominant component, amounting to 147.5 TPD, highlighting the prevalence of organic waste such as agricultural biomass (Fig. 21). Non-biodegradable waste generation is estimated at 40.25 TPD, largely comprising plastics that contribute significantly to the persistent pollution load. The inert waste fraction is estimated at 9.8 TPD, primarily consisting of construction debris. Within the non-biodegradable fraction, recyclable waste accounts for 20.05 TPD, non-recyclable waste for 14.27 TPD, and domestic hazardous waste for 1.98 TPD.

Among the local bodies, Kattappana Municipality contributes the highest biodegradable waste generation at 10.16 TPD, followed by Nedumkandam Grama Panchayat (7.67 TPD), Vandiperiyar Grama Panchayat (7.46 TPD), and Adimaly Grama Panchayat (7.4 TPD). This trend is primarily attributed to higher population density, urban characteristics, and greater per capita waste generation in municipal areas. In contrast, Edamalakudy (0.41 TPD) and Mankulam (1.75 TPD) generate the lowest biodegradable waste, reflecting low population density, remote location, and limited commercial activity.

A similar pattern is observed for non-biodegradable waste, with Kattappana Municipality generating the highest quantity at 3.63 TPD, followed by Nedumkandam (2.05 TPD), Vandiperiyar (1.99 TPD), and Adimaly (1.97 TPD). The lowest generation is recorded in Edamalakudy (0.11 TPD), Mankulam (0.47 TPD), and Mariyapuram (0.59 TPD). Inert waste generation is also highest in Kattappana (0.73 TPD), followed by Nedumkandam (0.51 TPD) and Vandiperiyar (0.50 TPD), mainly due to construction activities and urban infrastructure development, whereas remote panchayats show minimal inert waste generation.

With respect to recyclable and non-recyclable waste, Kattappana Municipality records the highest quantities, with 1.74 TPD of recyclable waste and 1.45 TPD of non-recyclable waste (Fig. 22). This is followed by Nedumkandam Grama Panchayat (1.02 TPD recyclable and 0.72 TPD non-recyclable) and Vandiperiyar Grama Panchayat (0.99 TPD recyclable and 0.70 TPD non-recyclable). Domestic hazardous waste generation is also highest in Kattappana Municipality at 0.15 TPD, attributable to greater use of consumer products, followed by Nedumkandam, Vandiperiyar, and Adimaly, each generating approximately 0.10 TPD (Fig. 23).

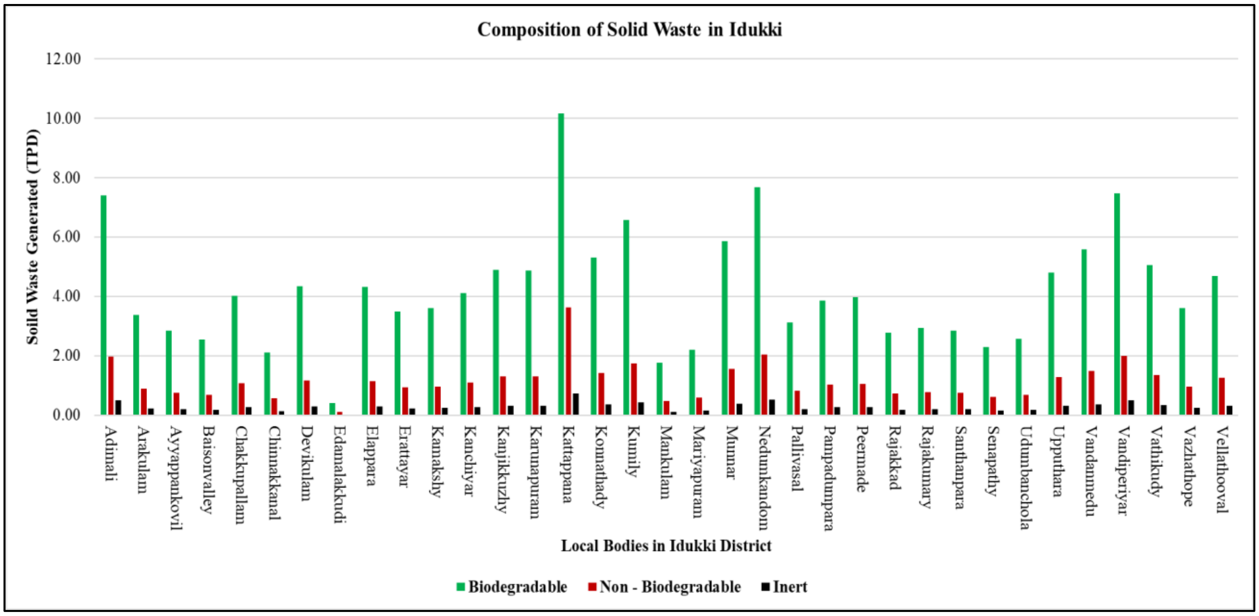

Fig. 21 Characterization of Solid Waste: Biodegradable, Non-Biodegradable, and Inert (Idukki)

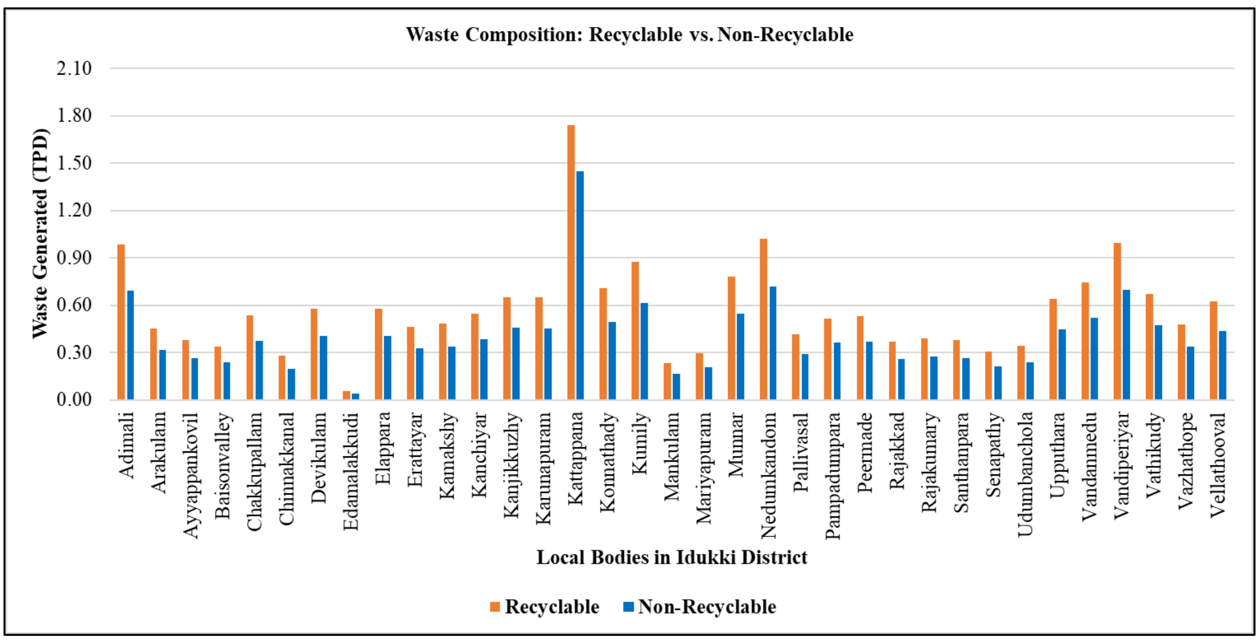

Fig. 22 Distribution of Recyclable vs. Non-Recyclable Waste: Idukki District

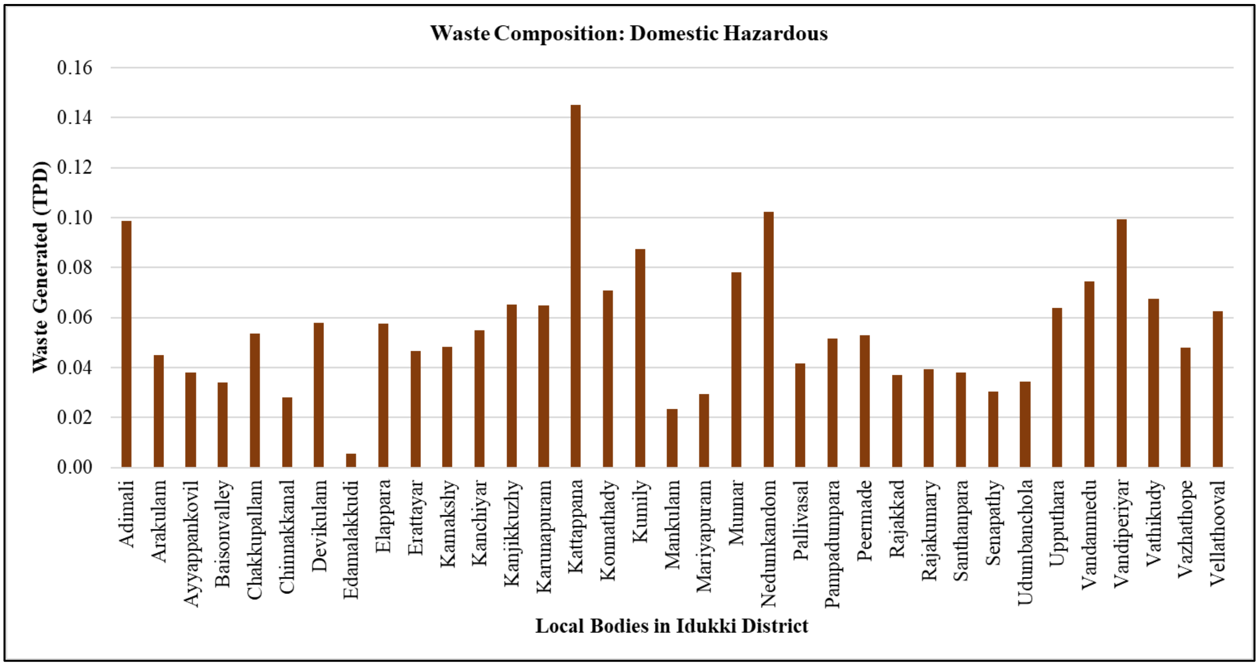

Fig. 23 Domestic Hazardous Waste Profile: Idukki District

This detailed breakdown of solid waste composition is critical for pollution load assessment in the Periyar River basin. Biodegradable waste significantly contributes to organic pollution and potential oxygen depletion in adjacent water bodies, while non-biodegradable and inert waste aggravate solid waste accumulation, drainage blockages, and land-based contamination pathways. Recyclable waste indicates the scope for material recovery and pollution reduction, whereas non-recyclable and domestic hazardous waste represent critical fractions requiring safe disposal and targeted management to prevent long-term environmental and health impacts on the river system.

4.9.Solid Waste Management: Collection, Transportation and Disposal Facilities

Solid Waste Management (SWM) in the Periyar River basin is governed by the Solid Waste Management Rules, 2016, notified under the Environment (Protection) Act, 1986. These rules establish a structured framework for municipal solid waste handling, with emphasis on segregation at source, accountability of waste generators, and scientific processing and disposal. From a pollution load perspective, effective solid waste management is critical for reducing organic load, plastic contamination, nutrient enrichment, and leachate generation that directly or indirectly impact river water quality. LSGs are the primary implementing agencies responsible for waste collection, transportation, processing, and disposal, with strong institutional and technical support from the Suchitwa Mission, Government of Kerala.

4.9.1. Collection of Solid Waste

The collection of solid waste in Kerala operates through a decentralized, two-tier system comprising primary and secondary collection. Primary collection targets non-biodegradable dry waste generated from households, shops, offices, markets, hotels, and institutions. Waste is collected at the source and transported to designated segregation points. This stage largely relies on non-motorized or low-capacity vehicles such as pushcarts, tricycles, and wheelbarrows, reflecting relatively smaller quantities handled at the household level. Collection frequency varies by land use, with residential areas generally covered on a monthly basis and non-residential or commercial areas on a weekly basis (KSWMP, 2020). Secondary collection is more prominent in urban and semi-urban areas, where waste from roadside collection points, community bins, markets, and transport hubs is aggregated and transported using mechanized vehicles such as tippers, covered trucks, closed carriers, and compactors. This stage plays a crucial role in preventing open dumping and secondary littering, which are significant contributors to diffuse pollution load entering drains and river systems.

A key institutional feature of Kerala's collection system is the HKS, a community-based workforce established under the Haritha Keralam Mission. HKS functions as the primary service provider for household and institutional non-biodegradable waste collection across the state. Comprising largely trained women entrepreneurs from Kudumbashree, organized as Micro Enterprise (ME) units, HKS operates in close coordination with LSGIs. Their responsibilities include door-to-door collection of dry waste, segregation at source, awareness generation among waste generators, and facilitation of decentralized biodegradable waste management practices (KILA, 2021). The services provided by HKS are subject to a collection fee (user fee) fixed by the respective LSGIs (Thomas et al., 2023).

4.9.2. Transportation and Intermediate Storage

Transportation forms a critical link between collection and final processing or disposal, directly influencing pollution pathways. HKS workers use a combination of government-supplied tricycles, walking, and, in some cases, personal vehicles such as auto-rickshaws to transport collected waste to designated MCFs or Mini-MCFs. Adequate transportation support is therefore essential to ensure timely evacuation of waste and to prevent spillage, temporary dumping, or leakage into stormwater drains and natural channels (Thomas et al., 2023).

The siting of MCFs and Mini-MCFs is undertaken considering factors such as safe distance from residential areas and water bodies, accessibility for collection workers, and connectivity for transport vehicles. These facilities function as intermediate storage and segregation nodes, enabling organized handling of collected waste and reducing uncontrolled accumulation in public spaces (KILA, 2021). At a higher tier, RRFs operate at cluster or block levels to handle larger volumes of segregated non-biodegradable waste, ensuring further sorting and preparation for recycling or reuse.

4.9.3. Disposal and Pollution Load Mitigation

Kerala's solid waste management framework emphasizes decentralized treatment and resource recovery to minimize disposal-related pollution. Biodegradable waste generated within the basin is managed through household-level composting pits and community-based systems such as Thumboormuzhi aerobic composting units, windrow composting facilities, vermicomposting units, and biogas plants. These systems reduce organic pollution load, methane emissions, and dependence on landfills while converting waste into compost, fertilizer, or biogas.

Non-biodegradable waste collected and segregated at MCFs and RRFs is directed to authorized recycling units. Non-recyclable fractions are diverted to co-processing facilities such as cement plants, contributing to energy recovery and significantly reducing landfill dependency. Hazardous waste streams are routed to authorized agencies such as the Clean Kerala Company for safe treatment and disposal (KILA, 2021). The inert fraction, which is neither recyclable nor biodegradable, is typically used for land reclamation or filling of low-lying areas in an environmentally controlled manner. This integrated disposal framework plays a key role in reducing leachate formation, plastic leakage, and nutrient runoff that contribute to river pollution. The Fig. 24 illustrates the overall process flow of Kerala's waste management system.

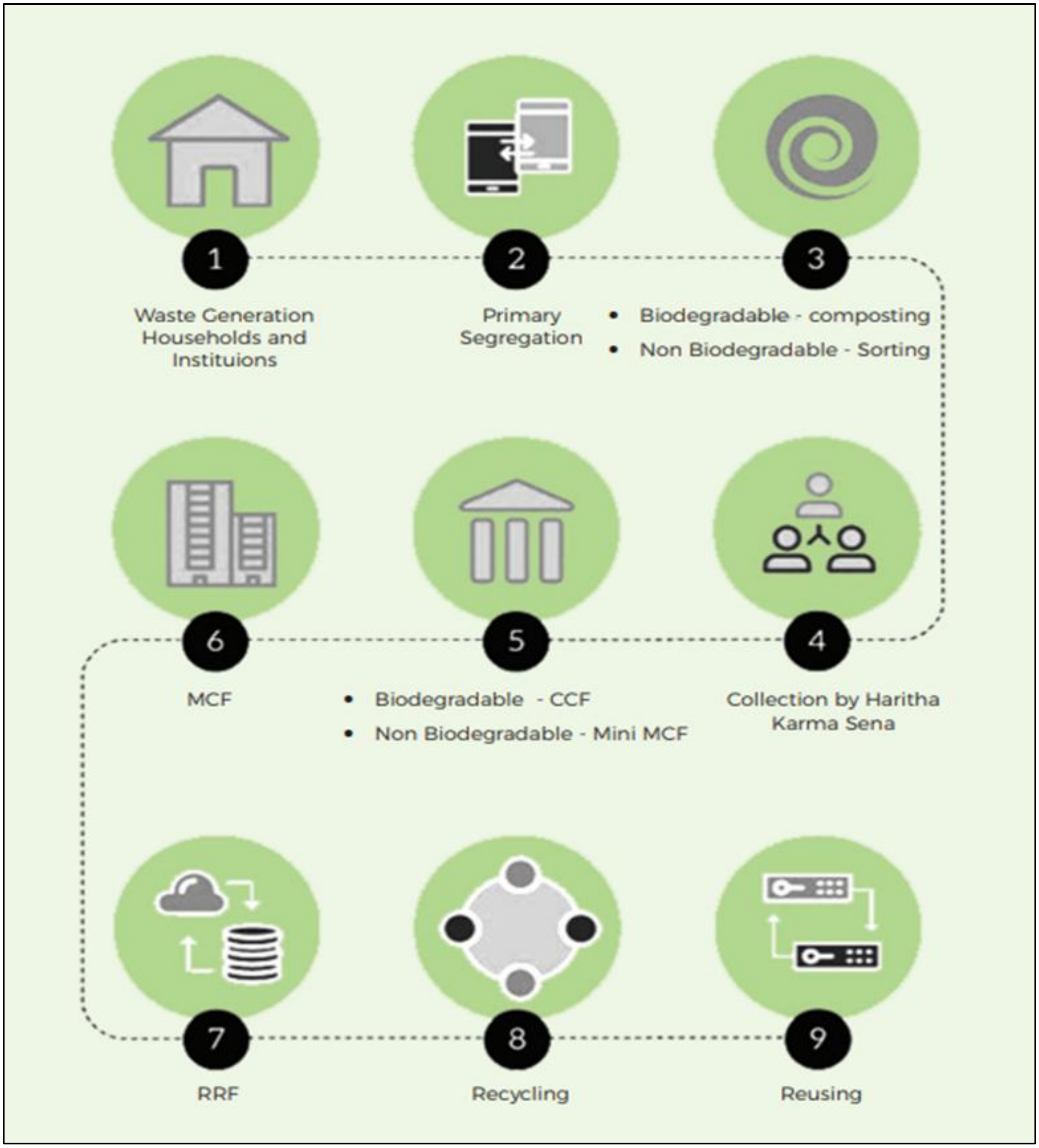

Fig. 24 Process Flow of Solid Waste Management in Kerala (Source: KILA, 2021)

4.9.4. Financial and Operational Considerations

The sustainability of the collection and transportation system is closely linked to the user fee mechanism. Although LSGIs are empowered to impose user fees, household-level compliance remains extremely low. Approximately 95% of Gram Panchayats and 77% of municipalities do not charge user fees for biodegradable waste. For non-biodegradable waste, user fee structures exist—typically ₹30–₹50 in Gram Panchayats and municipalities and up to ₹60 in corporations—but only about 1% of households across all LSGIs actually pay these fees. In contrast, institutional compliance is significantly higher, with around 72% of institutions paying user fees (KILA, 2021). This imbalance directly affects the financial viability and morale of HKS members, underscoring the need for strengthened Information, Education and Communication (IEC) campaigns and improved enforcement mechanisms (Thomas et al., 2023).

While nearly 97% of LSGIs have constituted HKS units, operational gaps persist in revenue crediting, adherence to collection schedules, and availability of adequate transport infrastructure. These challenges are particularly pronounced in rural areas, where dispersed settlements and limited resources constrain effective waste management operations (Nishad, 2024).

Overall, the collection, transportation, and disposal framework adopted in Kerala represents a structured, decentralized system that significantly contributes to pollution load mitigation. By ensuring segregation at source, controlled movement of waste, recovery of recyclable materials, and environmentally safe disposal of residuals, the system minimizes direct and indirect entry of solid waste into terrestrial and aquatic environments, thereby supporting improved river water quality and long-term ecological sustainability. Fig. 25 gives a representation of the Segregation, Collection, and Transportation System followed in solid waste management.

