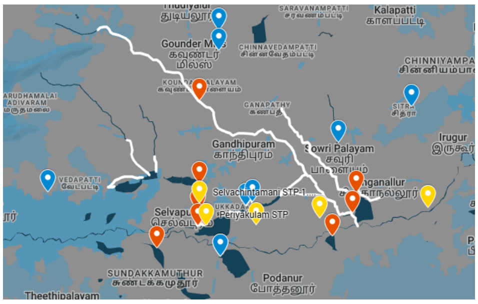
Water quality analyses of Coimbatore's water bodies as foundation for decentral water treatment concepts

AQUA-Hub





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1. Background

The development of the wastewater treatment scheme in Coimbatore, India, reflects the city's transition from a growing textile and industrial hub to a modern urban center grappling with rapid population growth and environmental challenges. Historically, Coimbatore's wastewater management was rudimentary, relying primarily on natural drainage systems to carry untreated sewage to water bodies such as the Noyyal River. During the mid-20th century, as industrialization surged, untreated industrial effluents and domestic sewage began to significantly pollute these water sources, leading to public health concerns and environmental degradation. Recognizing the urgent need for intervention, the city initiated its first structured wastewater treatment efforts in the late 20th century. Early measures included constructing sewage collection networks and small-scale treatment facilities, though coverage was limited and ineffective for the growing urban sprawl. By the 2000s, with increased awareness of sustainable urban development and support from government programs such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Coimbatore began modernizing its wastewater infrastructure. This included the construction of centralized sewage treatment plants (STPs), adoption of secondary and tertiary treatment processes, and expansion of the sewer network to cover a larger population. Notable projects, such as the Ukkadam Sewage Treatment Plant, improved the city's capacity to treat wastewater efficiently. Despite these advancements, challenges like inadequate sewer connectivity, reliance on septic tanks in peri-urban areas, and maintenance issues persist. Recent efforts have focused on integrating decentralized wastewater treatment systems and promoting reuse initiatives, such as using treated water for agriculture and industrial cooling, aligning with Coimbatore's vision of sustainable water management.

2. Objectives & Approach

In light of these developments with the integration of adequate treatment systems into the built environment the present concept study aims at supporting the development of sustainable wastewater treatment schemes in Coimbatore. Thus, the current and planned initiatives to expand Coimbatore's wastewater infrastructure was assessed. Major regulatory frameworks guiding the development of wastewater collection treatment were reviewed. Current gaps identified in the treatment scheme of Coimbatore's STP network were reviewed for potential locations of future STPs. Short-term flow studies along with water quality analyses from the respective sites were conducted in order to get a first idea of relevant water parameters. The results are evaluated according to various technological options at the respective sites to create a first draft concept of an expanded decentral wastewater treatment scheme. The conducted study presents a first step to a concept and does not function as detailed project report. Additional analyses and studies would have to be conducted. However, the present data and concepts can be useful for further steps on the way to develop the wastewater infrastructure in Coimbatore and shall support any initiative undertaken by local stakeholders to improve water quality in Coimbatore's surface and ground waters.

3. Current State of Wastewater Management Infrastructure

The wastewater infrastructure in Coimbatore has undergone notable development in recent years, yet it remains a work in progress as the city strives to meet the demands of rapid urbanization and industrial growth. Coimbatore's existing infrastructure includes several centralized sewage treatment plants (STPs), with major facilities like Ukkadam, Nanjundapuram, and Ondipudur collectively handling millions of liters of sewage per day. These plants employ a range of treatment technologies, including activated sludge processes and tertiary filtration systems, to ensure that treated effluents meet the standards set by the Tamil Nadu Pollution Control Board (TNPCB). Treated water is often reused for purposes like irrigation, industrial cooling, and landscaping, which reduces dependency on freshwater resources.

Despite these achievements, the wastewater infrastructure in Coimbatore has not yet achieved universal coverage. The sewer network serves only a portion of the city, leaving significant areas—especially the outskirts and peri-urban zones—reliant on septic tanks, soak pits, or open drains. These decentralized systems, while necessary in unconnected areas, are often poorly maintained, leading to problems such as groundwater contamination and the proliferation of mosquito breeding sites. Furthermore, the city's industrial zones, which generate considerable volumes of wastewater, add an additional layer of complexity. While many industries treat their wastewater on-site using effluent treatment plants (ETPs), compliance with environmental norms varies, and untreated or partially treated effluents occasionally make their way into natural water bodies, including the Noyyal River.

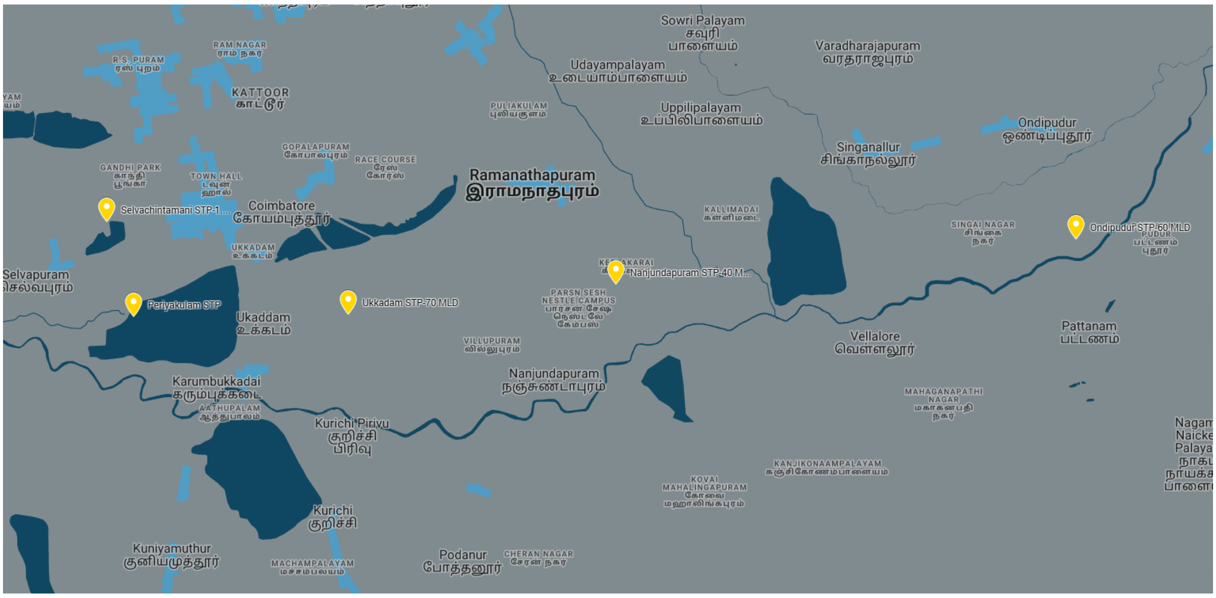


Figure 1: Existing STPs in Coimbatore. Yellow icons show the respective locations. Map was created using Google Maps ©2025 Google

Maintenance and operational challenges persist across the city's wastewater management system. Blockages in sewer lines, aging pipelines, and inadequate capacity in some areas lead to overflows and untreated sewage discharge during periods of heavy rainfall. Additionally, population growth and urban sprawl are outpacing the current infrastructure, straining the system's ability to keep up with increasing wastewater volumes. To address these challenges, the Coimbatore City Municipal Corporation (CCMC) is actively pursuing modernization and expansion projects. Under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and other state-level initiatives, efforts are being made to expand the sewer network, improve connectivity, and enhance the efficiency of existing STPs. Public-private partnerships are also being explored to leverage expertise and funding for large-scale infrastructure upgrades.

Technology integration is another focus area. Coimbatore is incorporating Geographic Information Systems (GIS) for mapping its sewer networks and smart sensors for real-time monitoring of STPs, enabling quicker responses to maintenance issues. Public awareness campaigns are being conducted to promote proper disposal of household waste and reduce the burden on the wastewater system. The city is also exploring innovative solutions such as bioengineering and phytoremediation to address contamination in untreated drainage zones.

Overall, while Coimbatore has made significant strides in wastewater management, challenges related to universal connectivity, operational inefficiencies, and environmental sustainability remain. Addressing these issues will require a combination of robust planning, investment in modern technologies, and a strong regulatory framework to ensure long-term resilience in the face of urban and industrial growth.