Fig. 25 Schematic Representation of the Segregation, Collection, and Transportation System

(Source: Technical Manual for Solid Waste Management, 2024)

4.9.5. Waste Management Practices in Idukki District

Within the Idukki district, where large stretches of the Periyar and its tributaries originate, an extensive system of collection, transportation, and disposal infrastructure has been implemented to minimize riverine pollution. The district employs a mix of Mini MCFs, full-scale MCFs, Thumboormuzhi composting units, windrow composting sites, and RRFs. At the community level, waste is handled through community compost pits, bio-facilities, and ring compost units, while households are supported with individual bio-composters and biogas bins. Facilities such as Bottle Booths further encourage segregation and recycling of plastic waste. The scale of operations is reflected in the spatial extent of MCF and RRF facilities, which collectively process substantial volumes of waste generated daily. These decentralized systems have been crucial in diverting municipal waste away from the riverbanks and open lands, thereby preventing direct dumping into the Periyar River basin. Together, these structured practices in Idukki create a strong link between waste management infrastructure and the reduction of pollution load on the Periyar River, highlighting the role of decentralized and community-driven interventions in maintaining river health.

I. Biodegradable Waste Management

Thumboormuzhi Composting Units and Windrow Composting

Thumboormuzhi composting units are modular aerobic composting systems developed in Kerala to manage biodegradable waste at the community level, while windrow composting is used for handling larger quantities of organic waste. In Idukki, Erattayar panchayat leads with 7 Thumboormuzhi units, followed by Kattappana (4 units) and Udumbanchola (3 units). Windrow composting facilities exist in Vandiperiyar, Kumily, Erattayar, Vandanmedu, and Chakkupallam, each hosting one unit.

These systems are vital for reducing the organic pollution load on the Periyar, as untreated biodegradable waste dumped in open areas often ends up leaching into water bodies, increasing BOD and COD levels. However, for several panchayats—including Devikulam, Edamalakkudi, and Munnar—data on composting facilities remains unavailable, indicating possible gaps in infrastructure coverage or reporting

Community-Level Compost Pits

Community compost pits are small-scale facilities designed to serve neighborhoods or clusters of households. In Idukki, Erattayar, Vandanmedu, and Chakkupallam panchayats each operate two units, with Erattayar combining them with other composting methods like Thumboormuzhi and windrow systems. Rajakkad has one biogas-based community compost pit, while Vandiperiyar and Nedumkandom have one each but are insufficient to meet demand. Ayyappankovil's compost pit is currently non-functional, pointing to operational lapses.

The absence of reliable data for multiple panchayats such as Adimali, Devikulam, and Munnar highlights a lack of systematic monitoring. Since community pits are crucial in minimizing the transportation burden of biodegradable waste and preventing illegal dumping, strengthening their presence is essential in managing the organic load on the river.

Household Compost Pits

At the household level, compost pits are a primary solution to manage kitchen waste at source. In Idukki, a total of 17,626 households have been provided with compost pits (Fig. 26). Kattappana leads with 3,500 households, which can be explained by its urban nature, population density, and municipal-level prioritization of household-level systems. Following this, Chakkupallam (2,500) and Erattayar (2,200) also report significant coverage. However, Elappara and Peermade panchayats have not implemented household compost pits.

Despite their presence, several panchayats—including Karunapuram, Mariyapuram, Vazhathope, Kumily, and Erattayar—report that the existing compost pits are insufficient to handle the actual waste generated. Expanding household composting is crucial since untreated organic waste contributes significantly to the organic pollution load and nutrient imbalance in the river ecosystem.

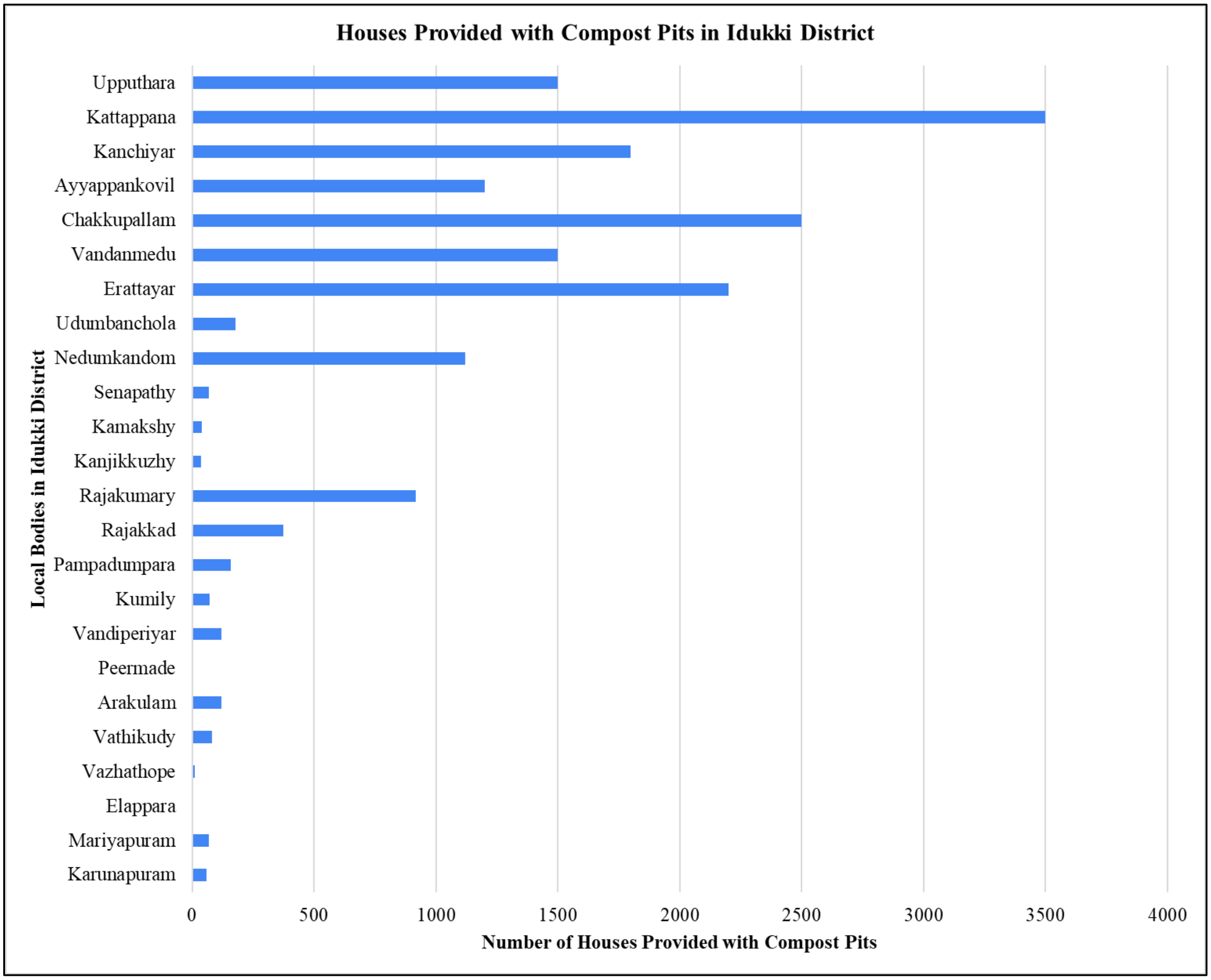

Fig. 26 Households Provided with Compost Pits in Idukki District

Community Bio-Facilities and Individual Bio-Facilities

Data on community bio-facilities is available only for selected panchayats. Among these, Adimali has the highest number with 180 community bio-facilities, followed by Pallivasal (35), while Devikulam, Edamalakkudi, and Mankulam have none. In contrast, Vellathooval leads in individual bio-facilities (21 units), followed by Pallivasal (9) and Konnathady (8). Notably, Adimali, despite having the highest number of community bio-facilities, has no individual bio-facilities, indicating a greater reliance on centralized systems rather than household-level solutions.

Ring Compost Units and Bio-Composter Bins

Ring compost units are simple, low-cost systems for decentralized organic waste treatment. In Idukki, data is available only for Konnathady (266 units) and Vellathooval (211 units), indicating significant investment in household-level biodegradable waste solutions in these panchayats.

Similarly, Konnathady also hosts 234 bio-composter bins, further strengthening its decentralized waste management infrastructure. While this indicates good practice, the absence of data for other panchayats suggests either limited adoption or reporting gaps.

II. Non-Biodegradable Waste Management

Material Collection Facilities (MCFs)

MCFs are pivotal nodes in the solid waste management chain, functioning as primary sorting and storage points for non-biodegradable dry waste such as plastics, paper, metals, and glass. In Idukki district, out of 34 grama panchayats and one municipality (Kattappana), MCFs are present in almost all local bodies except Devikulam and Edamalakkudi panchayats (Fig. 27). The absence of MCFs in these areas can be attributed to geographic remoteness, high-altitude terrain, and poor connectivity, which make waste collection and facility establishment logistically challenging.

Interestingly, Elappara and Rajakumary panchayats each operate two MCFs, while the remaining local bodies function with one facility each, bringing the total number of MCFs in Idukki to 35. Collectively, these facilities cover 47,634 sq. ft. The largest MCF area is in Munnar panchayat (4,200 sq. ft.), which is justified despite the relatively moderate solid waste generation rate of 7.81 TPD, due to the floating tourist population. Tourism-driven waste, especially single-use plastics needs larger storage and sorting spaces. Following Munnar, Erattayar (3,000 sq. ft.) and Vellathooval (3,000 sq. ft.) host relatively larger MCFs. In contrast, Vathikudy (400 sq. ft.) and Baisonvalley (430 sq. ft.) have the smallest MCF facilities.

Regarding operational adequacy, several MCFs have been reported as currently insufficient to handle waste volumes effectively. These include facilities in Karunapuram, Mariyapuram, Vazhathope, Vathikudy, Kamakshy, Udumbanchola, Vandanmedu, Ayyappankovil, Upputhara, and Kattappana. In other local bodies, however, detailed capacity assessments are yet to be undertaken, and further studies are required to evaluate their effectiveness in reducing the pollution load on the Periyar River. Fig. 28 shows an MCF unit in Kerala.

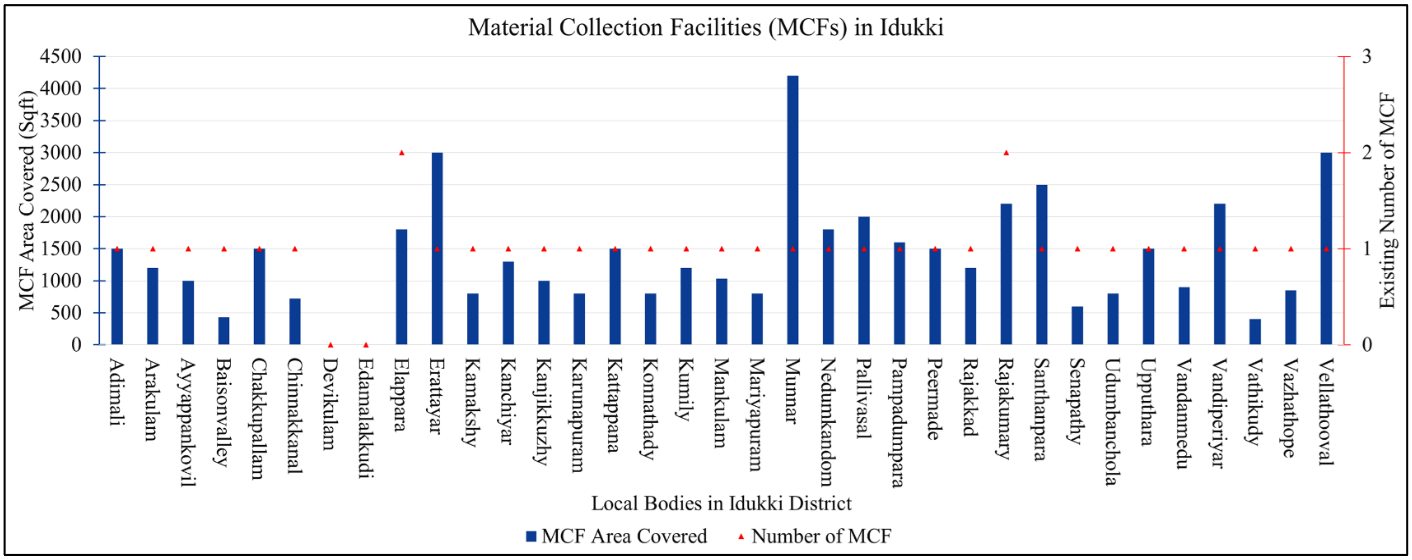

Fig. 27 Graph Showing the Number and Area Coverage of MCFs in Idukki District

Fig. 28 Material Collection Facility (MCF) (Source: The State of Decentralised Solid Waste Management in Kerala Report, 2021)

Mini Material Collection Facilities (Mini MCFs)

Mini MCFs serve as localized collection and segregation points within wards, reducing the logistical burden on larger centralized MCFs. In Idukki district, a total of 520 Mini MCFs have been established. Kattappana tops the list with 48 Mini MCFs, consistent with its status as the highest solid waste-generating urban center in the district due to its municipal status and commercial intensity (Fig. 29). Following this, Chakkupallam and Arakulam panchayats each host 35 Mini MCFs, reflecting their relatively high population densities. On the other end of the spectrum, Karunapuram (1 unit), Pallivasal (2 units), and Pampadumpara (3 units) have the lowest number of Mini MCFs. The lower number of mini MCFs indicates that these areas rely directly on MCFs due to their smaller population, rather than on mini MCFs.

In terms of adequacy, Mini MCFs in at least 20 local bodies—including Karunapuram, Mariyapuram, Elappara, Vazhathope, Vathikudy, Peermade, Vandiperiyar, Kumily, and Pampadumpara—are reported as insufficient. Conversely, some panchayats such as Adimali, Chinnakkanal, Mankulam, Vellathooval, Arakulam, Chakkupallam, and Kanchiyar have more Mini MCFs than required, suggesting over-allocation in certain areas compared to others. Fig. 30 and 31 shows images of Mini MCFs and how the waste is collected for transportation and processing.

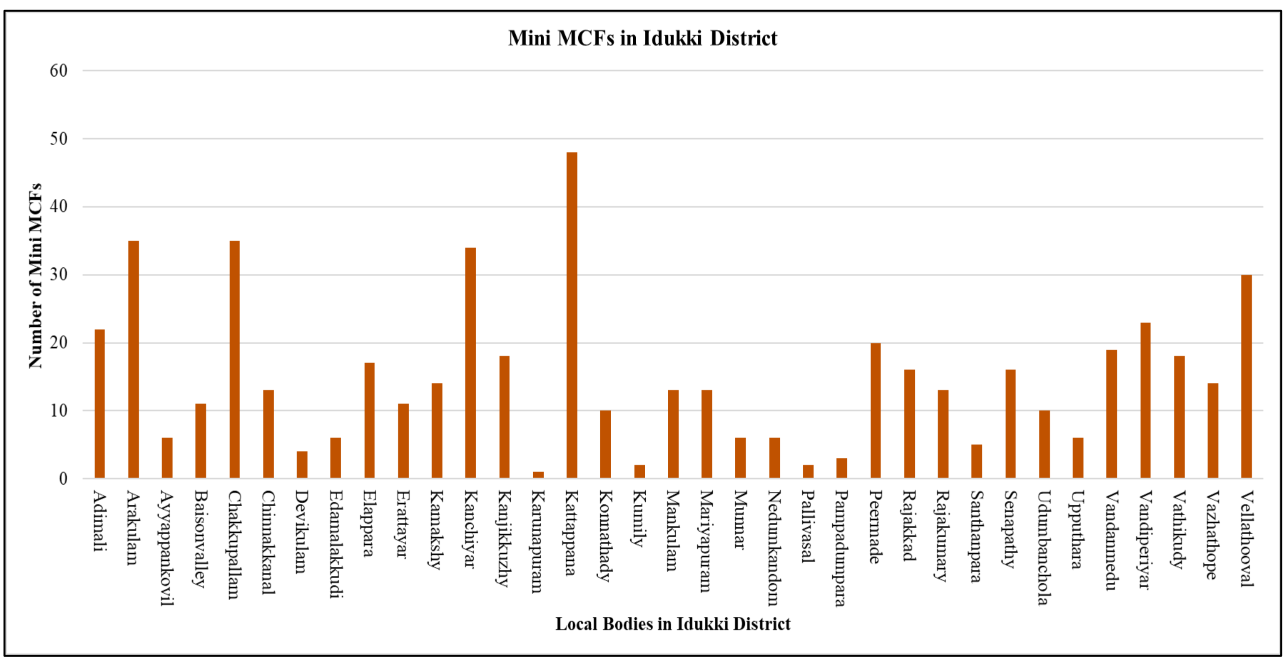

Fig. 29 Mini Material Collection Facilities (Mini MCFs) in Idukki District

Fig. 30 Mini MCF (Source: Technical Manual for Solid Waste Management, 2024)

Fig. 31 Waste Collection from Mini MCFs (Source: The State of Decentralised Solid Waste Management in Kerala Report 2021)

A gap analysis study conducted by Suchitwa Mission across 12 local bodies revealed significant mismatches between the existing and required number of Mini MCFs (Fig. 30). For instance:

- Devikulam has only 4 Mini MCFs against a requirement of 32, creating a deficit of 28.
- Munnar has 6 units against a requirement of 36, creating a gap of 30, again reflecting the high tourist inflow and floating waste population.
- Pallivasal requires 26 units but has only 2, a gap of 24.
- Vellathooval exhibits substantial excess capacity, with 30 units installed against a requirement of only 4.

The above findings highlight the necessity for balanced allocation and scientific planning of Mini MCFs, ensuring that both urbanized centers with high waste generation (like Kattappana) and tourist hotspots (like Munnar) receive adequate infrastructure.

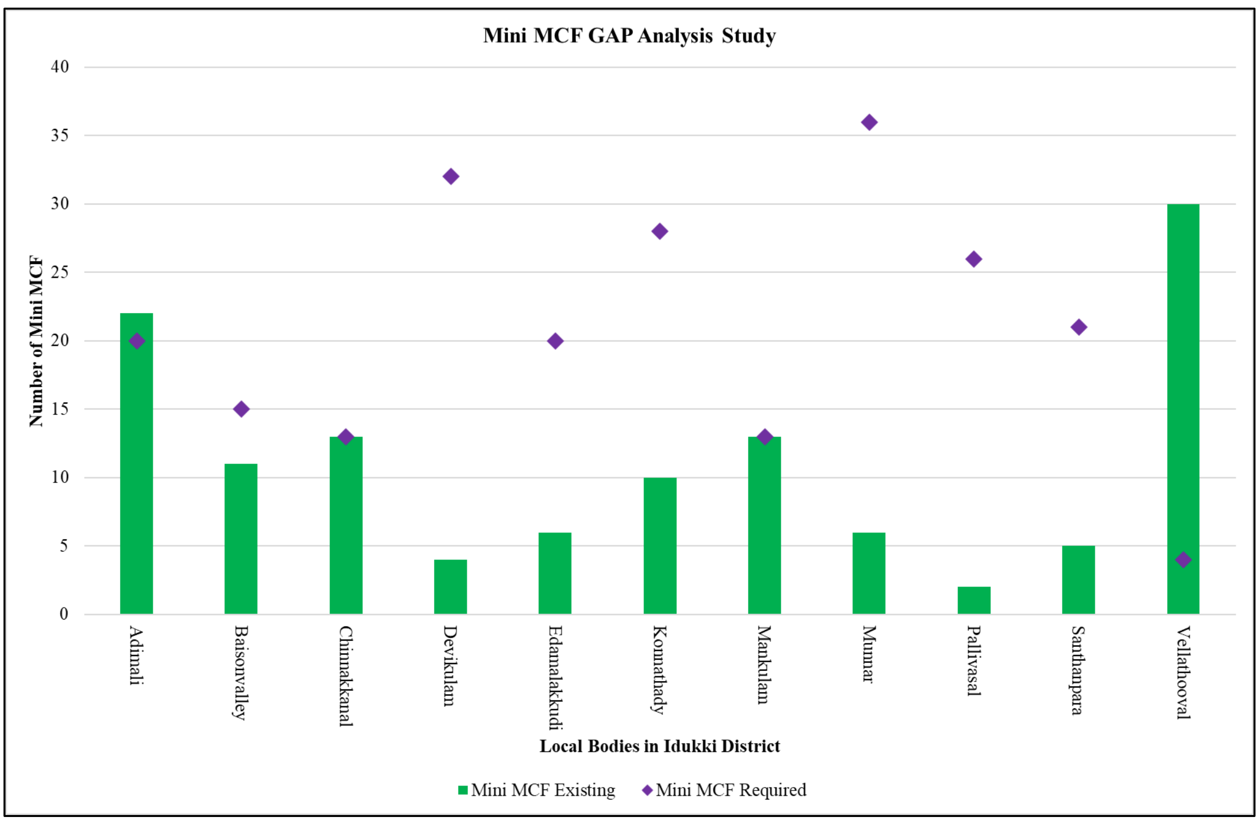

Fig. 32 Gap Analysis of Mini MCFs in Idukki District.

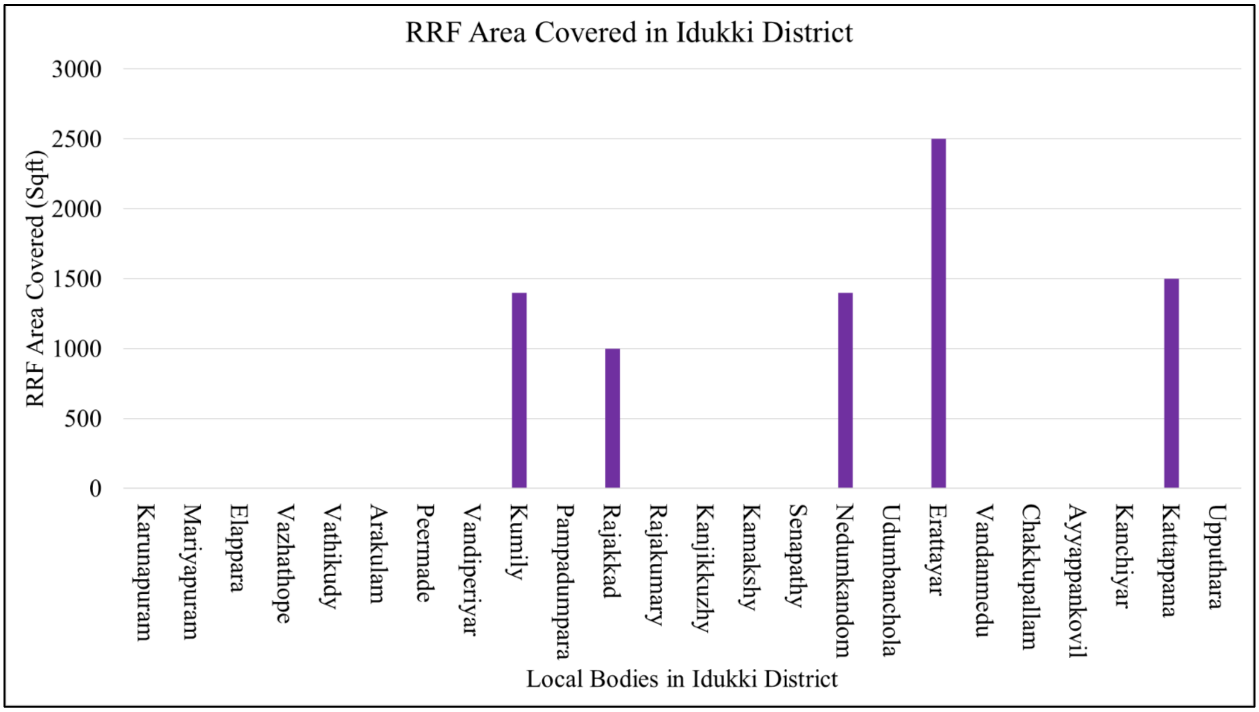

Fig. 33 Area Covered by Resource Recovery Facilities (RRFs) in Idukki District

Resource Recovery Facilities (RRFs)

RRFs function as secondary-level facilities where waste that is collected at MCFs is further sorted, processed, and stored before being sent for recycling or disposal. In Idukki, only a limited number of RRFs are operational (Fig. 33). These exist in Kumily, Rajakkad, Nedumkandom, Erattayar, and Kattappana, while in several panchayats such as Adimali, Devikulam, Munnar, and Pallivasal, the data regarding RRFs is unavailable. The remaining local bodies operate without any RRF.

In terms of infrastructure, the largest RRF in Idukki is located in Erattayar, with a built-up area of 2,500 sq. ft. Kattappana, despite being the largest waste generator in the district due to its municipal status and commercial activity, has an RRF of only 1,500 sq. ft., which highlights an infrastructure gap between waste generation and facility size.

The relatively low presence of RRFs across Idukki indicates that they are not prioritized equally across all local bodies. Many smaller or remote panchayats depend mainly on MCFs and local-level segregation systems. Establishing and operating RRFs requires land, higher investment, and consistent waste streams, which may not be feasible in hilly, sparsely populated regions. However, considering their role in ensuring secondary segregation and material recovery, RRFs are crucial in reducing the non-biodegradable load entering open dumping sites. The lack of RRFs in several areas, therefore, signals a major gap in the district's non-biodegradable waste management system.

Bottle Booths

Bottle Booths are decentralized collection points established to encourage source-level segregation and recycling of PET bottles and other plastic waste. In Idukki, a total of 253 Bottle Booths are functioning. The highest number is in Devikulam (40 booths), followed by Konnathady (38) and Munnar (32) (Fig. 34).

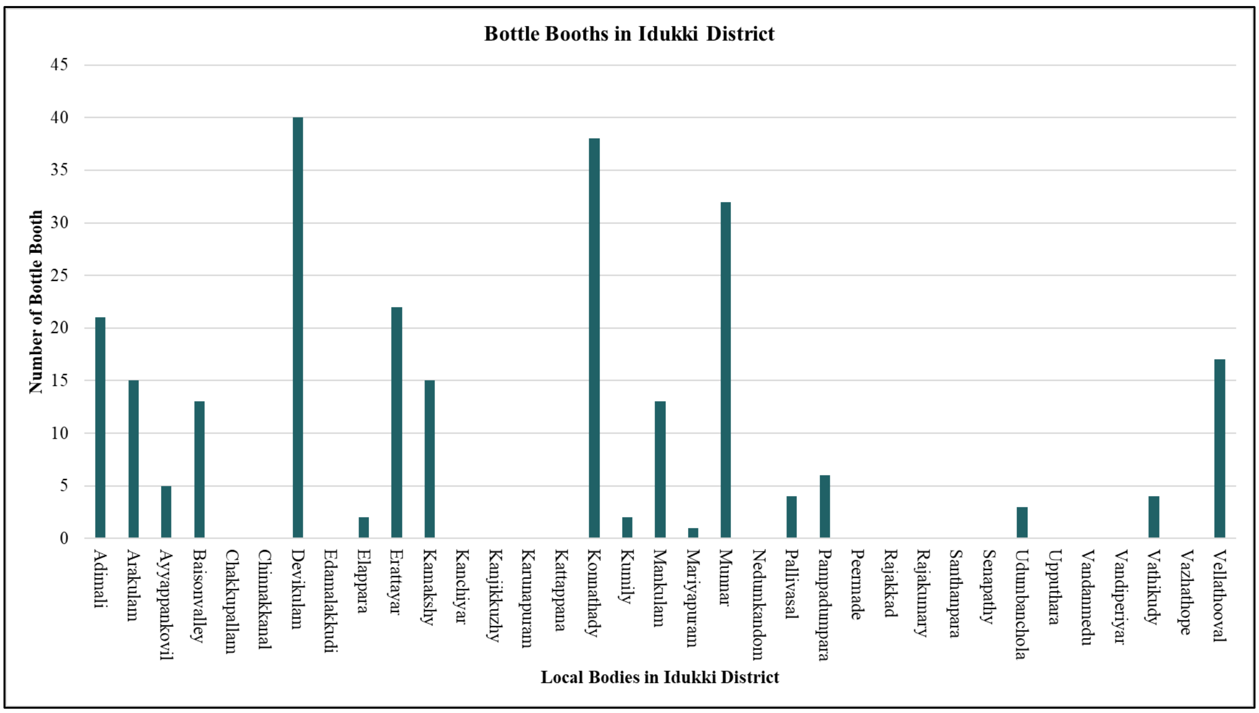

Fig. 34 Bottle Booths Installed in Idukki District

However, several local bodies such as Karunapuram, Vazhathope, Peermade, Vandiperiyar, Rajakkad, Rajakumary, Kattappana, and Edamalakkudi have no Bottle Booths established. While Bottle Booths may appear less important, they play a critical role in reducing plastic pollution load, as discarded PET bottles are among the most common pollutants found in Kerala's rivers. Expanding these facilities, especially in tourist-heavy local bodies like Munnar, Kumily, and Thekkady, would significantly reduce plastic leakage into the Periyar. Fig. 35 shows different bottle booth designs.

Fig. 35 Bottle Booths (Source: Technical Manual for Solid Waste Management, 2024)

Waste Management Practices in Kattapana Municipality

Kattapana Municipality, located within the Periyar River basin, holds a significant position in the district's waste generation profile due to its urban character and population density. The KSPCB Audit Report (2018–2019) records that the municipality generates around 18.57 TPD of solid waste, of which only 3.63 TPD is collected and 1.40 TPD is treated. At the household level, decentralized solid waste management has been initiated through 1,505 composting units, 345 biogas plants, and 450 compost pits, while institutions are equipped to handle 2.23 TPD of biodegradable waste and 0.4 TPD of non-biodegradable waste. For the non-biodegradable fraction, the municipality also operates a plastic shredding unit, a crucial intervention to reduce plastic waste accumulation and improve recyclability, thereby lowering the pollution load on the river basin.

According to Suchitwa Mission data, detailed information is available for Kattapana Municipality. The Census of 2011 recorded a population of 42,646 residents across 10,419 households and 2,456 institutions. Projections indicate an increase to 45,473 by 2023 and 46,610 by 2028. This population growth directly influences the quantum of waste generated. In 2023, the solid waste generation rate was estimated at 13.6 TPD, comprising 10.5 TPD biodegradable waste and 3.1 TPD non-biodegradable waste. By 2028, the Figure is projected to rise to 13.98 TPD (10.77 TPD biodegradable and 3.22 TPD non-biodegradable). The gradual rise in waste generation underscores the need for timely expansion of waste management facilities to prevent uncontrolled accumulation and subsequent discharge into the Periyar system.

Biodegradable Waste Processing Facilities

To address the challenge of biodegradable waste (BDW), Kattapana has adopted decentralized systems at household, institutional, and community levels. At the household level, 179 Geebins (0.085 TPD capacity), 755 ring compost units (0.359 TPD), and 243 biogas plants (0.116 TPD) have been installed, in addition to 1,118 compost pits and vermicomposting units. Together, these add up to 2,295 household-level processing units with a combined treatment capacity of 0.560 TPD.

At the institutional and community levels, Thumburmuzhi composting units provide localized waste treatment. Institutions operate 4 units with a capacity of 25 kg each, and communities maintain 2 additional units. These localized interventions reduce the load on central collection systems and contribute to the reduction of untreated biodegradable waste entering open drains and landfills.

Ongoing and Under-Construction Facilities

Recognizing that existing infrastructure remains insufficient, the municipality is scaling up operations. Ongoing projects include 1,700 ring compost units (0.808 TPD) and 200 domestic biogas plants (0.095 TPD), which will add 1,900 household-level units with a combined capacity of 0.903 TPD. At the institutional level, 4 new Thumburmuzhi composting units are under development. Once functional, these facilities are expected to provide additional treatment capacity, reducing pressure on natural ecosystems and supporting compliance with the Solid Waste Management Rules, 2016.

Total Treatment Capacity

Combining existing and upcoming facilities, Kattapana Municipality will soon achieve a total treatment capacity of 1.713 TPD of biodegradable waste. While this marks significant progress in structured waste handling, the capacity still falls short when compared to the projected generation rate. The shortfall highlights the urgency of scaling up infrastructure and ensuring that waste processing keeps pace with population growth and urban expansion.

Non-Biodegradable Waste Processing Facilities

Kattapana also manages non-biodegradable waste (NBDW) through one MCF and one RRF. Both span 311 m^2 with a processing capacity of 1.5 TPD each. The facilities operate on a monthly collection frequency, emphasizing segregation and recovery to divert recyclable and reusable materials from open dumping. By channeling plastics and other recyclables into secondary use pathways, these facilities play a vital role in reducing the solid waste burden and preventing NBDW from contributing to the pollution load of the Periyar River.

Identified Treatment Gaps

Despite the infrastructure in place, a significant treatment gap persists. Current data indicates that 9.05 TPD of biodegradable waste remains untreated, while 1.72 TPD of non-biodegradable waste is left unmanaged. These untreated fractions contribute to unregulated dumping and increase environmental stress on the river basin. The gap reveals structural weaknesses in treatment capacity, collection efficiency, and frequency of processing. To address this, Kattapana must strengthen monitoring systems, expand its treatment infrastructure, and explore innovative waste-to-energy or large-scale composting options.

Source Segregation of Waste

The District Environmental Plan Report (2021) shows that out of 35 wards, 20 wards have achieved 100% source segregation. However, 14 wards remain non-compliant, which limits the effectiveness of downstream processing. Unsegregated waste not only increases treatment costs but also contaminates recyclable fractions, adding to the pollution load. To improve compliance, the municipality has proposed awareness campaigns, incentives for compliant households, and insitu composting at community levels. Such interventions will ensure that segregation at source becomes universal, thereby reducing the likelihood of untreated waste entering natural water channels.

Collection and Transportation

Efficient waste management also depends on robust collection and transportation systems. In Kattapana, door-to-door collection covers only 20 out of 34 wards (58.82%), leaving nearly 40% of households without structured collection services. This lack of coverage directly results in indiscriminate dumping into drains and open spaces, which in turn increases the risk of solid waste entering the Periyar River. For transportation, however, the municipality has adequate infrastructure, with two mini trucks equipped with separate compartments to ensure segregation during transit. While the transportation system is aligned with requirements, its efficiency will depend on extending door-to-door collection coverage and integrating it seamlessly with MCFs and processing units.

Summary of Waste Management Practices in Kattapana Municipality

In summary, Kattapana Municipality demonstrates a proactive approach to solid waste management with decentralized infrastructure, institutional composting, and recycling facilities. Yet, treatment gaps, incomplete source segregation, and partial collection coverage remain critical bottlenecks. If left unaddressed, these gaps will contribute to continued solid waste leakage into the Periyar River system, aggravating pollution load. Strengthening household and institutional infrastructure, expanding door-to-door collection to all wards, and ensuring operational efficiency in MCFs and RRFs are essential steps toward building a resilient and sustainable waste management system in Kattapana.

Waste Management Practices in Ernakulam District

In Ernakulam district, Kochi Corporation generates the highest quantity of waste (277.07 TPD) and maintains strong day-to-day coverage with 90% of households and 60% of non-residential premises included, supported by a large workforce of 1200 collectors. Most municipalities, such as Angamaly, Perumbavoor, Kothamangalam, and North Paravur, report high collection efficiencies often above 90% with the collected quantity matching the waste processed. Aluva

Municipality shows lower household coverage (24%), indicating the need for improved outreach and collection systems (CPCB). The table 8 shows collection facilities in Ernakulam district.

Table 8: Collection facilities in Ernakulam district (Source: CPCB)

Local Body	**Population (as per 2011)**	**Quantity of Waste generated (TPD)**	**Percentage of day-to-day collection (Dry waste)**		**No. of collectors**	**As reported by local bodies**	
			Household (%)	**Nonresidential premises (%)**		**Quantity of waste collected (TPD)**	**Quantity of waste processed (TPD)**
Kochi (C)	648132	277.07	90	60	1200	160.907	160.907
Angamaly (M)	36027	11.979	90	72	37	11.979	11.979
Aluva (M)	24145	8.028	24	10.8	25	8.028	8.028
Kalamassery (M)	76476	25.428	77	80	54	21.51	21.51
Kothamangalam (M)	18574	13.902	95	95	40	13.902	13.902
Perumbavoor (M)	30262	10.062	90	90	83	10.062	10.062
Eloor (M)	39533	13.145	85	100	27	12.812	12.812
North Paravur (M)	33915	11.277	90	95	1	11.277	11.277

Note: M and C stands for Municipality and Corporation respectively.

The Table 8 presents the disposal facilities established within the Periyar River Basin in Ernakulam District, as reported by LSGIs. The major ULBs, Kochi Corporation, and the municipalities of Aluva, Angamaly, Eloor, Kalamassery, North Paravur, and Perumbavur, have set up a combination of centralized composting units and MCFs of varying capacities. Kochi Corporation has the largest infrastructure, with 9,350 household-level biodegradable waste management units, two centralized composting facilities, and RRFs with a capacity of 6.89 TPD, reflecting its urban waste load and management capacity. Municipalities such as Angamaly, Aluva, and North Paravur have moderate MCF capacities ranging from 2.32 to 3.25 TPD, while Eloor and Kalamassery show limited household-level systems and smaller RRF infrastructure. Perumbavur Municipality stands out with both centralized composting and a functional community-level biomethanation plant, indicating progressive waste processing practices. Among Grama Panchayats, facilities remain largely decentralized. Many panchayats, including Alengadu, Chengamanad, Kadungalloor, Mulavukadu, and Pallippuram, have introduced biomethanation or centralized composting facilities, though such installations are limited in number. Most rural local bodies rely on household composting methods (pipe/ring composts, biogas units) and small-scale MCFs, typically with capacities below 2.5 TPD. A few panchayats, such as Cheranallur and Kuttambuzha lack MCFs or RRFs entirely. Overall, the data indicates that while decentralized solid waste management is operational across much of Ernakulam, the absence of community-level biomethanation in most LSGIs, and limited RRF coverage, highlight the need for strengthening processing capacity, segregation efficiency, and infrastructure integration within the basin area. Fig. 36 and 37 shows the area covered by MCF and number of household biodegradable waste management facilities in Ernakulam District, respectively.