4. Plans by the local government

Coimbatore is currently undertaking significant efforts to upgrade and expand its wastewater infrastructure as part of its broader urban development goals. Key initiatives are embedded in the city's Smart City Mission, which has allocated substantial resources to enhancing wastewater management, stormwater systems, and surface water rejuvenation. The focus is on improving sewage treatment facilities, expanding sewage networks, and implementing state-of-the-art technologies like membrane bioreactors (MBR) and activated sludge processes in Sewage Treatment Plants (STPs). These upgrades are aimed at addressing the growing urban population and improving environmental sustainability.

A major aspect of Coimbatore's wastewater infrastructure development is the restoration of its historic lakes and water bodies. Over the past few years, significant investments have gone into the ecological revival of seven major lakes in the city, such as Periyakulam, Valankulam, and Krishnampathy lakes. This initiative, worth around ₹350 crore, not only focuses on water treatment and stormwater management but also aims to reclaim these water bodies as vital ecological and recreational spaces. The restoration of these lakes is part of a cascading water system that serves as a flood buffer and groundwater recharge zone, reducing the urban flood risk while enhancing biodiversity.

In terms of infrastructure, Coimbatore has also been upgrading its sewage and stormwater systems to improve efficiency. This includes the construction of new sewer lines, installation of modern treatment technologies, and expansion of existing STPs to meet increasing demand. These projects are supported by public tenders that have been issued over the past five years, reflecting the city's proactive approach to environmental management. Coimbatore's wastewater infrastructure development, alongside the rejuvenation of surface water bodies, is part of a comprehensive strategy to ensure a clean, sustainable urban future while adhering to national water and sanitation standards.

Here are five recent wastewater collection and treatment projects in Coimbatore:

1. **Ukkadam Sewage Treatment Plant (STP)**: The Coimbatore City Municipal Corporation (CCMC) is planning a significant upgrade to the Ukkadam STP with the installation of a 25 MLD Reverse Osmosis plant. This project, with an estimated cost of ₹245 crore, aims to treat wastewater more effectively and reduce reliance on freshwater sources. It will also address untreated sewage discharge into water bodies like the Noyyal River.
2. **Kumarasamy Lake STP**: In an effort to protect Coimbatore's water bodies, CCMC is constructing a new STP at Kumarasamy Lake. The plant will have a treatment capacity of 2 MLD, with an estimated cost of ₹3.6 crore. This is part of a broader plan to install STPs in lakes and ponds across the city.
3. **Singanallur Lake STP**: As part of rejuvenation efforts for Singanallur Lake, CCMC has begun constructing a 1 MLD STP at an estimated cost of ₹4.5 crore. This project includes the installation of the STP as well as lake desilting and rejuvenation work.
4. **Valankulam Lake STP Expansion**: Valankulam Lake, which already has a 3 MLD STP, is set to receive an additional 2 MLD unit to further improve water quality. This expansion is part of CCMC's ongoing efforts to treat wastewater before it enters water bodies.

5. **Krishnampathy Lake STP**: CCMC is also planning an STP for Krishnampathy Lake as part of its larger initiative to treat sewage entering Coimbatore's lakes. The city has committed to improving wastewater treatment and ensuring that treated water does not pollute local water resources.
6. **Vellakinar-Chinnavedampatty STP**: A 9.95 MLD STP is planned in the North of Coimbatore. Chinnavedampatty Lake is currently in a bad condition and the STP is expected to improve the condition of the lake.

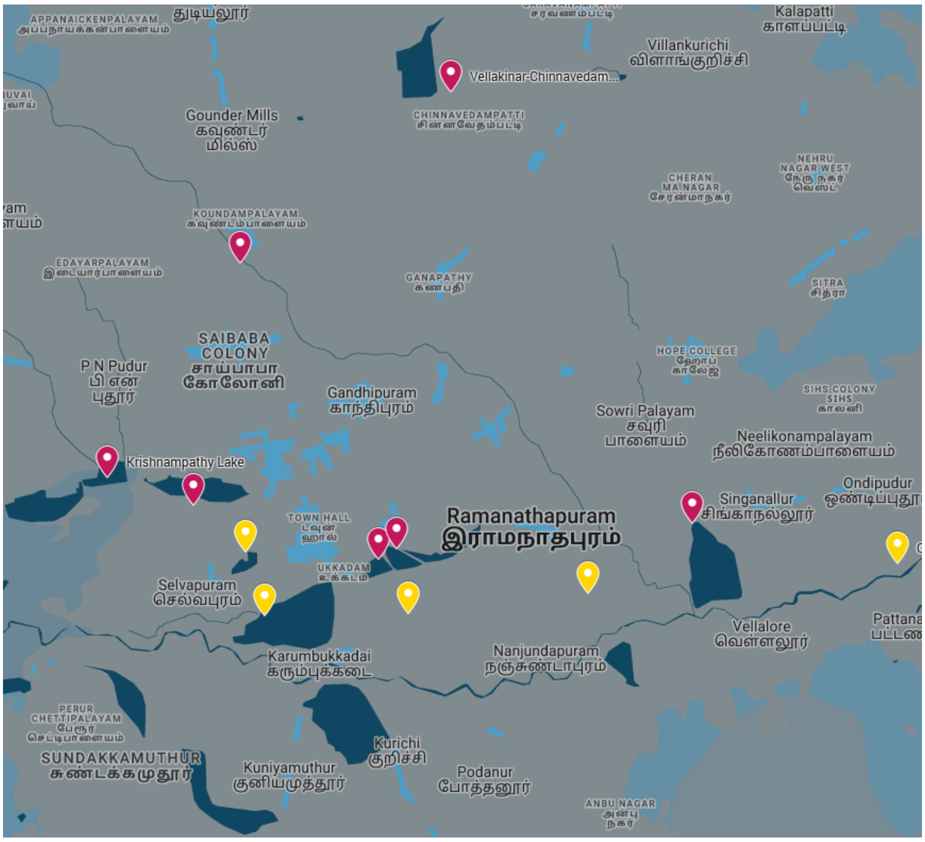


Figure 2: Planned installation of STPs in Coimbatore's surface water systems (proposed locations represented by red icons). . Map was created using Google Maps ©2025 Google

These projects highlight the city's commitment to enhancing its wastewater infrastructure and ensuring cleaner water bodies.

Coimbatore is actively working to reduce sewage from entering its channel systems through a series of planned interventions in wastewater treatment and stormwater management. The Coimbatore City Municipal Corporation (CCMC) has laid out comprehensive measures that focus on improving both the infrastructure and management practices to prevent untreated sewage from polluting the city's water channels, especially during the monsoon seasons.

Key Strategies:

1. **Expansion of Sewage Treatment Plants (STPs):**

CCMC is significantly expanding its sewage treatment capacity, with the construction of new STPs and the expansion of existing ones. For example, the ongoing installation of a 2 MLD STP at Kumarasamy Lake and the enhancement of Valankulam Lake's treatment capacity are part of this initiative. By increasing the treatment capacity, the city aims to treat a larger portion of the sewage before it is discharged into the channels or water bodies.

2. **Sewer Network Augmentation:**

   The city is expanding its sewer network to cover more areas, particularly those that were previously unconnected or had inadequate coverage. The inclusion of these areas into the centralized sewer system ensures that more sewage is captured and treated at the STPs, thereby reducing the amount of untreated wastewater entering the channel system.

3. **Decentralized Sewage Treatment:**

   Coimbatore is promoting decentralized treatment solutions in larger residential and commercial developments. These systems, such as decentralized Sewage Treatment Plants (STPs) in estates or complexes, help prevent wastewater from flowing into the larger drainage system by treating it at the source.

4. **Stormwater Management and Lake Restoration:**

   The restoration of lakes like Singanallur, Ukkadam, and others, as well as stormwater harvesting systems, are designed to manage both sewage and rainwater runoff effectively. These initiatives, including desilting of lakes and the installation of treatment plants within them, help reduce the contamination of water bodies from untreated sewage.

5. **Public Awareness Campaigns:**

   Alongside infrastructure improvements, Coimbatore is engaging in public awareness campaigns to encourage better wastewater management practices among residents and industries. The city is also implementing stricter enforcement of regulations to prevent the direct discharge of untreated sewage into public drains.

By combining infrastructural upgrades with improved regulatory frameworks and public engagement, Coimbatore aims to drastically reduce sewage entry into its channel systems and improve overall wastewater management across the city.