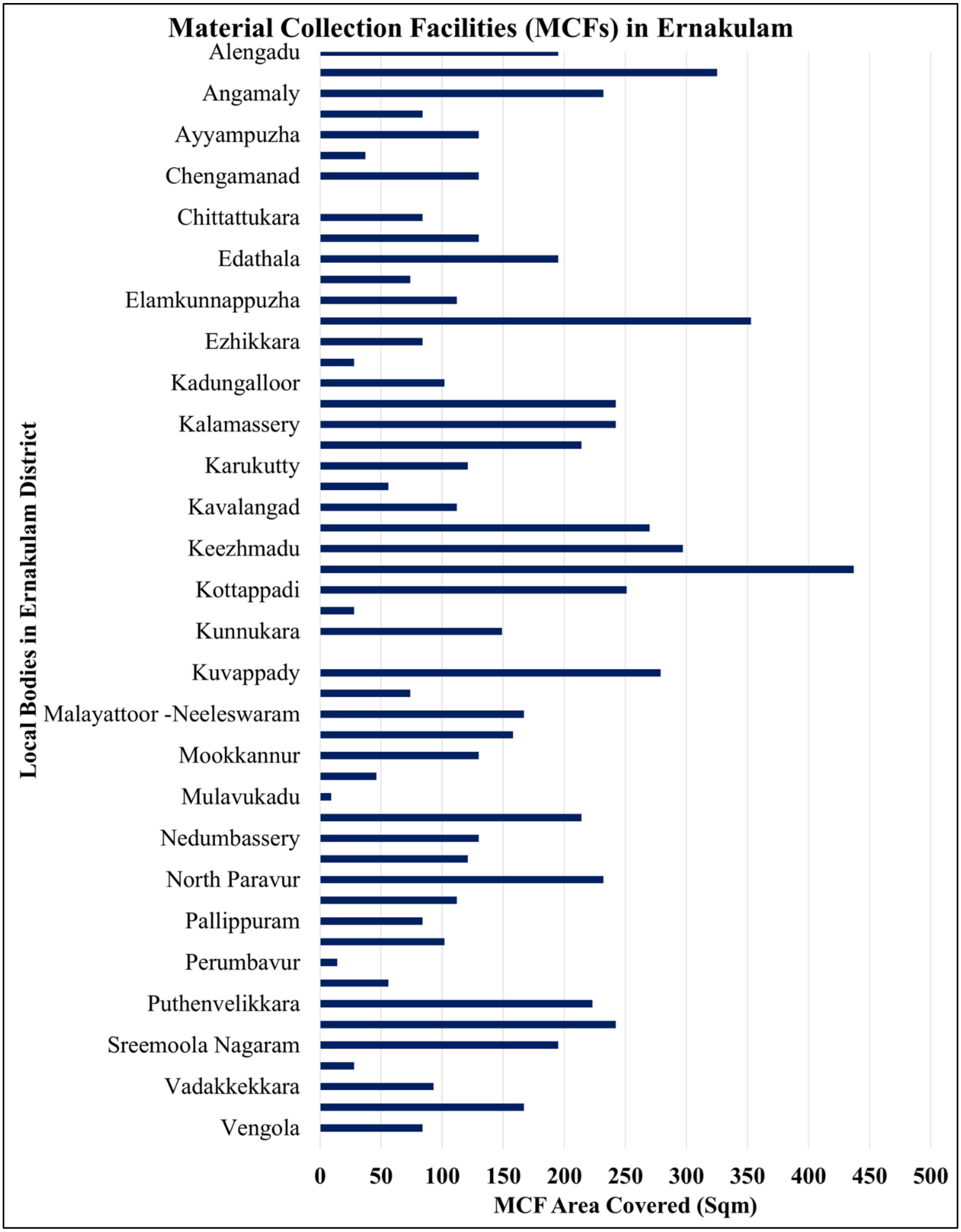

Fig. 36 Material Collection Facility (MCF) in Ernakulam District

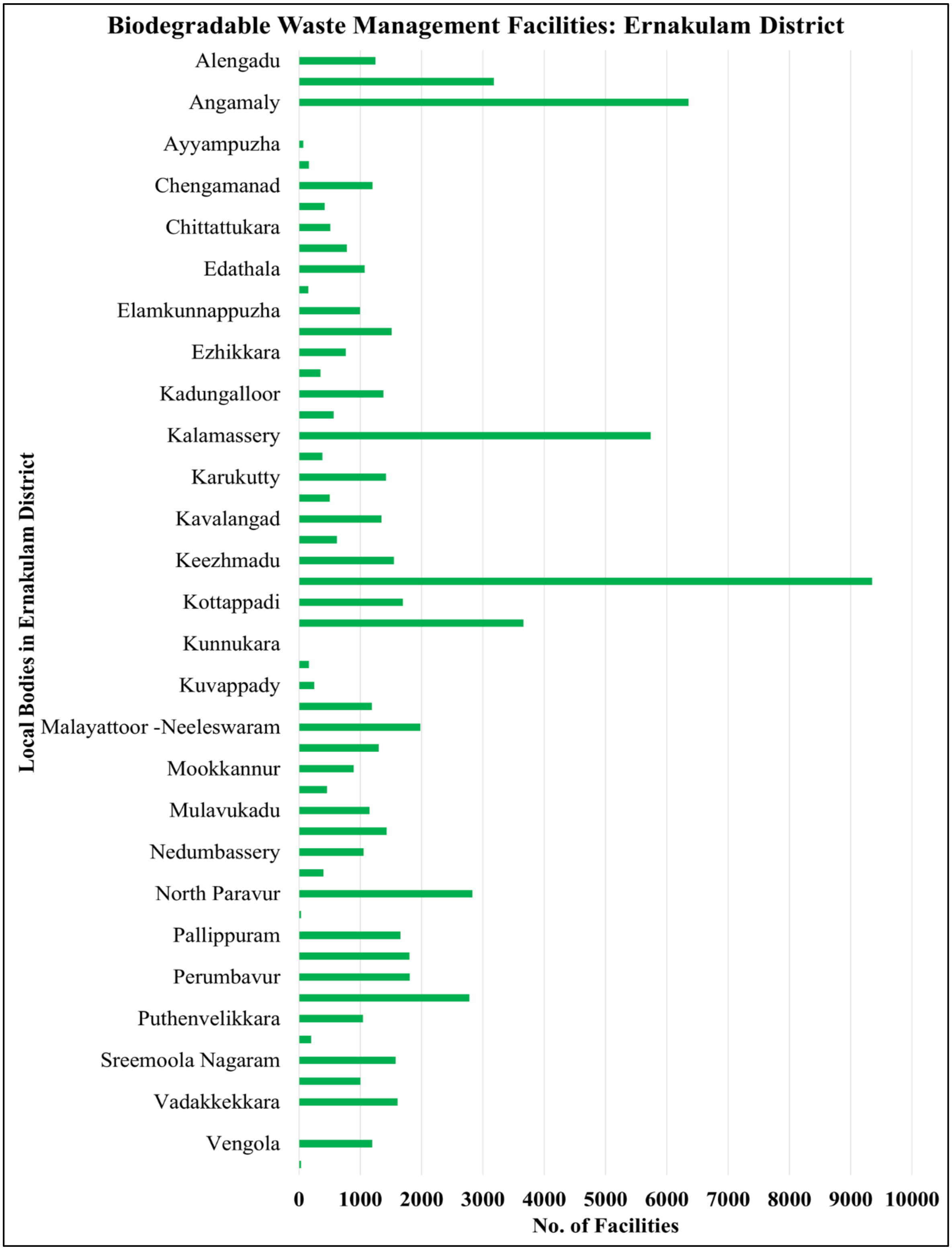

Fig. 37 Number of Household Biodegradable Waste Management Facilities (Pipe Compost, Ring Compost, and Biogas Plants)

4.9.6. Waste Management Practices in Thrissur District

In Thrissur district, Chalakkudi Block, Irinjalakkuda municipality and Kodungallur municipality demonstrate high levels of day-to-day coverage. Chalakkudy achieves 100% household coverage, while Irinjalakuda maintains full collection for both households and commercial premises through Kudumbasree and HKS teams. Kodungallur also records strong coverage with 90-95% inclusion across sectors. Waste collected in these municipalities is processed, indicating effective waste management operations (CPCB). Overall, the data show that most ULBs in both districts have established efficient collection systems, though certain municipalities still require improvement in household coverage and strengthening of collection workforce. The table 9 shows collection facilities in Thrissur district. Fig. 38 and 39 illustrate the MCF facilities in Thrissur district and the number of household biodegradable waste management facilities.

Table 9: Collection facilities in Thrissur district (Source: CPCB)

Local Body	Population (as per 2011)	Quantity of Waste generated (TPD)	Percentage of D2D collection (Dry waste)		No. of collectors	As reported by local bodies	
			Household (%)	Nonresidential premises (%)		Quantity of waste collected (TPD)	Quantity of waste processed (TPD)
Chalakkudy (M)	52801	17.556	100	60.5	51	17.556	17.556
Irinjalakuda (M)	66669	22.167	90	100	HKS -74, Kudumbasree - 12	22.167	22.167
Kodungallur (M)	76142	25.317	90	95	84	18.652	18.652

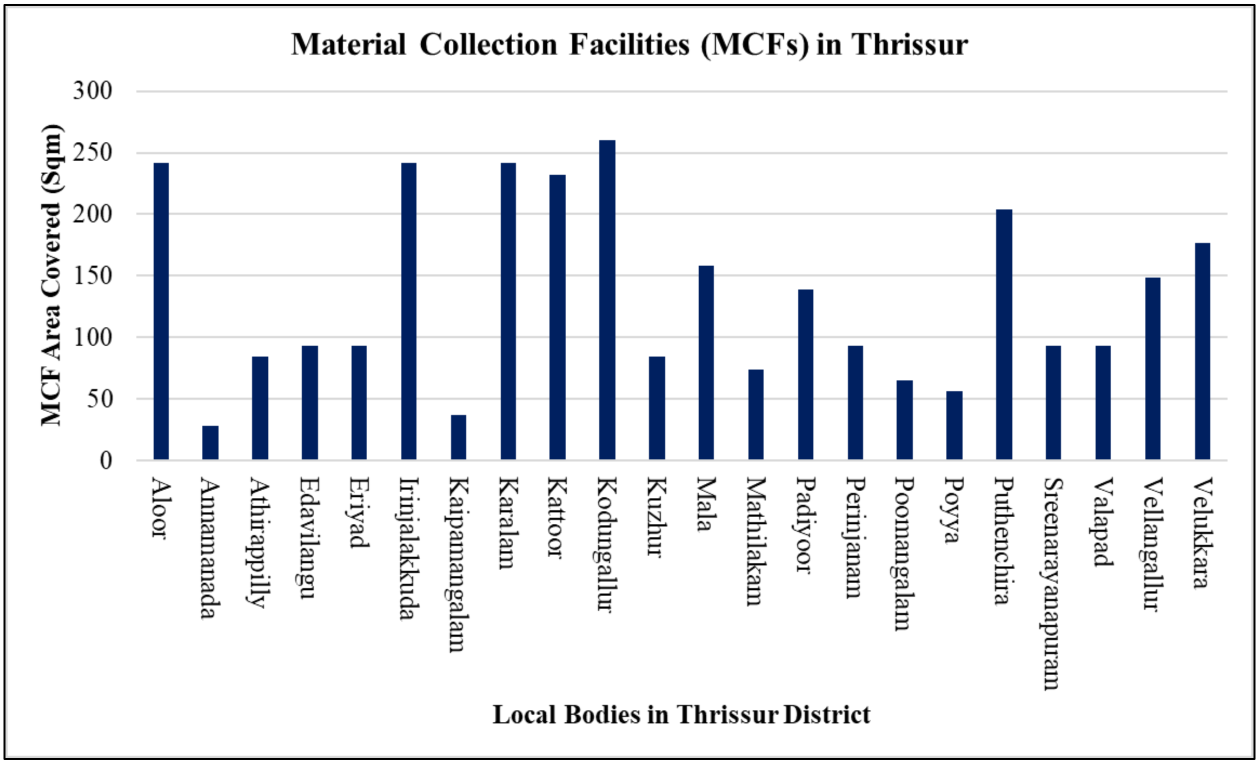

Fig. 38 Material Collection Facility (MCF) in Thrissur District

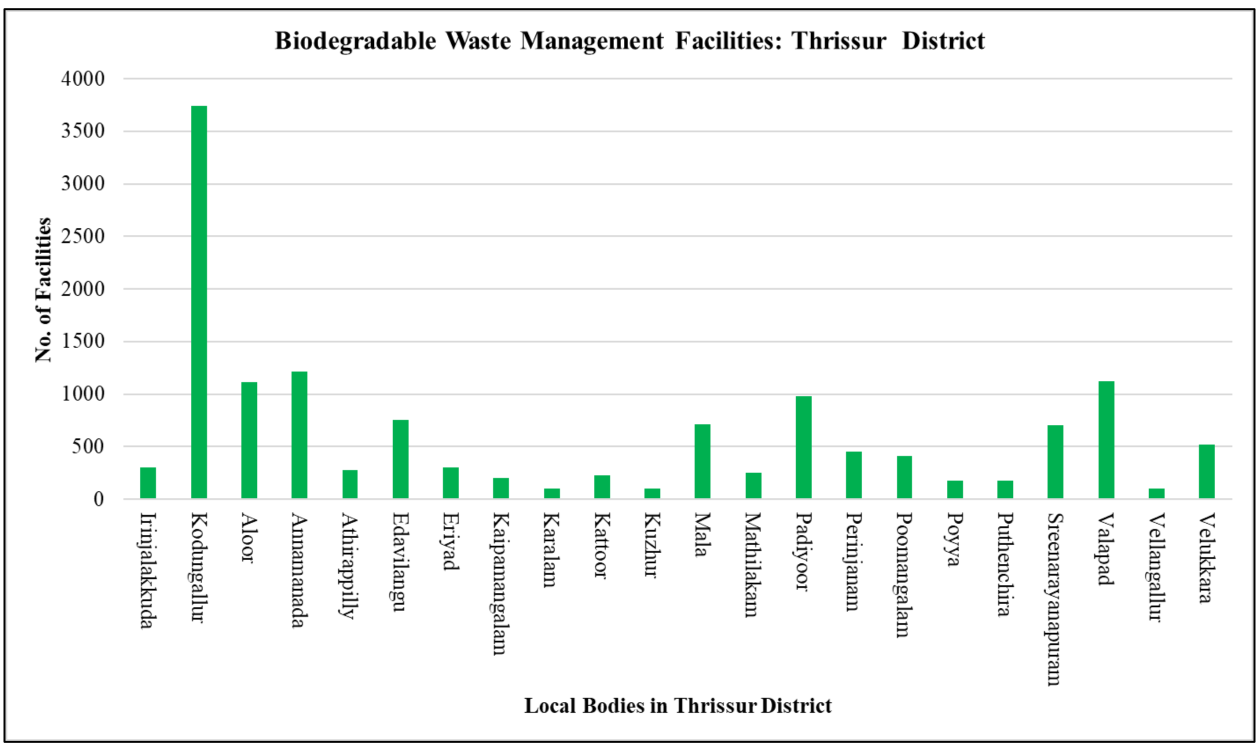

Fig. 39 Number of Household Biodegradable Waste Management Facilities (Pipe Compost, Ring Compost, and Biogas Plants)

The analysis of collection, transportation, and disposal facilities across the districts within the Periyar River basin highlights both progress and persisting challenges in solid waste management. While decentralized systems such as compost pits, Thumboormuzhi composting, windrow composts, bottle booths, and bio-facilities have contributed to reducing the pollution load, their uneven distribution and insufficient capacity in several local bodies continue to exert pressure on the river ecosystem. RRFs, despite their proven importance in segregating and channelizing non-biodegradable waste, remain absent or underutilized in many panchayats, indicating the need for improved planning and investment. Similarly, while community and household-level composting initiatives are operational in some areas, data gaps and operational inefficiencies limit their overall impact.

For sustainable pollution load reduction in the Periyar, strengthening existing infrastructure, ensuring uniform coverage across local bodies, and addressing operational shortcomings are critical. Integrating waste-to-resource strategies with community participation, supported by monitoring from agencies such as the Suchitwa Mission and Kerala State Pollution Control Board, can enhance the efficiency of solid waste management. Ultimately, improving collection, transportation, and disposal mechanisms will not only mitigate the direct waste inflow into the river but also contribute to safeguarding the ecological health and water quality of the Periyar basin in the long term.

5. Treatment & Management

5.1. Sewage Treatment Plants (STPs)

STPs are critical facilities designed to treat domestic sewage and sullage, thereby reducing organic load, suspended solids, and pathogenic contaminants before the treated effluent is discharged into water bodies. Alongside STPs, Faecal Sludge Treatment Plants (FSTPs) play an equally important role, where households commonly rely on on-site sanitation systems such as septic tanks and soak pits. Common Sewage Treatment Plants (CSTPs) are centralized facilities that serve clusters of households or ULBs, while FSTPs are specifically intended for treating septage collected through desludging operations. Together, these treatment systems form the backbone of municipal wastewater management and are central to reducing the pollution load on rivers, including the Periyar (CPCB).

To achieve effective treatment, these facilities adopt different technologies depending on scale, land availability, and effluent quality requirements. Commonly used methods include Moving Bed Biofilm Reactor (MBBR), a biological process where carriers provide surface area for microbial growth to degrade organic matter, and Electrocoagulation, a physico-chemical treatment that destabilizes pollutants using electrical current for easier removal. The capacity of an STP is expressed in MLD, while current utilization indicates the actual inflow being treated compared to design limits. Compliance with effluent discharge standards is monitored through parameters such as pH, BOD, COD, and Total Suspended Solids (TSS). In addition, the sludge generated must be managed carefully through drying beds or composting to prevent secondary contamination. The sustainability of these plants depends not only on technology but also on implementing agencies, financial provisions, and adherence to operational standards, making them a vital component of Kerala's pollution load management strategy.

5.2. Sewage Generation and Treatment Scenario in Kerala

Kerala generates a total of 3999 MLD of sewage and sullage, but the treatment infrastructure remains limited. The state currently operates 27 common STPs/CSTPs and 4 common FSTPs, along with 2020 individual STPs located in residential and institutional establishments. Out of these, only 14 common STPs and 4 FSTPs are fully functional. The combined treatment capacity through common STPs amounts to 138.31 MLD (Urban: 129.695 MLD, Rural: 8.615 MLD), while septage treatment capacity via common FSTPs is only 0.22 MLD. In addition, individual STPs in establishments contribute 95.461 MLD of treatment capacity. Despite this, the gap in treatment capacity remains significant, with around 80.024 MLD of sewage untreated in urban areas alone (KSPCB, 2025). Most individual households still depend on septic tanks and soak pits, which often discharge effluent into nearby drains without adequate treatment, contributing to diffuse pollution in river systems such as the Periyar. This gap in sewage management highlights the need for strengthening both centralized and decentralized sewage treatment solutions.

5.2.1. Details of existing STPs

Several STPs are currently in operation across Ernakulam, Idukki, and Thrissur districts, each varying in capacity, technology, and utilization. The STP owned by the Greater Cochin Development Authority at Marine Drive, Kochi, has an installed capacity of 0.9 MLD using the Activated Sludge Process and operates at full capacity, with plans to augment to 2 MLD. The STP at Elamkulam, Kochi (AMRUT), uses the MBBR process with a capacity of 5 MLD and co-treatment of 24 KLD but is currently facing temporary operational issues due to choking. Another Greater Cochin Development Authority (GCDA) owned plant at the International Stadium, Kaloor, has a capacity of 0.75 MLD but operates at only 0.05 MLD.

In Thrissur, the Guruvayur STP (3 MLD) operates at 0.5 MLD, while the Kuriyanchira Slaughterhouse STP (0.035 MLD, MBBR) functions at full capacity. The General Hospital, Thrissur STP (0.36 MLD) currently operates at 0.2 MLD.

In the Idukki district, there are two existing STPs. The Sewage Treatment Plant at the Comfort Station, Adimaly Grama Panchayat, has an installed capacity of 0.01 MLD and is currently non-functional. The latest compliance status indicates pH 7.01, Total Suspended Solids (TSS) of 32 mg/L, COD of 110 mg/L, and BOD of 26.4 mg/L. This facility is implemented by Areena Hygiene Solutions Pvt. Ltd. and funded under the Swachh Bharat Mission (Gramin) with a total project cost of ₹18,26,500, of which ₹13,39,000 was provided by Suchitwa Mission and ₹4,87,500 by the LSGD. The second STP in Idukki is located at the Taluk Hospital, Adimaly Grama Panchayat, with an installed capacity of 0.006 MLD and is currently operational, showing compliance parameters of pH 7.45, BOD 27 mg/L, COD 56 mg/L, Suspended Solids 24 mg/L, Oil and Grease below detectable limits, and nil faecal coliform as per analysis dated 04.03.2025; this plant is funded under Suchitwa Keralam Rural with a total cost of ₹47,76,000. The table 10 presents the details of existing STPs in the Ernakulam, Thrissur, and Idukki districts (Kerala State Pollution Control Board, 2024). The Fig. 40 shows the Location of STPs and ETPs in the Periyar River Basin.