5. Regulations

In Coimbatore, sanitation and wastewater treatment regulations are designed to address the challenges of urbanization, industrial activity, and environmental sustainability. These regulations are a mix of national laws, state policies, and local guidelines enforced by agencies such as the Tamil Nadu Pollution Control Board (TNPCB) and the Coimbatore City Municipal Corporation (CCMC). The Water (Prevention and Control of Pollution) Act, 1974, mandates that all wastewater, whether domestic or industrial, must be treated to specified standards before discharge into the environment. For industries, this means installing Effluent Treatment Plants (ETPs) to process wastewater on-site or joining Common Effluent Treatment Plants (CETPs), which are shared facilities for treating effluents generated by small and medium enterprises. Industrial discharges must meet stringent criteria for parameters such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and heavy metal concentrations. The CCMC manages centralized and decentralized Sewage Treatment Plants (STPs) that treat domestic wastewater, with treated water increasingly being reused for purposes like irrigation, landscaping, and industrial cooling. In many cases CCMC delegates the operation of such STPs to subcontractors.

Policies such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) aim to expand sewer connectivity, particularly in underserved areas, while promoting decentralized wastewater management solutions where centralized systems are unfeasible. Additionally, the National Green

Tribunal (NGT) has issued directives to prevent untreated discharges into the Noyyal River and other water bodies, requiring local authorities and stakeholders to ramp up monitoring and enforcement efforts. Moving forward, Coimbatore is expected to integrate sustainable practices such as nutrient recovery, energy generation from sludge, and further reuse of treated water, aligning with national goals under the Swachh Bharat Mission and Jal Shakti Abhiyan. These combined efforts are gradually creating a more robust and environmentally sustainable wastewater management framework for Coimbatore.

One of these policies is the Tamil Nadu Combined Development and Building Rules (2019). It stipulates that residential developments, such as large estates, gated communities and large apartment complexes above a certain size in Coimbatore, must install and operate on-site STPs to treat greywater and blackwater generated within their premises. These STPs must meet standards set by the Central Pollution Control Board (CPCB) and the TNPCB, ensuring treated water is safe for reuse or discharge. Reuse is strongly encouraged, and treated water is often used for purposes like flushing toilets, gardening, or even groundwater recharge. Estates must obtain Consent to Establish (CTE) and Consent to Operate (CTO) from the TNPCB before setting up an STP. Regular maintenance of these on-site systems is mandatory, with penalties imposed for non-compliance. Additionally, estates are required to submit annual compliance reports to the TNPCB to demonstrate adherence to treatment and discharge norms.

Residential Complexes:
Any residential complex with 50 or more dwelling units or an expected wastewater generation of more than 50,000 liters per day (50 Kilo Litre per Day, KLD) must install an STP.

Commercial Establishments:
Commercial buildings, offices, or malls generating more than 10,000 liters per day (10 KLD) of wastewater are required to have an on-site treatment facility.

Other Developments:
Industrial estates, educational institutions, hospitals, and hotels generating significant volumes of wastewater must also adhere to these requirements, often with stricter norms depending on the pollution load.

The choice of technology depends on the volume of wastewater, the nature of pollutants, available space, and intended reuse of treated water. Commonly approved technologies include:

1. **Activated Sludge Process (ASP):**

   A widely used method where microorganisms degrade organic pollutants. Suitable for medium to large-scale estates with consistent wastewater flow.

2. **Sequencing Batch Reactor (SBR):**

   A modern and efficient process where treatment occurs in batches, involving aeration and sedimentation in a single tank. Ideal for residential and commercial complexes with space constraints.

3. **Moving Bed Biofilm Reactor (MBBR):**

   Uses biofilm carriers for efficient biological treatment. Compact and suitable for high-density developments.

4. **Membrane Bioreactor (MBR):**

Combines biological treatment and membrane filtration, producing high-quality treated water fit for reuse in flushing, gardening, or industrial processes. Best for large estates with high water reuse requirements.

5. **Rotating Biological Contactors (RBC):**

A simpler, low-energy option for smaller estates, involving rotating disks to grow biofilm that treats wastewater.

6. **Anaerobic Digestion:**

Suitable for estates generating significant organic waste. Often combined with other processes for biogas recovery and nutrient removal.

Key Design Considerations are:

1. **Capacity:**

The STP must be designed to handle 150-200 liters per capita per day (LPCD) of wastewater for residential areas.

2. **Space Requirements:**

Developers often opt for compact technologies like MBR or SBR in urban areas with limited space.

3. **Treated Water Reuse:**

Treated water is encouraged for reuse in gardening, flushing, and other non-potable purposes to reduce freshwater consumption.

4. **Energy Efficiency:**

Preference for technologies with lower operational costs and energy requirements.

Table 1: Discharge Standards for Treated Sewage

Parameters	Standards applicable to all mode of disposal
pH	5.5-9
Biological Oxygen Demand (BOD)	10 mg/L
Total Suspended Solids (TSS)	20 mg/L
Chemical Oxygen Demand (COD)	50 mg/L
Total Nitrogen	10 mg/L
Total Phosphorus	1.0 mg/L
Fecal Coliform	desirable 100 MPN / 100 ml

While many of Coimbatore's municipal STPs meet these standards, challenges such as irregular maintenance, operational inefficiencies, and insufficient monitoring in decentralized systems occasionally result in subpar treatment. The city is gradually integrating real-time monitoring systems and stricter enforcement mechanisms to address these issues and ensure sustained compliance with discharge norms. To improve compliance, authorities have introduced real-time monitoring systems for larger facilities, including estates, industries, and municipal STPs. Sensors and online monitoring systems track effluent quality and discharge volumes, reporting directly to regulatory bodies. However, enforcement remains a challenge, particularly for decentralized systems in peri-urban areas, informal settlements, and smaller estates that lack the resources to invest in advanced treatment technologies.

The discharge standards for STPs in Coimbatore are governed by the (TNPCB, adhering to the guidelines established by the CPCB under the Environment Protection Act, 1986. These standards ensure that treated wastewater discharged into water bodies or reused for various purposes meets environmental and public health requirements. The key parameters and their permissible limits for STP effluents are shown in Table 1.

These standards apply to all Metropolitan Cities in Tamil Nadu with a population of more than 10 Lakhs (1 Mio) as well as Class-1 cities with a population of more than 1 Lakh (100,000). All STPs built from May 2019 must comply with these standards. Existing STPs are given an adaptation period of seven years from the date of notification.

6. Methodology

In order to support to the existing and upcoming efforts to enhance Coimbatore's wastewater collection and treatment system, the following approach was designed. After extensive research on current and planned measures to expand the treatment capacity of the City's infrastructure, key stakeholders were interviewed on their perspectives for future initiatives. In light of the mapped locations of Sewage Treatment Plants, a monitoring campaign for water flow and quality analyses was designed. After consultation of the Coimbatore Municipal Corporation, Siruthuli and the Tamil Nadu Agricultural University, five study points were selected.

The local company AuM Systems was contracted with the analyses of the respective flow monitoring points. Each of these points were monitored for 24 hours between June 21 and June 26, 2024 . Water samples were taken and handed over to the Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University for water quality analyses. The data was assessed by Fraunhofer IGB and formed the basis of the evaluation of technological options for amending the decentral treatment schemes.

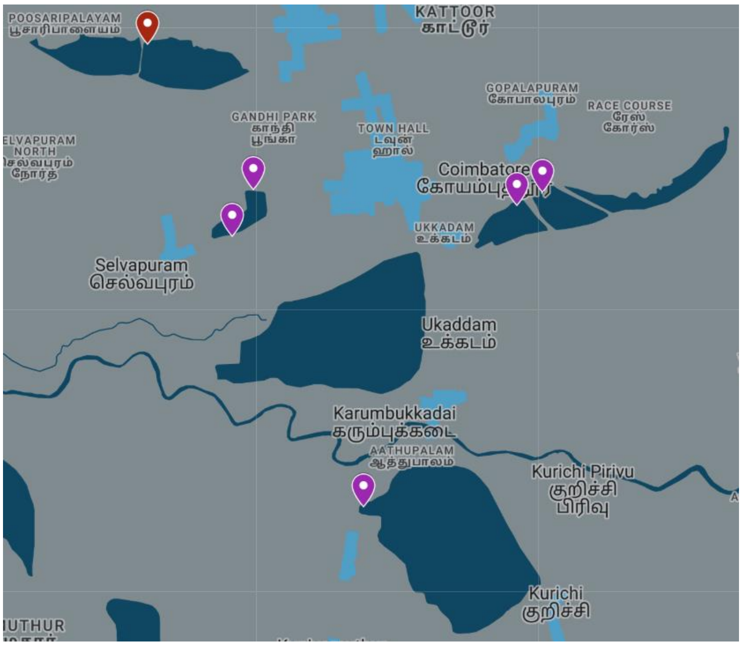


Figure 3: Selected study sites for flow and water quality monitoring. Purple icons indicate location where bot, flow and quality analyses were conducted. Red icons indicate sites where only water quality data is available. Map was created using Google Maps ©2025 Google

Sample and study locations were selected according to the relevance for future project developments and STP capacity extension. However, some initially selected sites were not suitable due to interrupted water flow from construction works or extensive water hyacinth cover. Thus, the finally selected sites pose a compromise in order to provide an example for future initiatives conducting similar analyses. The focus was on monitoring the inlets to various tanks in Coimbatore. This is in line with the approach followed by the local government to implement STPs at tank inlets to improve the water quality of waters flowing into the lakes. Thus, the following sites were selected for monitoring: Kumaraswamy Tank (only water quality), Selvachinthamani Lake, Chinnakulam Tank, Valankulam Tank, Kurichi Kulam Tank.

Although the standards issued by the CPCB and the TNPCB have been designed to apply for STP effluents, and the inlet to the lake does not represent an STP effluent but rather a canal, the standards have been referenced against the results of the water quality analyses in order to highlight the areas which require further improvement. Those parameters that comply with the standards set out by the CPCB and TNPCB, where applicable, are highlighted in green. Parameters ranging between acceptable and permissible thresholds are highlighted orange. Parameters out of range set out by the TNPCB and CPCB are highlighted in red.

7. Results of Monitoring campaign

Selvachinthamani Lake Inlet

Water Flow and quality analyses

Selvachinthamani Lake is located at the centre of Coimbatore. Its main water inflow comes from a canal on the north shore. It is of interest to further development since significant efforts have been undertaken in previous years to improve the water quality of the lake. Besides a small STP that has been built here, which treats only a small fraction of the water coming into the lake, parts of the riparian Zone have been rejuvenated to function as wetlands and floating wetlands system to further improve the water quality. The water flow and quality analyses were conducted in order to identify additional measures to further improve the water quality.

Flow monitoring on 24 and 25th of July 2024 registered 6053 m³/d of water at the inlet (Figure 5).

Figure 4: Selvachintamani Lake (Located at 10.993630, 76.947890) (Map sourced from Google Maps ©2025 Google; lake inlet photo by Beckett, IGB)

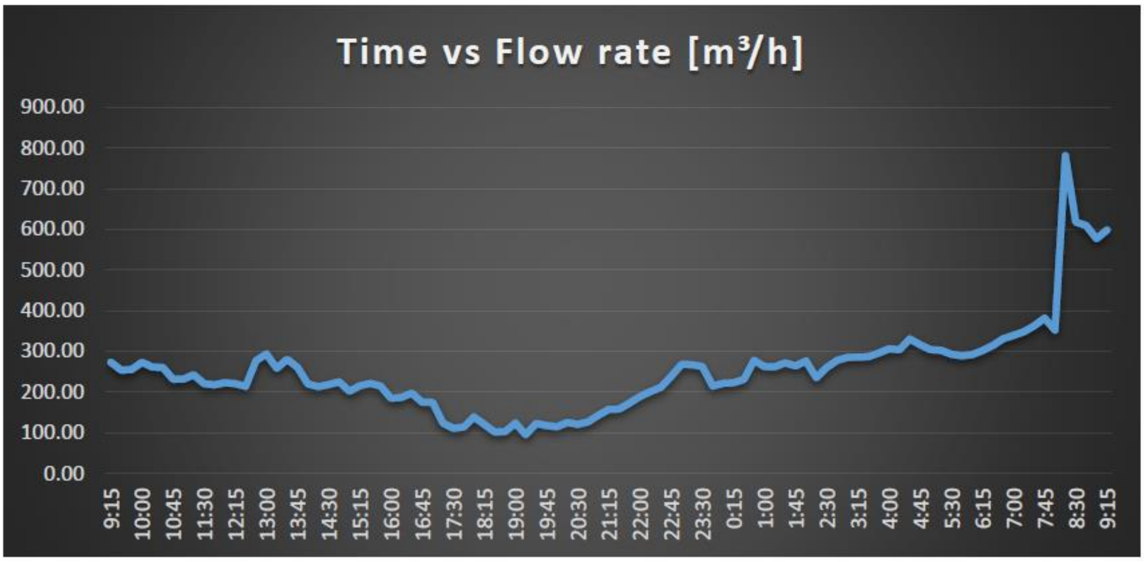


Figure 5: Flow monitoring at Selvachintamani Lake inlet between 24th and 25th of July; Measurements conducted by AuM Systems Ltd, on behalf of AQUA-Hub

Table 2: Water Quality Analyses for Selvachintamani Lake inlet

Parameter	Unit	CPCB Standards		TNPCB Standards	Inlet	Load (kg/d)
		acceptable	permissible			
pH		5.5-9	no relaxation		7.5	
EC	µS/cm	750	2250		1173	
TDS	mg/L	500	2000		646	3910.24
TSS	mg/L	100	600	20	250	1513.25
Turbidity	NTU	1	5		57.4	
Ca	mg/L	75	200		136	823.21
Mg	mg/L	30	100		49	296.60
Hardness	mg/L	200	600		299	
Chloride	mg/L	250	1000		210	1271.13
DO	mg/L	≥4	not < 3.5		3.8	
BOD	mg/L	5	30	10	29	175.54
COD	mg/L	20	250	50	135	817.16
Coliforms	MPN/100ml		500	230	149	
Fe	mg/L	0.3	1		3.50	21.19
Mn	mg/L	0.1	0.5		0.18	1.09
Zn	mg/L	5	15		0.29	1.76
Cd	mg/L		0.0003		0	0.00
Pb	mg/L		0.05		0.01	0.06
Cr	mg/L	0.05	no relaxation		0.09	0.54
Hg	mg/L	0.01			0	0.00
Total Nitrogen	mg/L		20	10	12.7	76.87
Phosphates	mg/L		5	1	0.02	0.12

Water quality analyses at Selvachintamani Lake inlet revealed important information on the water entering the lake. From the analyses it can be derived that Nitrogen, Chromium, Iron, BOD and COD, Total Suspended Solids and Turbidity require further attention. Especially the low BOD/COD ratio of 0.22 suggests the water contains a significant amount of non-biodegradable or refractory organic matter, requiring additional chemical or advanced treatments. This value is typical for stormwater in urban areas where run-off from streets, industrial complexes and estates can contain more non-biodegradable compounds. Stormwater with a low BOD/COD ratio typically requires advanced treatment techniques, such as chemical precipitation or filtration, due to the presence of non-biodegradable contaminants.

Treatment Options at Selvachintamani Lake

The existing STP at Selvachintamani Lake treats only a fraction of the water coming into the lake via the canal. Its main treatment process is a Moving Bed Bioreactor (MBBR). Given the significant variation in water flow depending on the season, along with the limited space available in the vicinity of the canal, any batch process treatment schemes such as activated sludge, sequencing batch or even membrane bioreactors can only treat a proportion of incoming water. This proportion decreases as flow in the canal increases e.g. to increased effluent discharge or during monsoon region. While pollution prevention is most efficient at its source and government initiatives indicate an expansion of sewer and treatment capacity to address the issue in this manner, a temporary solution or even integrative solution for Selvachintamani Lake Inlet would be desired. These could include nature based or nature inspired solutions with increased filtration capacities. Trickling filters as well as constructed or floating wetlands can pose a relief to the current situation in combination with upstream bar screens of different sizes to reduce the inflow of debris and larger particles. A beneficial side effect would also be achieved through a reduction of flow velocity, enabling more suspended solids to settle.

Figure 6: Example of plants islands and floating wetlands as nature-based solution to water pollution (Sources: LivingWaters, Water Environment Federation)

Another option would be to increase the capacity of the existing STP and direct more flow via the intake to the STP in order to treat a larger proportion of the incoming water. As mentioned a batch process as currently in place seems unfavorable given the large variation in hydraulic load across the year. Thus, the area could be transformed to a constructed wetland with an overflow at the current lake inlet.