Table 10: Details of existing STPs

Sl. No.	STP location	STP Installed capacity	Technology	Utilization	Status	Quality parameters
			Ernakulam			
1	STP owned by Greater Cochin Development Authority, Marine drive, Kochi	0.9 MLD	Activated Sludge Process	0.9 MLD Proposed to augment to 2 MLD	Operational	Analysis report dated 14.11.2024 (pH – 7.2, TSS – 18 mg/l, BOD – 17.9 mg/l, oil & grease – BDL)
2	STP at Elamkulam, Kochi (AMRUT)	5 MLD	MBBR with Co treatment 24 KLD	4 MLD	Co-treatment is temporarily stopped due to choking in the plant.	Analysis report dated 19.10.2024 (pH – 6.9, TSS – 11 mg/l, nitrate – 7.90 mg/l, phosphates – 1.4 mg/l, ammoniacal nitrogen – 3.88 mg/l, BOD – 7.5 mg/l, COD – 16 mg/l, oil & grease – BDL, total Kjeldahl nitrogen – 4.48 mg/l).
3	STP owned by GCDA, International Stadium Kaloor	0.75MLD	Activated Sludge Process	0.05 MLD	Operational	Analysis report dated 11.12.2024 (pH – 7.51, TSS – 21.5 mg/l, BOD – 4.6 mg/l, oil & grease – 5 mg/l).
4	STP at Kalamassery, Market, Kalamassery Municipality (PRS)	10 KLD	No data	No data	Started operating	No data
			Idukki			
5	Sewage Treatment Plant at Comfort Station, Adimaly Grama Panchayat	0.01 MLD	Electrocoagulation process	0.01 MLD	STP is not working currently. Show Cause Notice issued on 05.02.2024. Inspection conducted on 15.07.2024 and direction will be issued.	pH 7.01, TSS 32 mg/L, COD 110 mg/L, BOD 26.4 mg/L
6	Sewage Treatment Plant at Taluk Hospital Adimaly Grama Panchayat	0.006 MLD	MBBR	No data	Fully operational and functioning	Analysis report dated 04.03.2025 - pH 7.45, BOD 27 mg/L, COD 56 mg/L, Suspended Solids 24 mg/L, Oil and Grease BDL, Faecal Coliform: Nil
			Thrissur			

7	Sewage treatment Plant at Guruvayur,Thrissur District	3 MLD	Activated Sludge Process	0.5MLD	Operational	(pH – 8.19, BOD – 2 mg/l, COD – 32 mg/l, Suspended solids – 1.9 mg/l, Oil and grease – 4.0 mg/l, Faecal coliform – 80 cfu/100 ml, as per analysis report dated 03.01.2025). Instructions given for full utilization of treated effluent and for utilizing treated water. Planning to reuse the treated effluent for gardening and septage dilution. Provided dilution tank.
8	Revamping of 35 KLD STP at Kuriyanchira Slaughter House Corporation, Thrissur	0.035MLD	MBBR	0.035 MLD	Operational	(pH – 7, BOD – 165.6 mg/l, COD – 524 mg/l, SS – 0.63 mg/l, oil & grease – 15.2 as per the analysis report dated 02.09.2024) Action is being taken to prevent excess.
9	STP at General Hospital, Thrissur (AMRUT-1.0)	0.36 MLD	No data	0.2 MLD	Operational	No data

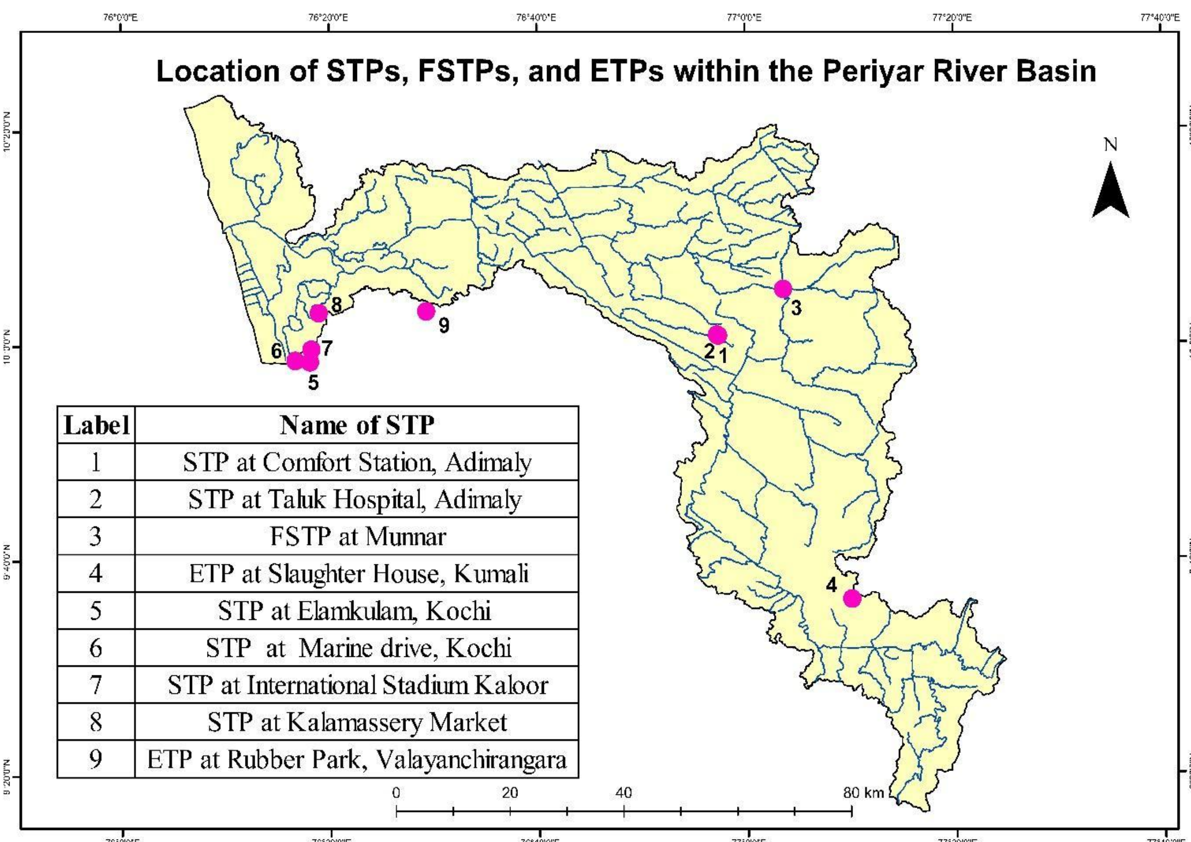

Fig. 40 Location of STPs, FSTPs and ETPs in the Periyar River Basin

5.2.2. STPs Under Construction

In addition to existing facilities, some STPs and FSTPs are under construction in Idukki district. These upcoming plants are expected to enhance sewage and septage treatment capacity, thereby reducing the untreated load reaching the Periyar. For example, an FSTP at Munnar (50 KLD capacity) is under development. However, work progress has been hindered due to a court case over land assignment. Currently, only 5% of construction is completed, and the District Collector has recommended re-assigning the land to Munnar Grama Panchayat. The timeline for completion remains pending under jurisdiction.

5.2.3. Details of Proposed STPs

To increase wastewater treatment capacity and enhance sewage management, several new STPs have been proposed in the districts of Ernakulam, Thrissur, and Idukki. Many of the projects in Ernakulam are moving through the DPR preparation, soil study, and tendering stages. These projects include both major AMRUT 2.0 facilities and smaller health center-based units. Many STPs are being built or are in the DPR stage in Thrissur, however some are delayed because of land problems or public opposition. Two small-scale STPs under Thodupuzha Municipality in Idukki district are located outside the Periyar River Basin. The overall goals of the proposed STPs are to decrease the amount of untreated sewage discharged throughout the three districts and improve decentralized wastewater treatment (Kerala State River Rejuvenation Committee). The Table 11 presents the details of proposed STPs in Ernakulam and Thrissur districts.

Table 11: Details of Proposed STPs

Sl. No.	Location	Implementing Agency	Capacity of the plant in MLD	Status of Project	Timeline of Completion
1	STP at Ambedkar Colony, Div-16, Edakochi South (AMRUT-1.0)	Kochi Corporation	1.1	1500 sewer connections are envisaged.	30.06.2025
2	CHC Kadayiruppu, Vadavucode Block Panchayat, Ernakulam	-	0.025	-	-
3	STP at RAY Flats, Fort Kochi, Kochi Corporation (AMRUT-2.0)	Kochi Corporation	0.105	DPR Stage	Expected by 31.12.2026
4	Chittur Thathamangalam	-	-	-	-
5	STP with septage co-treatment at Elamkulam, Kochi Corporation (AMRUT-2.0)	-	5	**Tendered:** KWA was directed to proceed with the proposal under AMRUT-2.0	31.12.2026
6	Viyoor central jail STP (Thrissur)	-	0.05	Work started on 23/04/2023	31.03.2025
7	Kunnumkulam, Thrissur	-	0.01	Completion stage and ready for commissioning	-
8	STP at CHC Cherpu BP, Thrissur	-	0.01	Plant construction completed	30.08.2024
9	STP at Community Health Centre Pazhayannoor Block Panchayath , Thrissur	-	0.025	Work awarded and started	31.07.2025
10	STP with Septage Cotreatment Capability at Kottapuram, Thrissur Corporation (AMRUT-2.0)	KWA	5	DPR Stage	Expected by 31.12.2026
11	STP at Athani, Wadakkanchery Municipality, Thrissur (PRS)	-	0.35	-	-
12	STP at Kokkala, Thrissur Corporation (AMRUT-2.0)	Thrissur Corporation	2.5	DPR Stage	Expected by 31.12.2026
13	STP at Wadakkanchery Municipality, Thrissur (Impact Kerala Ltd) (PRS)	IKL	-	DPR Stage	-
14	Pazhayanoor STP (Thrissur)	-	0.45 KLD	Work Awarded	-
15	General Hospital, Irinjalakuda Municipality, Thrissur (PRS)	-	0.150	-	-
16	Augmentation of existing 3 MLD STP at Chakkamkandam to 5 MLD with Septage Cotreatment Capability, Guruvayur Municipality (AMRUT-2.0)	KWA	2	DPR Stage	Expected 31.12.2026

5.3. Common Effluent Treatment Plants

Common Effluent Treatment Plants (CETPs) are established to treat wastewater generated from clusters of industries, particularly small and medium-scale units that lack the financial and technical capacity to set up individual ETPs. By pooling resources, CETPs provide a cost-effective and technically viable solution for the management of industrial effluents, thereby reducing the pollution load discharged into rivers and other receiving water bodies. In the context of the Periyar River, CETPs play a critical role in ensuring that industrial clusters do not contribute untreated effluents that degrade water quality and affect ecological balance.

The effectiveness of a CETP depends on several factors including its design capacity, operational efficiency, and the type of treatment technologies employed. Modern CETPs commonly use a combination of physical, chemical, and biological treatment processes such as screening, coagulation-flocculation, MBBR systems, and tertiary treatment with pressure sand filters and activated carbon filters. Capacity, usually expressed in KLD or MLD, is determined by the effluent volume generated by the member industries and future projections of industrial growth. However, actual utilization often falls below the designed capacity due to irregular connections, inadequate conveyance infrastructure, or industries bypassing treatment systems. Alongside wastewater treatment, proper sludge management through thickening, drying, composting, or secured disposal is equally important to prevent secondary pollution. Thus, CETPs serve as a vital component in reducing cumulative industrial pollution loads and safeguarding river ecosystems.

5.3.1. CETP/ETP Facilities in Ernakulam District

There are three CETPs located within the Ernakulam district in the Periyar River Basin region. The CETP at KINFRA Small Industries Park, Nellad, Mazhuvanoor in Ernakulam has a treatment capacity of 0.4 MLD and caters to 15 member units. It is operational and most parameters are within permissible limits, although exceedances in total suspended solids and sulphides have been reported as per the analysis dated 18.12.2024, for which action has been initiated. The Rubber Park India Pvt. Ltd. CETP at Valayanchirangara, Ernakulam, with a capacity of 0.25 MLD, treats effluent from 17 industrial units along with dormitory and canteen wastewater. The latest analysis on 18.12.2024 indicates general compliance, except for a high sulphide concentration for which corrective measures are underway. The CETP at Cochin Special Economic Zone (CSEZ), Kakkanad, with a capacity of 1 MLD and 14 member units, is operational but has previously recorded exceedances in nitrates and phosphates. The most recent report dated 27.08.2024 shows sulphide levels above standards, and unusually high residual chlorine possibly requiring operational verification. The Board inspection on 14.02.2024 resulted in the implementation of tertiary units such as softener, degasser, Reverse Osmosis (RO), and Multiple Effect Evaporator (MEE) on a trial basis to improve compliance.

5.3.2. CETP/ETP Facilities in Idukki District

Within the Idukki district, a CETP with a capacity of 120 KLD is located at Muttom; however, it falls outside the Periyar River Basin. In contrast, an ETP is present at the Kumali Slaughter House, situated within Kumali Grama Panchayat. The ETP has a treatment capacity of 6 KLD (0.06 MLD), designed specifically to manage wastewater generated from slaughterhouse operations. However, as of the present status, the slaughterhouse is not functioning, leading to the ETP being underutilized and currently non-operational. The implementing agency for this project was Hindustan Pre-Fab Limited, with a total project cost of ₹20.65 lakhs, fully funded by the LSGD. While the unit is relatively small in scale, its operational status is significant in assessing localized pollution loads. Since it is currently inactive, it does not contribute to reducing the pollution load in the Periyar basin.

Regular monitoring and timely upgradation of treatment technology are essential for maintaining compliance and improving efficiency. The Table 12 shows the details of existing CETPs in Ernakulam district, including their location, treatment capacity, operational status, number of member units, and compliance status.

Table 12: Existing CETPs in Ernakulam District

CETP Name	Treatment Capacity	Operational Capacity	Status	Number of member units	Whether complying with parameters
Kinfra Small Industries Park Nellad, Mazhuvanoor (10° 0'40.99"N, 76°31'40.33"E)	0.4 MLD	0.4 MLD	Operational	15	pH- 7.09 COD-120 mg/L Oil and Grease-BDL Total Suspended Solids – 111.8 mg/l Fluorides < 1 mg/L Chlorides- 109.9 mg/L Phosphate – 1.02 mg/L Nitrate- 4.77 mg/L Sulphates – 34.79 mg/L Sulphides – 6.2 mg/l Ammoniacal Nitrogen – 12.19 mg/l Phenolic Compounds - BDL (report dated 18.12.2024) Action is taken against exceedance.
Rubber Park India Private Limited (New Plant), Common Effluent Treatment Plant, 2 A, Kaudileeyam, Rubber Park, Valayanchirangara, Ernakulam-683556(10° 3'9.34"N, 76°30'7.76"E)	0.25 MLD	0.25 MLD	Operational	17 Units Dormitory and Canteen	pH- 7.53, COD-16 mg/L, Oil and Grease-BDL, Total Suspended Solids – BDL, TDS – 1962 mg/l, Chlorides-24.9 mg/L, Sulphates – 64.68 mg/L, Sulphides – 38 mg/L, Fluorides < 1 mg/L, Ammoniacal Nitrogen – BDL, Phenolic Compounds - BDL, Phosphates – 0.62 mg/l, Nitrate – 9.9 mg/l Total Residual Chlorine – BDL (analysis report dated 18.12.2024) Action is taken against exceedance.
CSEZ, Kakkanad, Cochin Special Economic Zone Ernakulam (10° 1'4.54"N, 76°23'55.86"E	1 MLD		Operational	14	pH-7.1 TSS- BDL TDS – 378 mg/l Chloride – 29.7 mg/l Residual Chlorine – 216 mg/l phosphate-0.2 mg/l sulphide- 10.88 mg/L ammoniacal nitrogen – 0.4 mg/L BOD- 2.2 mg/l COD-20 mg/l Sulphate – 15.4 mg/l Oil & grease – BDL Phenolic compounds – 0.001 mg/l Copper- BDL cadmium - BDL (analysis report dated 27.08.2024) Meanwhile CSEZ operated tertiary units (Softner, degaser, RO, MEE etc.) as trial run.

5.4.Dumping sites

A primitive method of disposing MSW is open dumping, which is still widely practiced in many developing nations. Such dumpsites pollute the environment through open burning, contamination of surface and groundwater by leachate, and the spread of disease-causing organisms, as they are the outcome of uncontrolled physical, chemical, and biological processes (Oketola & Akpotu, 2014). Since urbanization, industrialization, and economic growth have increased the per capita generation of MSW, Solid Waste Management (SWM) has become a major challenge for many ULBs in India, particularly in densely populated cities (Kumar et al., 2017). The unscientific handling and disposal of MSW have led to the proliferation of open dumpsites, which degrade the urban environment and pose serious health hazards to nearby communities (Joshi & Ahmed, 2016). Excessive and unregulated waste disposal creates geotechnical concerns such as slope instability, which can result in slope failure and even landfill collapse (Koelsch et al., 2005). Furthermore, as MSW volumes continue to rise, the demand for land for waste dumping is expected to grow, with no indication of decline in the near future (Kumar et al., 2017). In the context of the Periyar River basin, unregulated dumping near catchments and riverbanks can increase the pollution load, as leachate and waste particles are carried downstream during rainfall events. Thus, identifying and remediating dumping sites is a key step in reducing river pollution and safeguarding water quality.

5.4.1. Status of Dumping Sites in Kerala

According to the KSWMP and the KSPCB, a total of 59 dumping sites have been identified across the state, which includes 44 previously reported sites and 15 newly identified sites. These sites are spread across municipalities and gram panchayats, reflecting the widespread dependence on open dumping as a mode of waste disposal. Many of these sites are now undergoing biomining and remediation as part of the state's solid waste management strategy. However, the scale of accumulated waste and the varying stages of remediation highlight the continuing pressure on Kerala's river basins, including the Periyar, where dumping sites located in Ernakulam district can contribute significantly to pollution loads.

Dumpsites in Ernakulam District

Ernakulam district has five identified dumpsites located within the ULBs of Koothattukulam, Kothamangalam, Muvattupuzha, North Paravoor, and Kalamassery. The largest dumpsite is Kurianmala at Muvattupuzha, covering 3.5 acres and containing an estimated 44,589 MT of legacy waste, followed by the Kalamassery dumpsite, which spans 1.02 acres with approximately 44,742 MT of waste. The Kumbalathumuri dumpsite at Kothamangalam, with an area of 2.13 acres, holds about 23,932 MT of waste. In North Paravoor, the Vedimara dumpsite extends over 1.25 acres and contains around 18,666 MT of waste, while the Koothattukulam dumpsite, covering 0.29 acres, accounts for approximately 1,683 MT. The contracted quantities correspond to the total volume of waste proposed for scientific bioremediation at each location.

Dumpsites in Thrissur District

In Thrissur district, three dumpsites have been identified within the ULBs of Chalakkudy, Kunnamkulam, and Wadakanchery, all of which are proposed for funding under the KSWMP. Among these, the Kunnamkulam site is the largest, covering 2.014 acres, followed by the Kumbalangad dumpsite at Wadakanchery, which spans 1.3555 acres. The Chalakkudy dumpsite is comparatively smaller, with an area of 0.4072 acres.

Dumpsites in Idukki District

Within the Idukki district, three major dumping sites have been identified—Parakadavu in Thodupuzha, Puliyanmala in Kattappana, and Kallar Nallathanni in Munnar. Of these, the Parakadavu site in Thodupuzha lies outside the Periyar River basin and therefore does not directly affect its pollution load. However, the Puliyanmala dumping site in Kattappana Municipality, covering around 1 acre of land and receiving nearly 20 TPD waste, remains a long-standing challenge. This site has been operational for years and represents a critical point source of leachate that can infiltrate groundwater. In addition, a newly identified dumpsite at Kallar Nallathanni in Munnar Grama Panchayat has emerged, highlighting the persistence of waste accumulation in hilly regions. Munnar, being part of the upper catchments of the Periyar basin, makes this site particularly sensitive as leachate and surface runoff can enter tributaries feeding into the river.

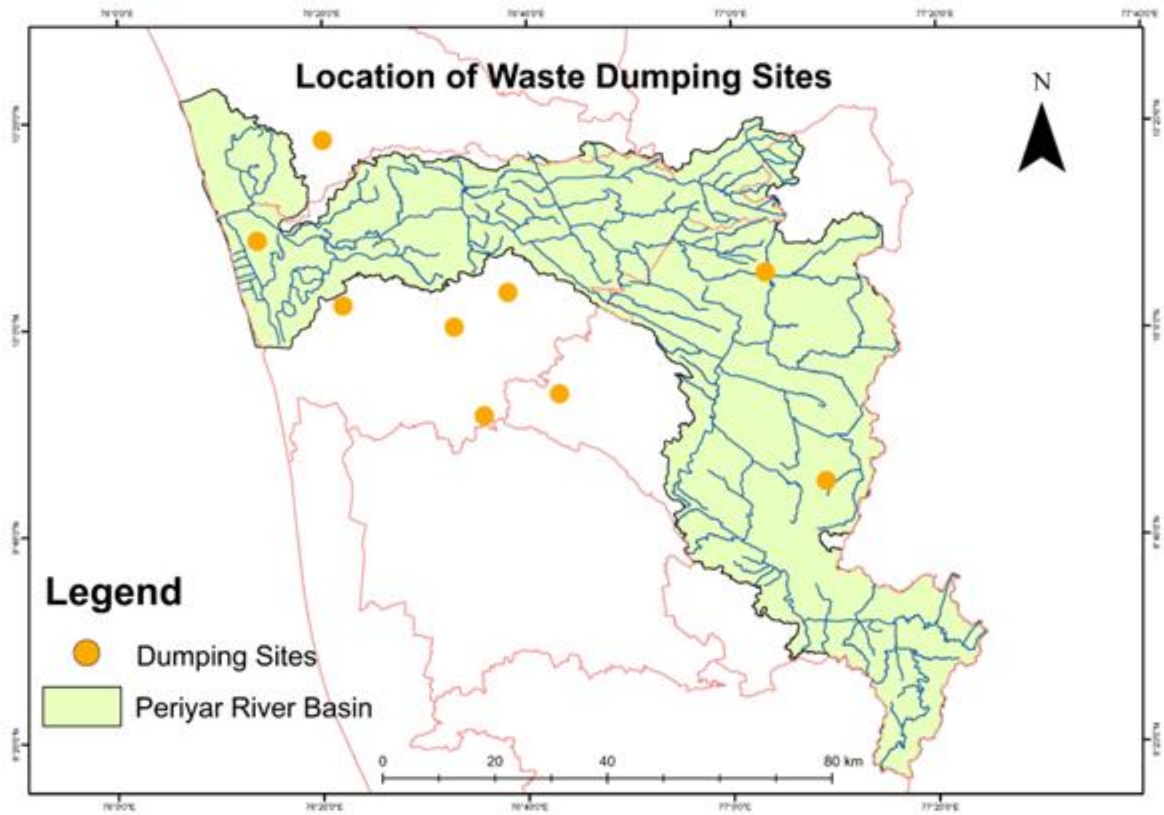

Fig. 41 Location of Waste Dumping Sites in the Periyar River Basin

5.4.2. Assessment of Pollution Levels at Dumpsites

An assessment of existing pollution levels was conducted at legacy dumpsites in Ernakulam and Thrissur districts. The evaluation involved testing of waste, leachate, soil, groundwater, surface water, air, noise, and odour samples from the identified sites. The results revealed exceedances in several critical environmental parameters. Groundwater and surface water samples from adjoining areas frequently exhibited turbidity, colour, high COD levels, and coliform contamination, pointing to leachate migration and deterioration of water quality. While soil samples at many sites were found to be within guideline limits, air and noise monitoring indicated occasional violations, with elevated PM_{10} levels and noise levels exceeding prescribed standards in certain locations. Odour nuisance was also observed in some cases, particularly near composting units. These findings confirm that dumpsites pose a significant pollution load on surrounding environmental receptors, underlining the urgent need for remediation and continuous monitoring. The Koothattukulam dumpsite in Ernakulam District was operational from 1981 to 2019, with no reported fire incidents. Waste characterization indicates low calorific value (124 kcal/kg) and predominantly inert composition (84.49%), with heavy metals within permissible limits as per the Solid Waste Management Rules, 2016. However, leachate analysis revealed elevated BOD (110 mg/L) exceeding the prescribed limit of 30 mg/L, indicating ongoing organic decomposition. Soil quality parameters were within applicable guideline limits (NY State Industrial Use standards, MoEFCC 2015, and Dutch standards). One groundwater sample showed elevated colour, turbidity, COD, and coliform levels, while surface water samples exhibited exceedances in BOD, COD, E. coli, and coliform, indicating contamination requiring treatment prior to potable use. Air quality, noise levels, and odour observations were within permissible limits.