The removal efficiency for two of the most critical parameters, Total Suspended Solids (TSS) and iron, in constructed wetlands is generally high, typically ranging from 70% to 90%, depending on factors such as type of constructed wetland, hydraulic retention time (HRT), plant species and substrate composition: The presence of certain minerals can aid in the adsorption of iron.

Figure 7: Schematic and example of a constructed wetland for water treatment (Sources: Global Wetland Technology, Biomatrix)

An additional beneficial factor is the fact, that the local government has already implemented a floating wetland system at Selvachintamani Lake. Hence, operational experience exists and scaling on these experiences might prove more cost effective. Further, synergistic effects include increased biodiversity potential, carbon storage and a higher quality of stay for visitors.

Kumaraswamy Lake

Water Quality Analyses

Kumaraswamy Lake is located to the North-West of Coimbatore's city center. It receives the overflow from Selvampathy Lake. It is likely that additional inlets exist that result in stormwater and wastewater entering the lake. CCMC is currently planning the installation of a 15.43 MLD STP on the south shore of the lakes to treat incoming waters from the southern catchment. Water from Kumaraswamy Lake continues to a channels that leads to the inlet of Selvachintamani Lake further south. Thus it is interesting to compare the outlet of Kumaraswamy with the data for the inlet at Selvachintamani Lake.

At Kumaraswamy Lake a similar pattern could be observed as at Selvachintamani Lake. Elevated levels of Iron, Turbidity, Lead, Chromium and Total Nitrogen could be identified. While Total suspended solids, BOD and COD exceeded the standards set out by the TNPCB the values remained within the permissible range set out by the CPCB. The BOD/COD ratio of 0.17 indicates a high-degree of non-biodegradable compounds in the water, making it challenging to design any biological water treatment options.

It should be kept in consideration that the waters tested are not STP effluents. The interpretation is a mere indication which parameters require further attention.

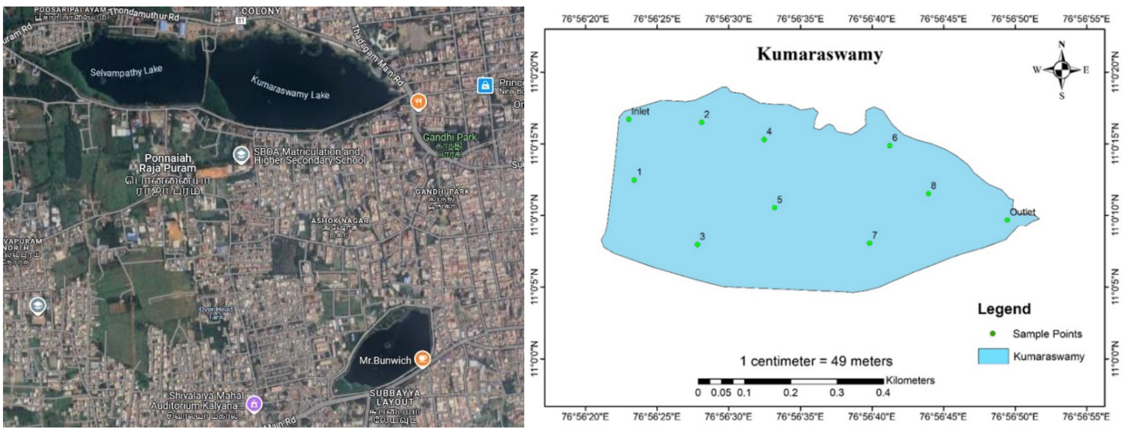


Figure 8: Location and map of Kumaraswamy Lake (Satellite Image by Google Maps ©2025 Google; Lake map provided by Tamil Nadu Agricultural University)

Table 3: Water Quality Analyses for Kumaraswamy Lake Inlet; Data generated by TNAU on behalf of AQUA-Hub

Parameter	Unit	CPCB Standards		TNPCB Standards	Inlet
		acceptable	permissible		
pH		5.5-9	no relaxation		8.6
EC	µS/cm	750	2250		1507
TDS	mg/L	500	2000		968
TSS	mg/L	100	600	20	110
Turbidity	NTU	1	5		53.75
Ca	mg/L	75	200		119
Mg	mg/L	30	100		58
Hardness	mg/L	200	600		297
Chloride	mg/L	250	1000		340
DO	mg/L	≥4	not < 3.5		5
BOD	mg/L	5	30	10	19
COD	mg/L	20	250	50	112
Coliforms	MPN/100ml		500	230	129
Fe	mg/L	0.3	1		1.98
Mn	mg/L	0.1	0.5		0.28
Zn	mg/L	5	15		0.04
Cd	mg/L		0.0003		0
Pb	mg/L		0.05		0.3
Cr	mg/L	0.05	no relaxation		0.07
Hg	mg/L	0.01			0
Total Nitrogen	mg/L		20	10	18.7
Phosphates	mg/L		5	1	0.06

Outlet Kumaraswamy Lake – Inlet Selvachintamani Lake

The available data from both sites gives an indication on water quality changes between the two water bodies. From Figure 9 it becomes clear that the water from Kumaraswamy Lake flows to Selvachintamani Lake via a connecting open channel. The length of the channel is approximately 1.2 km. Table 4 shows the compared data for both locations. While for many parameters only a small change can be observed, the increase in Fe, TSS, Mn and Zn is quite significant. At the same time DO reduces almost by half, indicating a high oxygen consumption by biological processes. One possible explanation is additional surface runoff from the surrounding streets and estates, while additional entries of industrial and household wastewater is also possible.

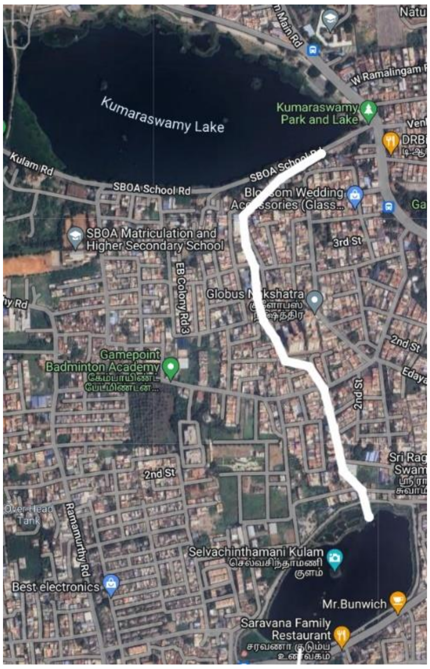


Figure 9: Aerial image of Kumaraswamy and Selvachintamani Lakes. The two lakes are connected via an open channel (white line); Satellite image by Google Maps ©2025 Google

Table 4: Changes in water quality between Kumaraswamy Lake outlet and Selvachintamani Lake inlet; Data generated by TNAU on behalf of AQUA-Hub

		K_outlet	S_inlet	Relative change
pH		9.5	7.5	79%
EC	µS/cm	1489	1173	79%
TDS	mg/L	956	646	68%
TSS	mg/L	98	250	255%
Turbidity	NTU	58.1	57.4	99%
Ca	mg/L	120	136	113%
Mg	mg/L	61	49	80%
Hardness	mg/L	289	299	103%
Chloride	mg/L	276	210	76%
DO	mg/L	6.8	3.8	56%
BOD	mg/L	17	29	171%
COD	mg/L	101	135	134%
Coliforms	MPN/100ml	115	149	130%
Fe	mg/L	0.3	3.50	1167%
Mn	mg/L	0.09	0.18	200%
Zn	mg/L	0.07	0.29	414%
Cd	mg/L	0	0	
Pb	mg/L	0.2	0.01	5%
Cr	mg/L	1.01	0.09	9%
Hg	mg/L	0	0	
Total Nitrogen	mg/L	12.1	12.7	105%
Phosphates	mg/L	0.02	0.02	100%

Treatment options for Kumaraswamy Lake

Development of a treatment concept for Kumaraswamy Lake is a challenging task. Firstly, it is not entirely clear how many inlets of water exist at this lake. The most obvious one, and probably most significant one, is the overflow from Selvampathy Lake. Thus, the most efficient and sustainable approach would be to address inflows to Selvampathy Lake. While a central water transfer point and a more predictable flow makes it technically a suitable location for a continuous water treatment system or even a batch process, the available land is limited. pH, TSS, organics, nitrogen and iron are the most crucial parameters derived from the water analysis. A potential solution could be a rotating contactor system that is powered by the water flow. It could be place beneath the bridge providing a surface for microorganisms to grow and treat and passing water. Because commonly these systems are not placed in flowing regimes some engineering adaptations are required especially regarding the engine of the system via natural water flow.

On the other hand, a nature based approach as suggested above, could also be beneficial at Kumaraswamy Lake. The areas in front and behind the sluice could be used for a vast area of floating wetland system (see Figure 11).

Figure 10: Example of a rotating disc contactor for wastewater treatment (Source: NetSolWater).

Figure 11: Potential coverage of a floating wetland system at Kumaraswamy Lake inlet; Satellite images by Google Maps ©2025 Google

Chinnakulam Lake Inlet

Water Flow & Quality Analyses

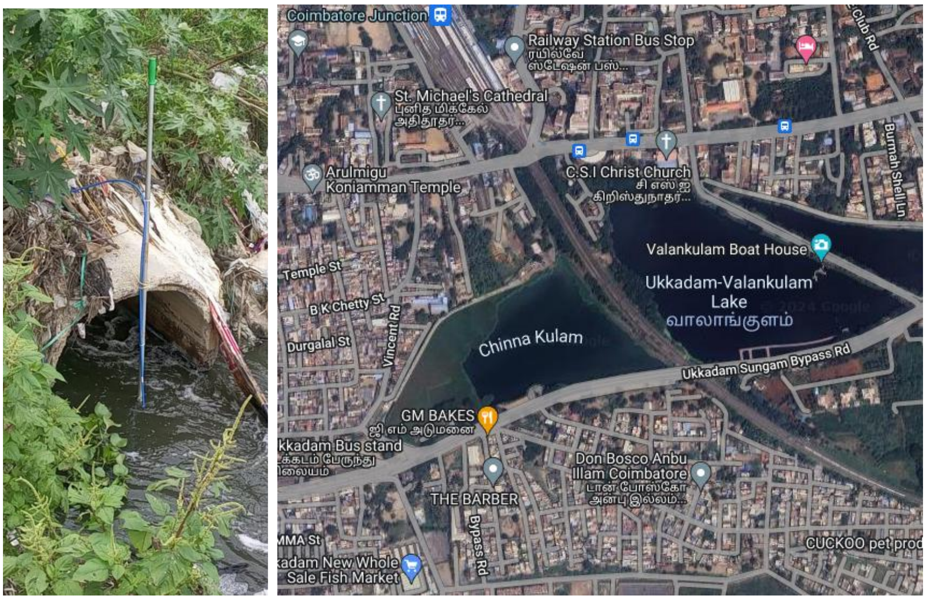


Figure 12: Water inlet and location of Chinnakulam Lake; Lake inlet photo by AuM Systems, Satellite image by Google Maps ©2025 Google

Table 5: Water Quality Lake Analyses of Chinnakulam Lake inlet, Data generated by TNAU on behalf of AQUA-Hub

Parameter	Unit	CPCB Standards		TNPCB Standards	Inlet concentr.
		acceptable	permissible		
pH		5.5-9	no relaxation		9.6
EC	µS/cm	750	2250		1716
TDS	mg/L	500	2000		1178
TSS	mg/L	100	600	20	378
Turbidity	NTU	1	5		65.8
Ca	mg/L	75	200		162
Mg	mg/L	30	100		71
Hardness	mg/L	200	600		479
Chloride	mg/L	250	1000		299
DO	mg/L	≥4	not < 3.5		3.1
BOD	mg/L	5	30	10	41
COD	mg/L	20	250	50	151
Coliforms	MPN/100ml		500	230	169
Fe	mg/L	0.3	1		5.2
Mn	mg/L	0.1	0.5		5
Zn	mg/L	5	15		1.3
Cd	mg/L		0.0003		0
Pb	mg/L		0.05		0.7
Cr	mg/L	0.05	no relaxation		0.4
Hg	mg/L	0.01			0
Total Nitrogen	mg/L		20	10	14.1
Phosphates	mg/L		5	1	12

Treatment options for Chinnakulam

At Chinnakulam inflow a high pH and high presence of metals and nutrients can be observed along with a high turbidity and low oxygen content. It becomes eminent that the water flowing into the lake affects the water quality, negatively. With a flow of several 100 m³/h and 10,900 m³ over the 24 hour monitoring period the treatment of such amounts of water becomes challenging. During preparation of this study the local government has initiated the implementation of an STP at the lake inlet. It is currently unclear which processes will be implemented here. In order to further contribute to the water quality improvements, the green area northeast of the STP poses a potential of additional treatment measures. In absence of a detailed land survey, it can only be postulated that anchored floating wetlands along the inlet canal or an integration of a constructed wetland e.g. with horizontal surface flow could decrease the pollution load entering the lake, while reducing water velocity.

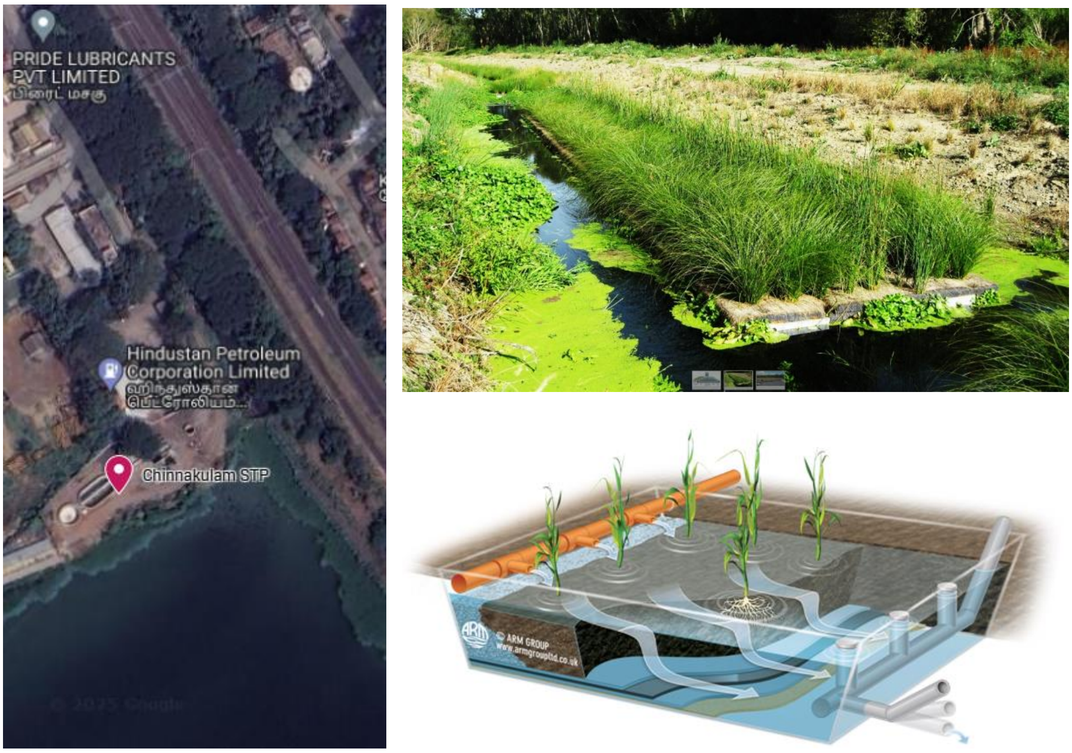


Figure 13: Aerial view of the Chinnakulam Inlet (Credit: Google Maps ©2025 Google). The construction of an STP is currently underway. Top right: example of a floating wetland in a canal (Photo: Department of Environment, Science and Innovation, Queensland); Bottom right: principle of a horizontal surface flow constructed wetland (Source: Global Wetland Technology)