The Kothamangalam dumpsite in Ernakulam District was operational from 1980 to 2018 and experienced fire incidents in 2019 and 2022. Waste characterization shows low calorific value (56 kcal/kg) with significant bio-earth content (36.60%) and inerts (48.19%), while heavy metals were within permissible limits as per the Solid Waste Management Rules, 2016. Leachate analysis indicated elevated BOD (110 mg/L) exceeding the allowable limit of 30 mg/L, suggesting ongoing organic decomposition. Soil parameters were within guideline limits as per NY State Industrial Use standards, MoEFCC (2015), and Dutch standards. Groundwater samples showed exceedances in coliform and COD, while surface water exhibited elevated turbidity, electrical conductivity, BOD, and COD, classifying it under Class III and indicating the need for treatment before potable use. Air quality was within limits; however, day and night equivalent noise levels (Leq) exceeded prescribed residential standards, while odour observations were reported as nil.

The Muvattupuzha dumpsite in Ernakulam District was operational from 1960 to 2022 and experienced fire incidents in 2020 and 2023. Waste characterization indicates a density of 0.897 g/cm^3 and calorific value of 187 kcal/kg, with heavy metals within permissible limits. The waste composition comprises 40.60% bio-earth, 49.80% inerts, 8.81% RDF, and 0.80% recyclables. Leachate BOD was found to be within allowable limits. Soil parameters were largely within guideline limits as per NY State Industrial Use standards; however, zinc (Zn) slightly exceeded Dutch standard limits (944 mg/kg against 720 mg/kg) in one representative sample, possibly due to natural rock sources or anthropogenic inputs. Groundwater samples showed exceedances in pH, colour, coliform, and E. coli, while surface water exhibited elevated colour, iron, coliform, E. coli, BOD, and COD, indicating Class III water quality requiring treatment before potable use. PM_{10}

concentrations were elevated, likely due to ongoing waste management activities, and night-time noise levels (Leq) marginally exceeded residential limits, while odour observations were nil.

The North Paravoor dumpsite in Ernakulam District was operational from 1997 to 2023 and experienced a fire incident in 2019. Waste characterization shows a density of 0.805 g/cm^3 and calorific value of 181 kcal/kg, with heavy metals within permissible limits. The waste composition comprises 21.40% bio-earth, 67.56% inerts, 10.91% RDF, and 0.05% recyclables. Leachate analysis indicated extremely high BOD (43,000 mg/L); however, the samples were collected as raw (untreated) leachate and therefore cannot be directly compared with Schedule II discharge standards under the Solid Waste Management Rules, 2016. Soil quality parameters were within applicable guideline limits (NY State Industrial Use standards, MoEFCC 2015, and Dutch standards). Groundwater samples showed exceedances in electrical conductivity, TDS, and COD, while surface water exhibited elevated turbidity, electrical conductivity, TDS, chloride, BOD, and COD, indicating contamination. PM_{10} levels were elevated, and both day and night noise levels (Leq) exceeded residential standards, while odour observations were nil.

The Kalamassery dumpsite in Ernakulam District was operational from 1990 to 2021 and experienced a fire incident in 2019. Waste characterization shows a density of 0.804 g/cm^3 and calorific value of 340 kcal/kg, with heavy metals within permissible limits. The waste composition comprises 30.70% bio-earth, 67.56% inerts, 7.90% RDF, and 0.27% recyclables. Leachate analysis revealed significantly elevated BOD (20,000 mg/L); however, as the samples were collected as raw (untreated) leachate, they are not directly comparable with Schedule II discharge standards under the Solid Waste Management Rules, 2016. Soil parameters were largely within guideline limits, though zinc (Zn) slightly exceeded Dutch standard limits in one representative sample, possibly due to natural or anthropogenic sources. Groundwater samples showed exceedances in pH, COD, and coliform, while surface water exhibited slightly acidic pH and elevated colour, iron, BOD, COD, E. coli, and coliform levels, indicating contamination. Air quality, noise levels, and odour observations were reported to be within permissible limits.

The Chalakkudy dumpsite in Thrissur district was operational from 2005 to 2019, with no recorded fire incidents. Waste characterization indicates a density of 1.131 g/cm^3 and calorific value of 85 kcal/kg, with heavy metals within permissible limits. No leachate was observed during site inspection. Soil quality parameters were within applicable guideline limits. Groundwater samples showed slightly acidic pH (5), along with presence of coliform bacteria. Surface water analysis indicated low pH, elevated colour, and coliform levels exceeding IS 2296 (Class A) limits, necessitating treatment prior to potable use. Ambient air quality and noise levels were within permissible limits, and no odour issues were reported.

The Kunnamkulam dumpsite in Thrissur district was operational from 1946 to 2016 and was closed following public protest, with no recorded fire incidents. Waste samples showed a density of 1.155 g/cm^3 and calorific value of 110 kcal/kg, with heavy metals within limits. No leachate was observed during inspection. Soil parameters complied with applicable standards. Groundwater samples showed slightly acidic pH, elevated turbidity, colour, iron, and presence of coliform bacteria. No surface water samples were collected due to inaccessibility of the nearby quarry pond. Ambient air monitoring indicated PM_{10} levels exceeding CPCB standards, and methane concentration of 870 ppm was detected within the site. Noise levels were within limits during daytime but frequently exceeded residential standards at night. Objectionable odour was reported from the windrow composting unit.

The Wadakkanchery dumpsite in Thrissur district operated from 2007 to 2018, with no recorded fire incidents. Waste characterization indicates a density of 0.95 g/cm^3 and a high calorific value of 915 kcal/kg, with heavy metals within permissible limits. No leachate was observed during site visit. Soil parameters were within applicable standards. Groundwater samples showed slightly acidic pH, elevated turbidity and colour, and presence of coliform bacteria. No significant surface water bodies were present near the site. Ambient air quality parameters (PM10, PM2.5, SOx, NOx, CO, and H_2S) were within limits; however, methane concentration of 740 ppm was detected within the dumpsite, posing potential fire risk during summer. Noise levels were within permissible limits, and no significant odour issues were reported (KSWMP, 2023).

5.4.3. Legacy Waste

Legacy waste refers to solid waste that has been deposited in dump sites over many years without proper treatment or scientific management. Such waste accumulates organic matter, plastics, metals, and other durable materials that persist in the environment, and over time produce leachate, release methane and other greenhouse gases, and degrade soil quality. In Kerala, where urban expansion and high population density intensify waste generation, these unmanaged dumpsites pose serious environmental risks—including contamination of water bodies, soil pollution, and public health hazards. For example, studies in Kerala's urban districts such as Ernakulam show that open dumping at places like the Brahmapuram landfill affects water quality and contributes to air pollution through frequent fires and leachate outflows. Thus, legacy waste management in these districts is an essential component for reducing the long-term pollution load of the Periyar River (Downtoearth,2025).

Legacy Waste Management

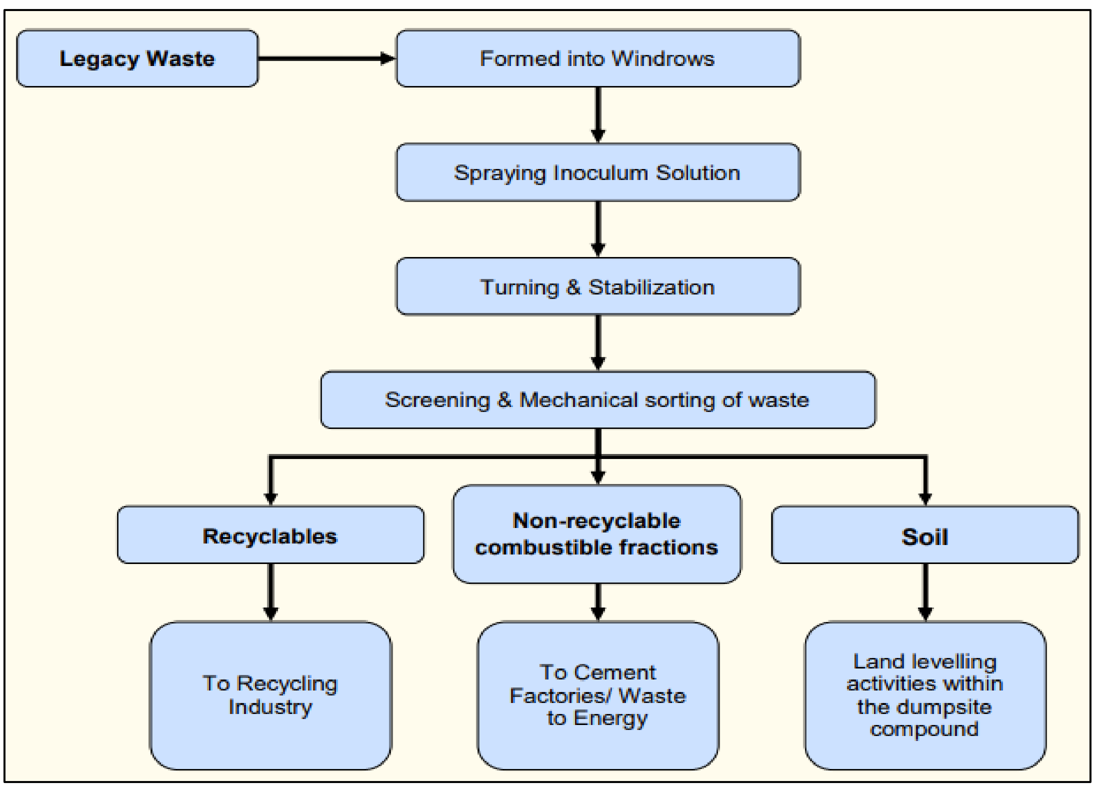

Fig. 42 Dumpsite Remediation Process Flow (Source: Technical Manual for Solid Waste Management, 2024)

Legacy waste management in Kerala is being carried out primarily through biomining, a scientific process that utilizes microorganisms and natural methods to excavate, treat, segregate, and recover valuable materials from old and unmanaged waste dumps. Over the years, legacy dumpsites accumulate diverse waste streams, including plastics, metals, glass, tires, footwear, textiles, wood, and large volumes of compacted organic matter. Through biomining, this waste is excavated and segregated into usable fractions such as refuse-derived fuel (RDF), recyclables, and soil-like material. The soil fraction generated from biomining is often used to fill low-lying areas, ensuring its reuse and reducing the need for new dumping grounds. Fig. 42 gives a process flow of dumpsite remediation. Across Kerala, 59 dumpsites have been identified, including the previously reported 44 and 15 newly added sites. As per the latest data, remediation has been completed at 24 dumpsites, while work is currently ongoing at 10 sites, and 25 more sites are awaiting commencement of remediation. This stepwise remediation effort reflects the state’s strategy to systematically reduce the legacy waste burden.

In total, Kerala has previously reported 44 dumpsites, with an estimated 17,61,871.98 tonnes of legacy waste accumulated over the years. Out of these previously reported 44 dumpsites, biomining has been successfully completed at 19 sites, while 10 sites remain under active remediation and 15 sites are yet to begin the biomining process. As of May 2025, approximately 8,07,160.15 T of waste has been remediated or biomined, according to the KSPCB. This progressive achievement demonstrates the effectiveness of biomining as a remediation strategy, though the large volume of untreated dumpsites highlights the scale of the challenge that remains. Such quantified assessments provide a clear measure of how much potential pollutant load has been reduced and how much still remains in unmanaged conditions.

Legacy Waste Management in Ernakulam District

Legacy waste has been identified in a few municipalities and blocks within the Periyar River Basin in Ernakulam District, as reported by LSGIs. Kochi Corporation has the largest site, covering 39 acres with an estimated 8,43,000 (MT), and remediation work is currently ongoing. Other notable sites include Kalamassery Municipality, where 2.7 acres of legacy waste amounting to 35,000 MT have been remediated, and North Paravur Municipality, with 0.5 acres and 18,666 MT of waste. Several other municipalities and blocks, including Perumbavoor, Eloor, Aluva, Angamaly, Kothamangalam, Parakkadavu, Koovappady, Paravoor, Vypin, Alangad, Vazhakulam, Edappally, Pattanakkad have not reported legacy waste data.

Legacy Waste Management in Thrissur District

Legacy waste has been identified in a few municipalities and blocks within the Periyar River Basin in Thrissur District, as reported by LSGIs. In the blocks, Chalakudy has 0.26 acres of legacy waste totaling 6,769 MT, with 72% of the remediation work completed. For all other Grama Panchayats listed including Aloor, Annamanada, Athirappilly, Edathiruthy, Edavilangu, Eriyad, Kaipamangalam, Karalam, Kattoor, Kuzhur, Mala, Mathilakam, Padiyoor, Perinjanam, Poomangalam, Poyya, Puthenchira, Sreenarayanapuram, Valapad, Vellangallur, and Velukkara and muncipalities including Kodungallur and Irinjalakuda no legacy waste data has been reported.

Legacy Waste Management in Idukki District

Within the Idukki district, three dumpsites have been identified as part of the legacy waste mapping exercise—Parakadavu in Thodupuzha, Puliyanmala in Kattappana, and Kallar Nallathanni in Munnar. Among these, the Parakadavu site in Thodupuzha is located outside the Periyar River basin. In terms of remediation within the basin, the Puliyanmala dumpsite in Kattappana is scheduled for biomining, with an estimated waste quantity of 12,000 MT spread across an area of 0.89 acres. Additionally, a newly identified site at Kallar Nallathanni in Munnar has been mapped with a waste accumulation of 18,163 MT over 1.50 acres of land. These highland sites, though smaller, require urgent remediation due to the sensitive ecological conditions of Idukki and the potential for leachate and surface run-off to affect streams feeding into the Periyar basin. The remediation of such sites will play a crucial role in ensuring that pollution load from legacy waste in highland regions does not add to the cumulative stress on the Periyar River ecosystem.

5.5. Successful Solid Waste Management Models

Successful solid waste management (SWM) models refer to integrated systems that ensure efficient collection, segregation, treatment, and disposal of municipal solid waste while minimizing environmental impacts and maximizing resource recovery. Such models play a crucial role in reducing pollution load on rivers, land, and ecosystems by preventing the uncontrolled release of organic and inorganic waste into the environment. In the Periyar River basin, the adoption of proven SWM approaches is essential for improving river health and ensuring compliance with the Solid Waste Management Rules, 2016. In Kerala, LSGIs have emerged as role models by implementing innovative and community-driven waste management practices, including organized waste collection systems, green protocol enforcement, compost production, reuse and recycling initiatives, and zero-waste campaigns. These efforts demonstrate practical and replicable pathways that can be adapted and scaled within the Periyar River basin to strengthen waste management systems and reduce overall pollution load.

5.5.1. Thumboormuzhi Aerobic Composting Model

A key sign of successful solid waste management in Kerala is the widespread use of the Thumboormuzhy Aerobic Composting Model. It is the most popular community composting method in the state, making up over 37% of all such facilities. This model is sustainable, odor-free, and requires very little maintenance, making it ideal for treating biodegradable waste, which accounts for nearly 70% of municipal solid waste. First developed at the Thumboormuzhy campus of the Kerala Veterinary University in Thrissur, it is now widely adopted by municipalities, gram panchayats, institutions, and residential communities, showing a strong move toward decentralized waste management. Kerala currently has 1,430 Thumboormuzhy community composting units with a combined daily handling capacity of over 2,50,988 kg. This widespread network helps reduce pressure on centralized waste systems and improves waste processing at the local level (KILA, 2021; Thanal, "Standard Operating Procedure of Community Aerobic Composting Bins - Thumburmoozhi Model," 2017).

Each aerobic bin, constructed from ferro-cement (4 ft × 4 ft × 4 ft), facilitates aerobic decomposition through proper air circulation, drainage, and layered addition of biodegradable waste and dry leaves. The process converts organic waste into nutrient-rich compost suitable for soil conditioning in agriculture and gardening. The aerobic environment prevents methane formation and minimizes foul odors, while the heat generated during composting destroys pathogens and unwanted seeds. Leachate produced in the process is collected, diluted (1:20), and used as organic fertilizer.

The risks to the environment and human health that come with open dumping and landfill disposal are eliminated by this technique. Participation from the community, appropriate waste segregation at the source, and routine maintenance are essential to its success. The Thumboormuzhi approach, which greatly lessens the load on landfills and encourages a circular economy through compost reuse, has established itself as a standard for decentralized waste management systems in Kerala (Suchitwa Mission; Thanal, "Standard Operating Procedure of Community Aerobic Composting Bins - Thumburmoozhi Model," 2017).

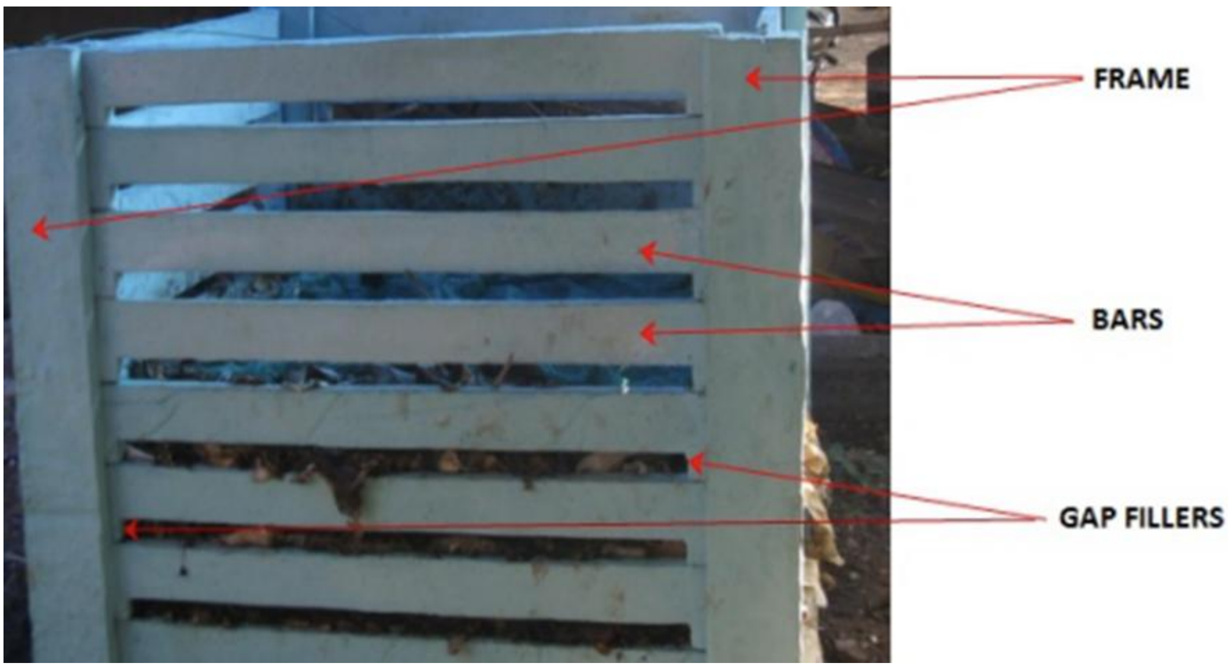

Fig. 43 Structure of an Aerobic Bin (Source: Thanal, "Standard Operating Procedure of Community Aerobic Composting Bins – Thumburmoozhi Model," 2017)

Details of Thumboormuzhi Units Installed in Test-Checked ULBs

Thumboormuzhi aerobic compost units have been established in several ULBs in Kerala as part of decentralized solid waste management programs (Table 13). Eloor Municipality established six units at six places in the test-checked ULBs, all of which are in good operating order. On the other hand, Angamaly Municipality installed three units at three different places; but, after their installation, litigation concerns have rendered all of them non-operational. This emphasizes how crucial it is to maintain community and administrative cooperation for decentralized composting systems to run sustainably (Report of the Comptroller and Auditor General of India on Waste

Management in Urban Local Bodies, Government of Kerala, 2022).

Table 13: Details of Thumboormuzhi units installed in test-checked ULBs (Source: Report of the Comptroller and auditor general of India on waste management in urban local bodies, Govt. of Kerala, 2022)

Sl. No.	Name of ULB	No. of units installed	Number of locations	Number of units damaged	% of units in working condition	Reason for damage
1	Eloor Municipality	6	6	0	100	-
2	Angamaly Municipality	3	3	3	0	Not functioning since its installation, due to litigation

5.5.2. Swachhata Hi Seva Campaign, Kodungallur Municipality, Thrissur District

The *Swachhata Hi Seva 2024* campaign in Kodungallur Municipality proved to be a remarkable success, showcasing how collective community action can drive sustainable change. With active participation from schools, governmental organizations, NGOs, and residents, the municipality organized a wide range of impactful activities including cleanliness drives in all 44 wards, mass cleaning of public spaces such as KSRTC, private bus stands and parks, plogging and plantation drives, water body cleaning, Swachhata rallies, and awareness sessions for various stakeholder groups. Initiatives like the Swachh Pledge, Safai Suraksha Shivir, and targeted awareness programs for street vendors further emphasized the holistic approach of the campaign. This model demonstrates a successful case of decentralized SWM and civic engagement, where planning, awareness, and execution were carried out in synergy with the community. By integrating education, participation, and sustainable practices, Kodungallur Municipality has set a strong example of a replicable model for other regions in the basin. The outcomes highlight that fostering civic responsibility, ensuring multi-stakeholder collaboration, and combining awareness with action are key strategies for building cleaner, healthier, and more resilient communities (Suchitwa mission, Thrissur).

5.5.3. Green Check Post - Vagamon, Idukki

Checkposts were set up at tourist entry points to collect single-use plastics from vehicles, preventing littering in scenic areas. Fig. 44 shows a green check post installed at Vagamon, Idukki district.

Fig. 44 Green check post at Vagamon, Idukki District (Source - KILA, 2021)

5.5.4. Upcycling Challenge - Ernakulam District

An “Upcycling Challenge” was conducted in collaboration with schools, colleges, and Kudumbashree NHGs to promote creative reuse of materials typically discarded as waste. Few entries from the challenge are shown in Fig. 45.

Fig. 45 Entries from the “Upcycling Challenge” held in Ernakulam District (Source - KILA, 2021)

5.5.5. Collectors @ School” Campaign - Ernakulam

This campaign aims to promote waste segregation and build awareness among students. Children often become effective messengers to bring positive behavioral changes in their households.

Fig. 46 Bins placed in school as part of “Collectors@School” Campaign to collect segregated waste, Ernakulam district (Source - KILA, 2021)

5.6.Waste to energy/compost

5.6.1. Waste-to-energy/compost facility in Ernakulam District

Among the municipalities, Kochi has two centralized composting facilities but no community-level biomethanation plants, while Aluva, Eloor, and Kalamassery do not have centralized composting facilities, and North Paravur has two. Perumbavur is equipped with both one centralized composting facility and one community-level biomethanation plant. Several grama panchayats, including Alengadu, Chengamanad, Kadungalloor, Mulavukadu, Pallippuram, and Vengoor, have community-level biomethanation plants, while most other panchayats do not have reported facilities. This distribution highlights the need for expanding decentralized waste management solutions, including composting and biomethanation, to improve organic waste treatment within the basin.

5.6.2. Waste to energy/compost facility in Thrissur District

All two municipalities, Irinjalakkuda, and Kodungallur, have one centralized composting facility each, while none of them have community-level biomethanation plants. In the case of grama panchayats, Kattoor Grama Panchayat is the only grama panchayat that has a community-level biomethanation plant (one unit). None of the grama panchayats, including Aloor, Annamanada, Athirappilly, Edavilangu, Eriyad, Kaipamangalam, Karalam, Kuzhur, Mala, Mathilakam, Padiyoor, Perinjanam, Poomangalam, Poyya, Puthenchira, Sreenarayanapuram, Valapad Vellangallur, and Velukkara, have reported composting or biomethanation facilities. This highlights the limited availability of waste-to-energy and compost infrastructure within the basin and underscores the need for expanding decentralized organic waste treatment solutions across municipalities and panchayats.

5.6.3. Waste to energy/compost facility in Idukki District

In Idukki district, there are currently no waste-to-energy plants operating. Rather than viewing this as a limitation, it reflects the district's strategic alignment with its ecological and topographical characteristics. The high moisture content, fragmented waste streams, and lower volumes compared to large cities make large-scale incineration or energy recovery systems less viable. Indeed, in Kerala's context, critics caution that capital- and energy-intensive waste-to-energy

(WTE) technologies can be counterproductive when waste has low calorific value and high moisture content, as is common in Kerala (India Mongabay,2025). Hence, Idukki has opted to rely on waste to compost approaches, which are more suitable for decentralized, wet waste-rich conditions, and better aligned with community-level operations and lower infrastructural intensity.

Composting Methods in Idukki

Three primary composting methods are in operation in Idukki: Thumburmuzhi bins, windrow composting, and vermicomposting. The Fig. 47 shows the Quantity of Waste Treated by Various Composting Methods in Idukki district.

Waste Treated by Thumburmuzhi Composting Units in Idukki

The Thumburmuzhi composting method is adopted in several local bodies across Idukki. Kattappana processes around 2,000 kg per day of waste, Santhanpara handles about 1,400 kg per day, Upputhara approximately 250 kg per day, and Erattayar about 500 kg per day. Analysis of this data shows that Kattappana, being a larger and more urbanized local body, treats significantly higher volumes of organic waste. Santhanpara follows with a moderate scale of operation, while Upputhara and Erattayar manage relatively smaller amounts. Despite their varying capacities, all four locations effectively divert biodegradable waste away from open dumping or direct discharge into drains, thereby reducing organic pollution loads that would otherwise contribute to eutrophication and water quality deterioration in the Periyar basin.

Waste Treated by Windrow Composting Units in Idukki

Windrow composting is also widely used in Idukki, particularly in areas with available land resources. Data indicates that Vandanmedu treats about 400 kg per day of waste, Kumily about 1,000 kg per day, Munnar about 2,000 kg per day, and Erattayar about 250 kg per day using this method. The scale of windrow operations in Munnar is notable, likely due to its high tourist influx and associated waste generation. Kumily, another tourism-linked town, also treats a substantial amount, reflecting the method's adaptability to semi-urban and high-inflow conditions. Vandanmedu and Erattayar, by contrast, operate smaller facilities, showing that windrow composting can also function at modest scales. Collectively, these operations highlight windrow composting's role in handling seasonal and high-volume biodegradable waste streams, preventing their uncontrolled entry into natural drainage channels feeding the Periyar.

Waste Treated by Vermicomposting Units in Idukki

Vermicomposting in Idukki is practiced primarily in Kumily, where about 5,000 kg per day of waste are processed. This scale of vermicomposting demonstrates not only the feasibility of handling significant organic loads but also the potential for generating revenue through the sale of high-quality vermicast. The success of this model in Kumily could encourage replication in other panchayats of the Periyar basin, particularly where there is agricultural demand for organic manure. Importantly, this model demonstrates how waste management can evolve from a pollution control exercise into a value-added, circular economy practice. Fig. 47 shows the merits of different composting methods adopted in different local bodies of Idukki district.

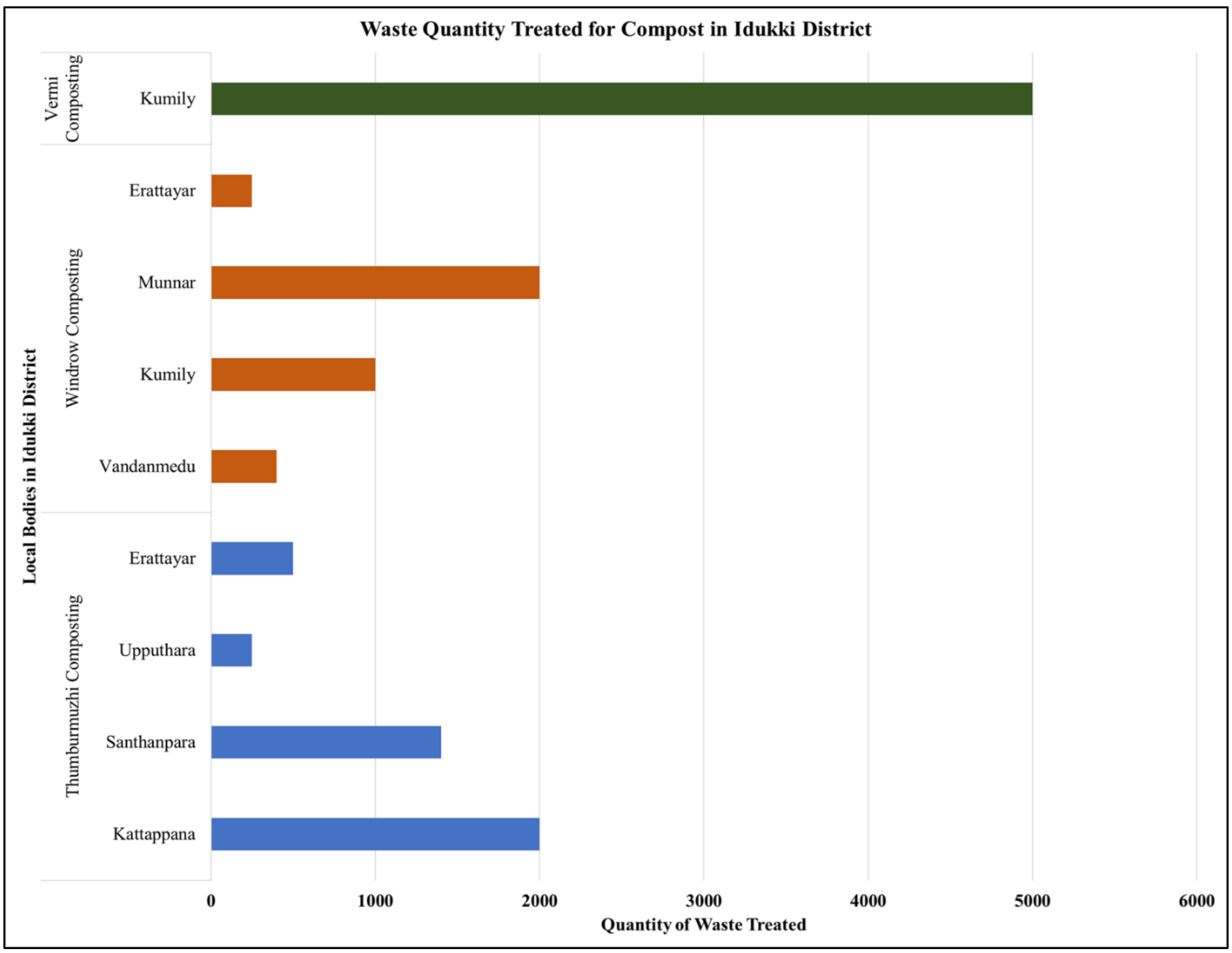

Fig. 47 Quantity of Waste Treated by Various Composting Methods

6. Stakeholders & Roles

Effective pollution load assessment and management in the Periyar River basin requires coordinated action among multiple government agencies and institutions, each playing a defined role in data generation, regulation, infrastructure development, monitoring, and implementation. The key stakeholders involved in this study and their respective roles are outlined below.

Kerala State Pollution Control Board (KSPCB)

KSPCB is the primary regulatory authority responsible for monitoring water quality, controlling pollution, and enforcing environmental standards under the Water (Prevention and Control of Pollution) Act, 1974. In the context of the pollution load report, KSPCB provides critical data on effluent quality, industrial wastewater generation, compliance status of STPs and CETPs, and drains. The Board also issues consent, conducts inspections, and initiates regulatory actions against non-compliant units, directly influencing pollution load reduction.

PCB Regional Office and PCB District Offices

The regional and district offices of KSPCB act as the field-level implementation arms, responsible for routine sampling, inspections, and localized monitoring of industries, STPs, and dumping sites. These offices support the pollution load assessment by supplying district-wise data, facilitating site-specific information, and operational status of treatment facilities within the river basin.

Kerala Water Authority (KWA)

KWA plays a central role in domestic wastewater management through planning, construction, and operation of sewerage networks, pumping stations, and sewage treatment plants. For the pollution load report, KWA is a key source of information on sewerage coverage, household connections, STP capacity and utilization, and proposed infrastructure projects. The effectiveness of KWA-managed systems directly influences the volume of untreated or partially treated sewage entering the Periyar River.

District Industries Centre (DIC) and Directorate of Industries and Commerce

These agencies support industrial data generation by maintaining inventories of industrial units, their categories, scale, and operational details. Their role in the pollution load report is to complement KSPCB data by providing baseline information on industrial clusters and sectoral distribution within the Periyar basin.

Local Self-Government Department (LSGD)

LSGD is responsible for decentralized service delivery at the local body level, including sanitation, solid waste management, and small-scale wastewater treatment. In the pollution load context, LSGD facilitates data on local body–wise waste generation, collection efficiency, treatment facilities, dumping sites, and legacy waste. The department also coordinates implementation of national and state schemes that aim to reduce land-based pollution loads to rivers.

Suchitwa Mission

Suchitwa Mission is the Technical Support Group in the Waste Management sector under the LSGD, Kerala. It provides technical and managerial support to LSGs in sanitation and solid and liquid waste management. The mission aims for a waste-free Kerala with improved public hygiene, better quality of life, and overall environmental upgradation. Its key functions include assisting LSGIs in achieving Total Sanitation coverage, providing policy, planning, and monitoring support, organizing awareness campaigns and capacity-building activities, and promoting Green Protocol compliance. It also serves as the nodal agency for implementing the Swachh Bharat Mission (Urban and Rural) and the Communication and Capacity Development Unit in Kerala (Suchitwa Mission, 2025; LSGD Kerala, 2025).

Haritha Keralam Mission

Haritha Keralam Mission, launched in 2016 as part of the Government’s “New Kerala” initiative, aims to promote environmental sustainability by integrating hygienic waste management, water conservation, and sustainable agricultural development. With a strong focus on cleanliness, water security, soil and water conservation, and safe food production, especially through organic farming, the mission encourages eco-friendly waste management and active public participation. It is implemented through Local Self-Government institutions with the involvement of community groups, NGOs, students, and the general public to move towards a clean, green, and zero-waste Kerala (Haritha Keralam Mission, 2025; Comptroller and Auditor General of India, 2022).

Kerala Solid Waste Management Project (KSWMP)

The KSWMP is a joint initiative of the Government of Kerala and ULBs to strengthen solid waste management in urban areas. It aims to make Kerala's cities cleaner, healthier, and more sustainable by improving institutional and service delivery systems. Key interventions include promoting decentralized treatment of biodegradable waste, upgrading community-level and regional treatment facilities, improving collection and recycling infrastructure, and managing Biomedical and Construction & Demolition wastes. The project is funded by the State Government with additional support from the World Bank (KSWMP, 2025; SEA for KSWMP, 2020).

Clean Kerala Company Limited

Clean Kerala Company Limited, functioning under the LSGD, plays a key role in maintaining the State's hygiene through scientific and efficient waste management practices. It focuses particularly on the safe handling of harmful waste such as plastic and e-waste, and supports ULBs by establishing MCFs and RRFs. The company enables effective waste processing and recycling by providing and maintaining essential equipment such as shredders and bailers, while encouraging participation from both public and private sectors (Clean Kerala Company, 2025; Comptroller and Auditor General of India, 2022).

In addition to institutional and regulatory agencies, the project recognizes waste generators and community-based organizations as key stakeholders, as their compliance and participation directly influence project outcomes.

Households

Households are primary generators of municipal solid waste and domestic wastewater in the project area. Their role in the project includes source segregation of waste, adoption of on-site treatment practices where promoted, payment of user charges, and compliance with solid and liquid waste management protocols implemented by LSGIs.

Commercial Establishments and Institutions

Commercial units (shops, markets, offices, hotels, hospitals, educational institutions) generate significant quantities of solid waste and wastewater. Within the project, their role includes segregation at source, on-site treatment of biodegradable waste where mandated, safe handling of recyclable and hazardous waste, provision of relevant data for waste load assessment, and compliance with standards and directions issued by LSGIs and KSPCB.

Industrial Units

Industrial units within the project area are key stakeholders as regulated waste and wastewater generators. Their role is limited to operating ETPs or CETPs, maintaining compliance with discharge norms, furnishing data on effluent quantity and quality for project assessments, and adhering to consent conditions issued by KSPCB. They are not implementation agencies but regulated entities under the project framework.

Non-Governmental Organizations (NGOs) and Community-Based Organizations

NGOs, resident welfare associations, and community-based organizations act as supporting stakeholders in the project. Their role includes awareness generation, behavioural change communication, community mobilisation, facilitation of citizen participation, and support to LSGIs and missions in implementing project interventions at the local level.

The combined and coordinated roles of regulatory bodies, infrastructure agencies, local governments, and technical missions form the backbone of pollution load assessment and management in the Periyar River basin, highlighting that effective river health improvement depends on multi-agency collaboration rather than isolated interventions.

7. Data Gaps & Uncertainties

Assessment of pollution load in the Periyar River Basin is constrained by data availability, consistency, and spatial–temporal coverage. While multiple datasets were collected from line departments and secondary sources, certain critical gaps and uncertainties remain, which influence the precision of pollution load estimation and the interpretation of results.

Data gaps and uncertainty remain in the assessment of domestic wastewater load within the Periyar River Basin. Although district-wise domestic wastewater load data for 2024 were obtained from the KSPCB, local body level wastewater generation data for Idukki District were not received despite follow-up with the LSGD and Suchitwa Mission. In addition, discharge location details from KSPCB are still pending.

Significant data gaps persist in assessing the status of sewerage networks and household connectivity. In Ernakulam District, division-wise data on domestic, non-domestic, industrial, and total sewerage connections were obtained from the KSPCB and the KWA. However, data on the population served by these connections, LSGI-wise sewerage coverage, the extent of unsewered households or areas, and details of existing or proposed sewerage networks were not available. Furthermore, KWA reported that no centralized sewerage network data are available for Idukki District. Information on interception and diversion works and pumping stations was not available at the time of analysis, despite requests submitted to KSPCB and KWA. Additionally, no data on sewerage pumping stations were provided by KWA, KSPCB, or District PCB offices. Consequently, these components could not be assessed in the present study.

Drain-wise discharge quantity and quality data were available only for selected locations in Ernakulam District from KSPCB. Comparable datasets for Thrissur and Idukki districts could not be compiled, as the required information was not available at the time of assessment. Even within Ernakulam District, discharge quantity details for certain drains and information on outfall locations remain to be consolidated. In addition, industrial and domestic drain data specific to the Periyar River Basin from district-level PCB offices are yet to be incorporated into the assessment. The available information largely pertains to drains discharging along the Eloor–Aluva industrial region and adjoining stretches of the river, including parts of the Edayar, Muttar River, and Kalady stretches where monitoring has been undertaken by KSPCB. Therefore, the drain discharge and water quality observations presented in this section represent site-specific data for these monitored stretches rather than a complete basin-wide inventory of drains. As a result, the assessment is limited to partial drain information for Ernakulam District and does not comprehensively represent basin-wide drain discharges.