Valankulam Lake Inlet

Water Flow & Quality Analyses

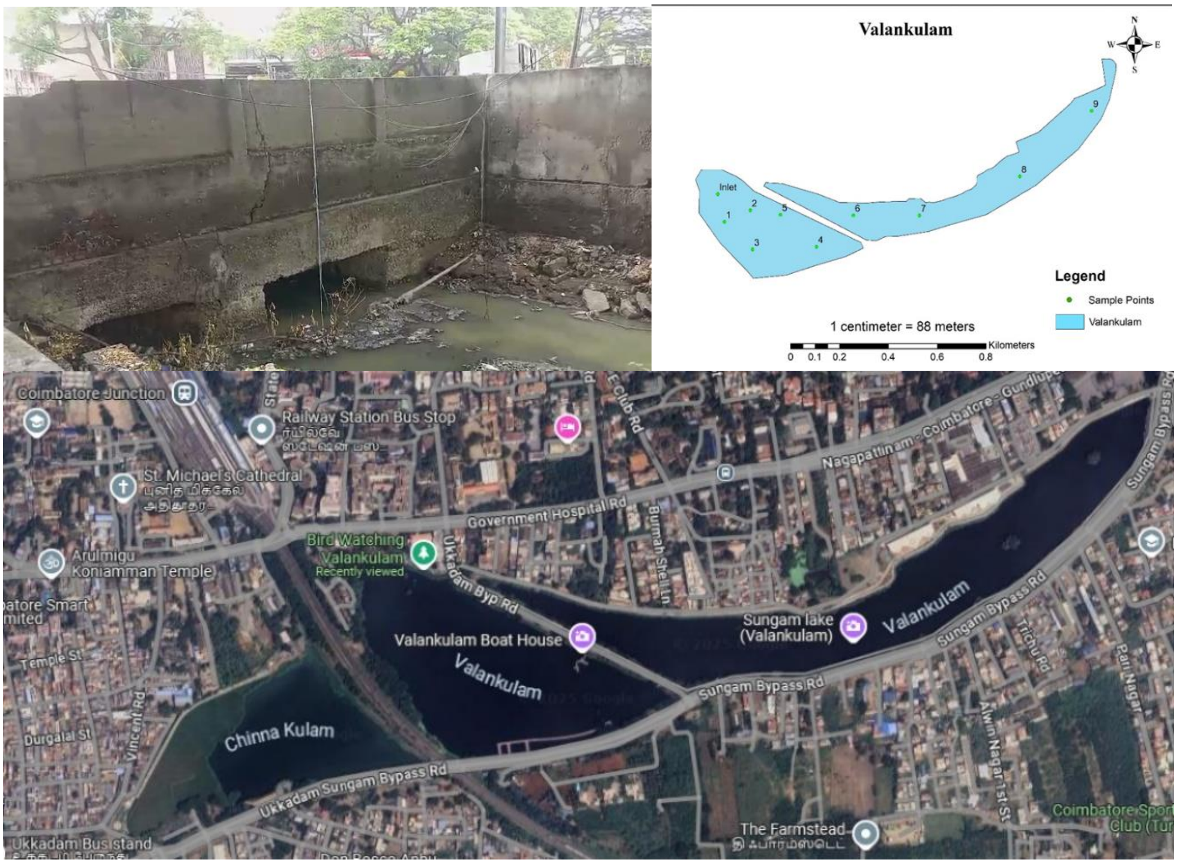


Figure 14: Inlet and map of Valankulam Lake; Inlet photo by AuM Systems, Lake map by TNAU, Satellite Image by Google Maps, ©2025 Google

Table 6: Water Quality Analyses of Valankulam Lake inlet, data generated by TNAU on behalf of AQUA-Hub

Parameter	Unit	CPCB Standards		TNPCB Standards	Inlet concentr.
		acceptable	permissible		
pH		5.5-9	no relaxation		9.2
EC	µS/cm	750	2250		1846
TDS	mg/L	500	2000		1194
TSS	mg/L	100	600	20	384
Turbidity	NTU	1	5		59.4
Ca	mg/L	75	200		183
Mg	mg/L	30	100		78
Hardness	mg/L	200	600		552
Chloride	mg/L	250	1000		309
DO	mg/L	≥4	not < 3.5		3.4
BOD	mg/L	5	30	10	38
COD	mg/L	20	250	50	179
Coliforms	MPN/100ml		500	230	175
Fe	mg/L	0.3	1		5.1
Mn	mg/L	0.1	0.5		1.4
Zn	mg/L	5	15		0.11

Cd	mg/L		0.0003		0
Pb	mg/L		0.05		0.13
Cr	mg/L	0.05	no relaxation		0.1
Hg	mg/L	0.01			0
Total Nitrogen	mg/L		20	10	13
Phosphates	mg/L		5	1	0.02

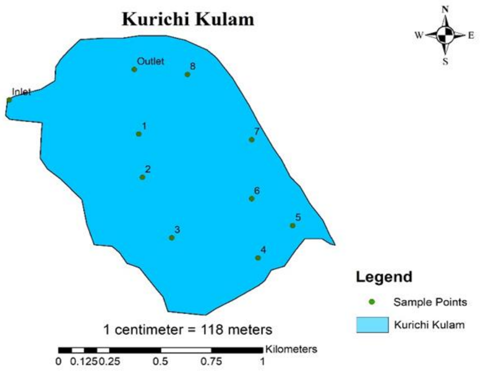
Treatment options for Valankulam Inlet

Valankulam Lake has a 3 MLD STP, is set to receive an additional 2 MLD unit to further improve water quality. This expansion is part of CCMC's ongoing efforts to treat wastewater before it enters water bodies. However, it is not entirely clear whether the STP receives the inflow that has been identified during this study. It is very likely that two separate water inflows to the lake exist. Flow monitoring at the lake inlet selected in this study observed a daily flow of around 2000 m^3. This could bear the option to dam up the water and feed it into a batch-type process if the available land is suitable for this operation. Given the high amounts of metal, in particular iron, nitrogen and the elevated pH an advanced treatment involving coagulation, flocculation and pH neutralization would pose a pollution relief. The challenge lies in the unfavorable BOD/COD ratio of 0.21, indicating the presence of non-biodegradable substances. A multimedia trickling filter consisting of coarse and fine substrates to bind the metals while providing a surface for microorganisms to grow on could drastically improve the water quality. Another option could be a rotating contactor as discussed for Kumaraswamy Lake. Similarly, engineering of such a structure should take into account the water flow to drive the rotation. Finally, nature-based solutions like constructed wetlands or floating wetlands could possibly be integrated into the inlet structure and blend into the environment. However, it can be expected that the metal uptake and adsorption might be less efficient than in technical systems.

Kurichi Lake Inlet

Water Flow & Quality Analyses

Water quality at Kurichi Lake Inlet to the southern center of Coimbatore, is characterized by high turbidity, a low BOD/COD ratio (0.19) increased levels of iron and nitrogen. Overall, the water quality seems to be a bit better than for the other studied locations. Likely this is attributed to the higher flow. By far the highest flow was monitored for Kurichi Lake (121,572 m^3/24 hours). Thus, it can be expected that a significant dilution effect contributes to these water analysis results. However, due to the proximity to the Noyyal River it is very likely that a significant proportion of that increased water flow derives from water originating from the river flowing into Kurichi Lake.



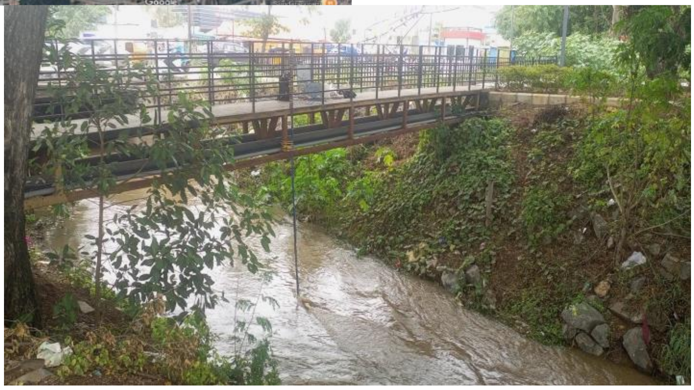


Figure 15: Map and Inlet of Kurichi Kulam Lake; Satellite image Google Maps ©2025 Google; Lake map created by TNAU, Inlet photo by AuM Systems

Table 7: Water quality analyses of Kurichi Kulam Lake inlet Data generated by TNAU on behalf of AQUA-Hub