Data gaps and uncertainty also affect the assessment of industrial wastewater load. Detailed information on industry name and address, type, category, scale, water consumption, effluent generation, ETP details, and disposal practices was largely available for industries in Ernakulam District. However, sector-wise effluent quantity and quality data are limited, and information related to industries in Idukki District remains incomplete. Additionally, details on effluent treatment systems and disposal practices for industries in the district are yet to be captured in the assessment. Consequently, the industrial wastewater assessment is predominantly representative of Ernakulam District and does not fully capture industrial pollution loads across the basin.

Limitations are also evident in the assessment of solid waste management. Data on collection, transportation, and disposal practices were obtained primarily from CPCB and KSWMP, but information on transportation facilities, waste flow pathways, and system efficiency remains incomplete. Details on Mini MCFs, RRFs, bottle booths, compost bins, and community and individual bio-facilities were sourced from Suchitwa Mission, though gaps persist at the local body level.

Data gaps and uncertainty persist in evaluating wastewater treatment and management infrastructure. District-wise information on existing STPs, including location, technology, installed capacity, utilization, operational status, and selected effluent quality parameters, was obtained from KSPCB. However, critical details such as geographic coordinates, actual influent and effluent flow rates, sludge handling and disposal practices, treated wastewater reuse or discharge locations, treatment efficiency, and LSGI coverage areas remain unavailable. Information on proposed and under-construction STPs was collected from KWA and the Kerala State River Rejuvenation Committee, but data on timelines, coverage linkage, septage integration, and post-commissioning operational plans are incomplete. As a result, the assessment is limited to secondary information and does not comprehensively capture treatment performance or basin-wide coverage. Similar limitations apply to the assessment of CETPs. District-wise information on CETP location, design capacity, operational status, number of member units, and effluent quality was obtained from KSPCB for Ernakulam and Idukki districts. However, data on geographic coordinates, actual influent and effluent flows, reuse or discharge locations, sludge generation and disposal practices, sector-wise connectivity, treatment efficiency, and long-term compliance trends are largely unavailable. Consequently, the assessment does not fully reflect CETP performance or treatment adequacy across the basin.

Data gaps and uncertainty remain in assessing dumping sites within the Periyar River Basin. District-wise information on identified legacy dumpsites, including local body name, location, dump area, waste quantity, remediation status, and environmental quality assessment, was obtained from KSWMP for Ernakulam and Thrissur districts. However, waste quantity details for certain Thrissur dumpsites are incomplete, and corresponding data for Idukki District are unavailable. In addition, site-specific geographic coordinates, historical waste inflow rates, current accumulation status, leachate generation rates, and post-remediation monitoring data are limited. Limitations are also evident in the assessment of legacy waste. District-wise information on the presence, estimated quantity, area occupied, and remediation status of legacy waste for selected municipalities and blocks in Ernakulam and Thrissur districts was obtained from LSGIs. However, many municipalities, blocks, and Grama Panchayats have not reported data, resulting in incomplete spatial coverage. Furthermore, information on waste composition, leachate characteristics, historical accumulation periods, remediation timelines, and post-remediation monitoring is largely unavailable. Limited local body–level environmental impact data from KSPCB further constrains the assessment.

Finally, data gaps and uncertainty affect the assessment of waste-to-energy and compost facilities. Local body–wise information on the number of centralized composting facilities and community-level biomethanation plants in Ernakulam and Thrissur districts was obtained from LSGIs. However, detailed operational data such as treatment capacity utilization, quantities processed, technology type, output reuse or disposal pathways, and performance efficiency were not available. Information on waste-to-energy and compost facilities in Idukki District was also not received despite follow-up with KSPCB and LSGD. Consequently, the assessment is limited to facility counts and does not fully capture functional status or overall contribution to organic waste management within the basin. Addressing these data gaps through strengthened monitoring, standardised reporting, and inter-agency data sharing is essential to reduce uncertainties and improve the accuracy of pollution load assessment for effective management of the Periyar River.

8. Recommendations

Based on the identified pollution sources, priority should be accorded to reducing the discharge of untreated domestic wastewater into the Periyar River through a phased programme of interception and diversion of major drains, particularly in urban and peri-urban stretches. Immediate focus should be placed on preventing direct sewage inflow from open drains and unsewered areas by integrating interception structures with existing and proposed treatment facilities. Special attention is required during the monsoon season, when mixed sewage stormwater flows significantly increase pollution loads, underscoring the need for coordinated management of drainage and wastewater systems at the basin scale.

Strengthening the performance of existing sewage treatment infrastructure should be prioritised alongside the creation of new assets. Operational efficiency of existing STPs should be improved through capacity optimisation, resolution of operational constraints, and regular performance monitoring to ensure treatment prior to discharge into the river. In non-sewered and low-density regions, particularly in the upper reaches of the basin, decentralized treatment solutions and fecal sludge and septage management systems should be systematically implemented and integrated with urban STPs to reduce untreated wastewater loads entering the river system.

Industrial pollution control measures should be strengthened through a hotspot-based approach, with focused interventions in critical industrial stretches such as the Eloor–Edayar belt. While regulatory consent mechanisms are in place, enhanced monitoring of red- and orange-category industries, improved performance of effluent treatment systems, and stricter control of cumulative discharges are essential to mitigate basin-level impacts. Common effluent treatment facilities and individual ETPs should be assessed for adequacy and operational efficiency to ensure sustained compliance with discharge standards and protection of downstream river stretches.

Effective pollution reduction in the Periyar River Basin requires stronger institutional coordination and policy integration across responsible agencies. Basin-level planning and implementation mechanisms should be strengthened to align sewerage expansion, industrial regulation, solid waste management, and river conservation objectives. Integration of pollution load reduction targets into local body planning processes, coupled with clear accountability for untreated discharges, is essential to translate assessment findings into measurable improvements in river water quality and ecological health.

The assessment highlights the need for strengthening data availability and coordination among responsible agencies. It is recommended that KSPCB, KWA, LSGD, Suchitwa Mission, and district-level PCB offices establish a coordinated and time-bound mechanism for sharing basin-specific data, particularly for local body level wastewater generation, discharge locations, sewerage coverage, and infrastructure details. A standardized data reporting format across districts would reduce inconsistencies and delays. To address uncertainties in domestic wastewater assessment, local body–wise wastewater generation, sewerage coverage, and unsewered household data should be systematically compiled, especially for Idukki District where centralized sewerage data are currently unavailable. Given the absence of information on interception and diversion structures and sewerage pumping stations, it is recommended that KSPCB and KWA jointly inventory existing and proposed interception, diversion, and pumping infrastructure, including location, capacity, and operational status, to enable their inclusion in future assessments.

Drain-wise discharge assessment should be strengthened by ensuring basin-wide availability of discharge quantity, quality, and outfall location data across Ernakulam, Thrissur, and Idukki districts. Pending drain and outfall information for Ernakulam and complete drain data for Thrissur and Idukki should be prioritized to achieve a representative basin-scale analysis. For industrial wastewater assessment, sector-wise effluent quantity and quality data should be consolidated for all districts within the basin. Pending information on industries in Idukki District, including ETP details and disposal practices, should be obtained from the District Industries Centre and the Directorate of Industries and Commerce to reduce district-level bias in pollution load estimation. In solid waste management assessment, it is recommended that detailed waste composition data be generated at the local body level rather than relying on district-level proxies. Data on transportation systems, waste flow pathways, and operational efficiency of collection and disposal infrastructure should be systematically documented, with pending inputs from LSGD addressed to improve completeness. For wastewater treatment infrastructure, additional operational data on STPs including influent and effluent flows, sludge management practices, reuse or discharge points, and treatment efficiency should be collected. Clear linkage between STP coverage areas and LSGIs, along with timelines and operational plans for proposed and under-construction STPs, is required to improve treatment performance assessment. Similarly, CETP assessment would benefit from the collection of detailed operational and performance data, including influent and effluent flows, sludge handling, sector-wise connectivity, and compliance trends, to better evaluate treatment adequacy across the basin. To improve dumpsite and legacy waste assessments, it is recommended that complete district-wise data, including geographic coordinates, waste quantities, leachate generation, remediation status, and post-remediation monitoring information, be compiled for all districts, particularly Idukki. Enhanced reporting by municipalities, blocks, and Grama Panchayats is necessary to address spatial gaps. Documentation of successful solid waste management models should be strengthened through systematic basin-wide compilation of best practices and innovations identified by Suchitwa Mission, KILA, and other agencies, enabling their consideration in future planning exercises. Finally, for waste-to-energy, composting, and biomethanation facilities, it is recommended that operational performance data such as capacity utilization, quantities processed, technology type, and output management be collected and maintained, including for Idukki District. This would allow a more accurate evaluation of their functional status and contribution to organic waste management within the Periyar River Basin.

9. Summary

The Pollution Load Assessment of the Periyar River Basin highlights domestic wastewater, industrial effluents, and solid waste as the dominant contributors to pollution in the Periyar River. Among the assessed districts, Ernakulam generates the highest domestic wastewater load at approximately 405 MLD, followed by Thrissur with 372 MLD, while Idukki contributes 117 MLD. ULBs contribute disproportionately higher loads, with Kochi Municipal Corporation alone generating 93.17 MLD, reflecting higher per capita water use and population density. Municipalities such as Kalamassery, Aluva, Perumbavoor, Angamaly, and Eloor also record notable sewage loads. Sewerage network data indicate that domestic connections dominate across urban subdivisions, while industrial and special connections remain limited. In contrast, Idukki district lacks an organized sewerage network, with widespread dependence on pit toilets.

The absence of interception and diversion projects along the Periyar further exacerbates the direct discharge of untreated or partially treated wastewater into the river system. This is compounded by the lack of a comprehensive and properly designed drainage network, with wastewater commonly conveyed through open drains carrying mixed flows of sewage and stormwater, leading to frequent overflows and direct discharge into the river, particularly during the monsoon. Industrial pollution load analysis reveals a highly uneven distribution, with large red-category industries—especially chemical, petrochemical, fertilizer, mining, and leather units—generating substantial wastewater volumes and discharging treated effluent into the river, notably in downstream stretches below the Pathalam bund. Medium and small-scale industries exhibit wide variability in wastewater management practices, ranging from structured effluent treatment systems to basic containment measures such as soak pits, septic tanks, or neutralization tanks, contributing cumulatively to the pollution load. Industrial pollution pressures are particularly pronounced in the Eloor–Edayar industrial belt, which hosts a dense concentration of large and medium-scale industries, including red-category chemical and allied units, making this stretch a critical hotspot influencing basin-level water quality.

Solid waste generation adds further pressure on the river system, with Kochi Corporation producing the highest quantities, followed by municipalities such as Kalamassery, Eloor, Angamaly, and several ULBs in Thrissur district. In Idukki district, solid waste generation is dominated by biodegradable waste, reflecting the prevalence of organic and agricultural residues, while non-biodegradable waste, particularly plastics, contributes to persistent pollution risks. The presence of multiple legacy dumpsites across Ernakulam, Thrissur, and Idukki districts continues to pose long-term threats through leachate generation and unregulated runoff.

At the basin scale, existing sewage treatment infrastructure within the Periyar River Basin remains limited and fragmented relative to the generated wastewater load. Operational STPs within the basin include small to medium capacity plants in Kochi and select urban centres, with several facilities operating below design capacity due to operational constraints. In the upper reaches of the basin, particularly in Idukki, treatment infrastructure is minimal, with only small institutional STPs currently in place. To address this gap, proposed sewerage and septage management schemes within the basin envisage a combination of network-based STPs in higher density urban and tourist centres such as Kattapana and Munnar/Devikulam, complemented by decentralized FSSM facilities in low-density and scattered settlements, indicating a phased move towards basin-wide wastewater interception and treatment. Despite these challenges, the basin also demonstrates promising solid waste management initiatives, including the Thumboormuzhi Aerobic Composting Model, Green Check Post at Vagamon, Upcycling initiatives in Ernakulam, and community-based programmes such as *Collectors @ School*, which provide replicable models for reducing pollution loads at source.

Overall, this Pollution Load Assessment & Pollution Mapping establishes a comprehensive baseline for understanding the magnitude and spatial distribution of pollution sources in the Periyar River Basin and serves as a critical data repository for planning and implementation under the District River Management Plan and Nirmal Dhara initiatives. The findings underscore the need for targeted reduction of untreated domestic wastewater, improved industrial effluent management, strengthened solid waste processing, and systematic closure of treatment and infrastructure gaps. Adoption of a load-based, integrated river management approach, supported by periodic data updates and inter-agency coordination, will be essential to progressively reduce pollution loads and move towards long-term restoration of water quality and ecological health of the Periyar River.

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Annexure 1 – Detailed Water Quality Analysis of Drains and Streams in Ernakulam District (*Source: KSPCB)*

Name of Chal / Drain / Stream	Latitude (N)	Longitude (E)	Nature of Water Body	pH	DO	BOD	COD	EC	TC	FC	Streptococci	Cl^-	PO_4^{3-}	TH	Sb	Cr	Cu	Cd	Fe	Pb	Mn	Mo	Hg	Ni	Zn	Co	Remarks
				-	mg/L	mg/L	mg/L	µS/cm	CFU/100 ml	CFU/100 ml	CFU/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Drain between Alpha Crumb Rubber & Malaya Rubtech, Edayar	10.07989	76.31517	Drain	6.9	0	420	1680	13790	7000	1000	100	3500	1.512	2800	BDL	BDL	0.016	BDL	4.536	BDL	0.318	BDL	BDL	BDL	0.703	BDL	Industrial drain joining Periyar (U/S Pathalam Bund)
Drain inside CMRL (East side), IDA Edayar	10.07803	76.31364	Drain	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Only sediment sample collected
Drain inside Srisakthi Paper Mill compound (East side)	10.07933	76.31492	Drain	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Sediment sample only; red coloured sediments
Drain joining upstream near Navigation Channel, Pathalam Bund	10.07703	76.30903	Irrigation canal	6.1	0.9	180	720	14330	2400	700	NIL	4200	BDL	3600	BDL	BDL	BDL	BDL	0.659	BDL	0.113	BDL	0	BDL	0,147	BDL	Connects Periyar River & Edayattuchal paddy fields
Drain near Marksmen Marine Products (D/S Pathalam Bund)	10.07706	76.30858	Drain	6.7	–	–	–	17340	3000	800	20	4800	0.673	4100	–	–	–	–	0.62	–	0.18	–	–	–	–	–	Storm water drain of IDA
Storm water drain of Indogerman, IDA Edayar	10.07811	76.30197	Drain	6.3	0	440	1760	3594	–	–	–	750	0.685	670	–	–	–	–	–	–	–	–	–	–	–	–	Sample collected from delay pond
Edayattuchal	10.09186	76.30133	Small stream	6.5	3.6	500	1840	2433	1700	300	NIL	920	BDL	840	BDL	BDL	BDL	BDL	1.752	BDL	0.589	BDL	0.001	BDL	0.593	BDL	Originates from paddy fields; industrial influence
Ongithodu	10.09947	76.29017	Medium stream	6.4	4.2	220	880	3902	1700	200	NIL	980	BDL	770	BDL	BDL	BDL	BDL	1.1	BDL	0.049	BDL	BDL	BDL	0.169	BDL	Flows through residential areas
Stream near Pallathunadupalam (Adichilikadavu)	10.09364	76.27986	Small stream	6.5	2.6	420	1600	21050	3500	400	40	5800	BDL	4300	BDL	BDL	BDL	0.002	0.464	BDL	0.114	BDL	BDL	BDL	0.623	BDL	Reverse flow during high tide
D-Drain, FACT UD	10.07633	76.30214	Storm water drain	6.8	1.9	420	1680	4897	–	–	–	1500	2.555	1100	BDL	BDL	0.014	BDL	0.769	BDL	0.854	BDL	0.005	BDL	0.242	BDL	Sample from delay pond
C-Drain, FACT UD	10.0782	76.3001	Storm	5.1	2.3	320	1040	328	3800	600	20	890	0.45	720	BDL	0.03	0.01	BDL	8.84	BDL	0.56	BDL	0.00	BDL	2.91	BDL	No flow; delay

	8	7	water drain					1					2			5	2		5		5		1		7		pond sample
O4-Drain, TCC	10.0755	76.30639	Storm water drain	6.2	2.8	540	1840	14340	–	–	–	3400	BDL	2800	BDL	BDL	0.016	BDL	0.246	BDL	0,09	BDL	0	BDL	0.161	BDL	Authorised discharge; zero liquid discharge unit
Drain at Pathalam Bridge – Eloor side	10.08097	76.31786	Storm water drain	6.2	0	240	880	10930	4100	700	20	3100	2.491	2400	BDL	0.04	BDL	BDL	66.34	0.017	1.18	BDL	BDL	0.048	4.383	0.015	Domestic sewage influence
E-Drain, FACT PD	10.07006	76.29072	Storm water drain	5.1	1.3	640	2160	11100	2600	400	20	3600	BDL	3100	BDL	BDL	0.05	BDL	9.91	BDL	BDL	BDL	BDL	0.013	0.242	BDL	Joins Muttar River
Unthithodu	10.07292	76.28697	Stream / drain	6	3	80	224	6022	1900	300	NIL	1800	BDL	1100	BDL	BDL	BDL	BDL	0.436	BDL	0.05	BDL	BDL	BDL	0.166	BDL	Major tributary to Muttar River
Drain at eloor-ferry road	10.07292	76.28697	stream water drain	6.2	2.7	140	336	7883	4300	700	–	3300	0.023	2700	BDL	BDL	BDL	BDL	0.704	BDL	0.6091	BDL	BDL	BDL	0.173	BDL	
Stream at Palliyattukarakadavu	10.07661	76.28447	Small stream	6.3	2	120	360	20590	4700	700	20	5800	BDL	5200	BDL	BDL	BDL	0.001	0.319	BDL	0.081	BDL	BDL	BDL	0.38	BDL	Branch of Unthithodu
Drain at Periyar Road, Varapoli	10.07825	76.28614	Drain	6.3	2.1	180	408	19620	3600	500	20	5200	BDL	4800	BDL	BDL	BDL	0	0.962	BDL	0.24	BDL	BDL	BDL	0.384	BDL	Urban runoff
Drain near Methanamkadavu	10.09547	76.28947	Drain	6.4	2.9	500	1680	19560	3600	500	–	6100	BDL	5600	0.003	BDL	BDL	0.002	0.457	BDL	0.1	BDL	BDL	BDL	84	BDL	Downstream of Pathalam Bund
Drain near Popular Lime Shell	10.06506	76.29453	Drain	6.9	1.2	160	368	3423	3200	600	NIL	910	0.195	860	BDL	BDL	BDL	BDL	1.818	BDL	0.194	BDL	BDL	BDL	0.092	BDL	Industrial storm water
Drain at Amrutha Sag Pharma	10.07461	76.312	Small stream	6.3	1.2	120	320	2564	5000	900	40	750	2.314	660	BDL	BDL	BDL	BDL	2.718	BDL	0.084	BDL	BDL	BDL	0.158	BDL	Industrial influence
B-Drain FACT PD	10.06914	76.29056	Drain	6	2	120	560	4030	1900	300	NIL	1100	0.36	890	BDL	BDL	BDL	0.014	0.74	0.016	0.329	BDL	BDL	BDL	BDL	BDL	
Storm water drain of IRE	10.08258	76.2985	Drain	6.9	3.1	560	1840	35470	–	–	–	6500	0.157	4800	BDL	BDL	0.034	BDL	2.25	BDL	0.346	BDL	0.006	BDL	0.779	BDL	
Drain at Manjali Bridge	10.28455	76.46156	Drain	5.5	3.9	200	720	2121	900	100	NIL	790	BDL	670	–	–	–	–	–	–	–	–	–	–	–	–	Industrial storm water
Drain at Pazhampillythuruth Bridge	10.07989	76.31517	Drain	6	4.2	360	1280	53310	2100	200	NIL	13900	BDL	13200	–	–	–	–	–	–	–	–	–	–	–	–	Industrial storm water
Drain at Ryan School	10.07803	76.31364	Drain	6.3	4.4	160	640	1736	200	NIL	NIL	350	BDL	210	BDL	BDL	BDL	0.001	1.214	BDL	0.07	BDL	BDL	BDL	0.109	BDL	Branch of Unthithodu

TH- Total hardness TC- Total coliform FC-Faecal coliform

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