Parameter	Unit	CPCB Standards		TNPCB Standards	Inlet concentr.
		acceptable	permissible		
pH		5.5-9	no relaxation		8.4
EC	µS/cm	750	2250		1517
TDS	mg/L	500	2000		1099
TSS	mg/L	100	600	20	149
Turbidity	NTU	1	5		58.4
Ca	mg/L	75	200		139
Mg	mg/L	30	100		51
Hardness	mg/L	200	600		372
Chloride	mg/L	250	1000		281
DO	mg/L	≥4	not < 3.5		4.8
BOD	mg/L	5	30	10	23
COD	mg/L	20	250	50	118
Coliforms	MPN/100ml		500	230	115
Fe	mg/L	0.3	1		2
Mn	mg/L	0.1	0.5		0.2
Zn	mg/L	5	15		0.1
Cd	mg/L		3		0
Pb	mg/L		0.05		0.1
Cr	mg/L	0.05	no relaxation		0.02
Hg	mg/L	0.01			0
Total Nitrogen	mg/L		20	10	16.1
Phosphates	mg/L		5	1	0.009

Treatment options for Kurichi Lake Inlet

Improving the water quality flowing into Kurichi Lake is challenging due to the vast amounts of water flowing in from the Noyyal River. It seems unrealistic to establish a treatment concept at the inlet. Most areas adjacent to the riparian zones of Kurichi Lake are densely built-up. Thus, preventing effluent from street run off and buildings are of highest priority. Developing the remaining riparian zone or even extending it by artificially implemented nature-based elements (e.g. wetlands) could improve the overall quality of Kurichi Lake water quality. This could be complemented by an increased number of floating wetlands in other parts of the lake. However, the greatest environmental impact would come from a stormwater and wastewater collection system that directs polluted water to adequate treatment facilities.

8. Water Monitoring Analyses

The water quality analyses were conducted for 49 locations in total, resulting in 1078 water quality data points. These include sampling points from other locations than the inlets. The monitoring campaign was conducted during the monsoon season in 2024. When compared against the water quality standards set out by the CPCB and the TNPCB, it can be observed that overall, 78% of all samples taken fall at least within the permissible range of the CPCB. Table 8 illustrates the proportion of compliance for each parameter.

Table 8: Ratio of water samples complying with CPCB standards

	Unit	CPCB Standards		Within acceptable	Within permissible	Non compliant
		acceptable	permissible			
pH		5.5-9	no relaxation	65%		35%
EC	µS/cm	750	2250	0%	100%	0%
TDS	mg/L	500	2000	0%	100%	0%
TSS	mg/L	100	600	10%	90%	0%
Turbidity	NTU	1	5	0%	0%	100%
Ca	mg/L	75	200	0%	100%	0%
Mg	mg/L	30	100	0%	100%	0%
Hardness	mg/L	200	600	0%	100%	0%
Chloride	mg/L	250	1000	29%	71%	0%
DO	mg/L	≥4	Not < 3.5	73%	90%	10%
BOD	mg/L	5	30	0%	65%	35%
COD	mg/L	20	250	0%	100%	0%
Coliforms	MPN/100ml		500	0%	100%	0%
Fe	mg/L	0.3	1	0%	18%	82%
Mn	mg/L	0.1	0.5	14%	41%	45%
Zn	mg/L	5	15	100%	100%	0%
Cd	mg/L	0	0.0003	0%	100%	0%
Pb	mg/L	0	0.05	0%	20%	80%
Cr	mg/L	0.05	no relaxation	16%	20%	80%
Hg	mg/L	0.01	no relaxation	100%	100%	0%
Total Nitrogen	mg/L	-	20	0%	94%	6%
Phosphates	mg/L	-	5	0%	82%	18%

Overall, it can be observed that Turbidity levels for all samples exceeded the respective standards. This is closely associated with a high concentration of TSS for most samples, although they comply with the standards set out by the CPCB. Further, with average of 0.2 the BOD / COD ratio indicates a strong presence of non-biodegradable organic compounds which can be attributed to commercial or industrial effluents entering the water systems as also indicated by the presence of metals such Iron, Lead and Chromium. However, these might not be caused by direct inflow from the original location but could also find their way via street and surface run-off.

With regards to the Standards set out by the TNPCB no sample complied with the values for TSS and COD. Only 2% of samples complied with the BOD standard, while for nutrients 27% (Total Nitrogen) and 82% (Phosphates) complied with the standards. On the other hand, all samples complied with the standard set out for Coliforms. While these results indicate a significant presence of solids, organics and nitrogen entering the surface water system in Coimbatore, it should be kept in mind that only few samples in a limited period of time were taken. Furthermore, the standards set out by TNPCB refer to STP effluent and samples were taken from water bodies that indeed receive STP effluents, but where the majority of water influx is attributed to stormwater and in some cases even directly affected by the Noyyal River. Hence, influxes from diffuse sources play a crucial role. Nevertheless, the results highlight areas that require special attention in the future to improve Coimbatore's surface waters' quality.

In addition, some environmental factors come into play. The analyses revealed high levels for iron in most samples. This can also be attributed to geological factors as iron-bearing minerals and rocks in the geology of the region might result in natural weathering and leaching processes that release iron into ground and surface water, especially during heavy rains or monsoons. Groundwater in Coimbatore often has high iron concentrations, which can mix with surface water through springs or seepage. In regions where iron-rich groundwater is used for irrigation, surface runoff and infiltration from agricultural fields can carry iron into water bodies. A significant stretch of the Noyyal River upstream of Coimbatore is characterized by agricultural activities that might contribute to water quality in Coimbatore's lake system but outside of the local authorities jurisdiction. Additionally. In stagnant or poorly aerated water bodies (e.g., tanks, ponds) with anoxic conditions, iron in sediments can dissolve into the water. This is particularly common during the dry season when water levels drop.

9. Summary

The present study aimed at identifying potential measures to address water quality issues in Coimbatore's urban lake and canal issues. This exercise was conducted in order to support initiatives by local stakeholders such as the local government and NGOs. One objective is to expand the network of STPs and treatment capacities for waters entering the lake. From the analyses conducted it becomes clear that it is a challenging tasks. On the one hand, the local government is challenged with the situation that in theory the respective regulations are in place to reduce the discharge of and untreated sewage and wastewater to Coimbatore's waters. As seen above, according to the Tamil Nadu Combined Development and Building Rules, 2019 and estates with a certain water consumption are required to provide adequate treatment systems on their premises. However, with only limited resources to monitor compliance with these regulations and enforcing them, it becomes extremely challenging for any authority to rely solely on regulations. Thus, treatment of streams that flow into the lakes can make sense as an intermediate solution until the regulations are adopted more widely and the number of treatment systems increases. However, as seen from the analyses, proposing a treatment concept is challenging due to various reasons. Firstly, due to the monsoon season and the connection to the Noyyal River any STPs designed to treat lake inlet water need to accommodate for a significant variation in water flow. At the same time, the water quality analyses showed an overall low potential for biodegradability (low BOD/COD ratio). Accompanied by the strong presence of metals including several heavy metals, these characteristics pose challenges to conventional biological treatment systems such as activated sludge process. Thirdly, the availability of land in the urban center of Coimbatore makes it challenging to find enough space to implement STPs with sufficient size to actually impact the water quality of the lakes. With more space available on the actual water bodies themselves, the integration of nature based solutions, such as constructed or floating wetlands, pose a viable option that includes additional benefits. With lower investment and operational costs and positive impacts on the beautification of the environment, carbon storage and biodiversity, these plants can contribute to water quality improvements. However, as several initiatives of this kind already exist in the city, there is a limit to the treatment capacity such nature-based solutions can have, especially in terms of removal of metals and non-biodegradable substances. For higher impact they need to be combined with technical systems for example to solids removal (velocity reduction, filtration, bar screens etc.) and other advanced treatment forms. A beneficial aspect of an increased focus on nature-based solutions is the complementarity to the city's plans to expand sewer coverage and implementation of measures to monitor enforcement of existing regulations. As these measures are expected to have the greatest impact on the quality of Coimbatore's waters. However, expansion of nature-based solutions is not limited to the lakes themselves. A coordinated approach to stormwater collection, storage and controlled release can be supported by green infrastructure elements and eventually reduce the load entering the lakes.

10. Limitations of the study

It is important to emphasize that the study was conducted under varying and challenging circumstances. Initially conceptualized in 2022 during the COVID-19 pandemic the study had planned to use more advanced spatial analysis tools and georeferenced data in order to conduct higher level analyses. It was planned to take into account GIS Data to assess elevation profiles, flow regimes and land characteristics (building types, land use etc.) in more detail. However, despite various efforts on multiple levels to acquire the respective data alternative approaches had to be explored. It is clear that the present data on water quality and flow regimes are limited and larger observation timeframes would be required in order to further design and detail any planned interventions. The experiences made here and under the AQUA-Hub project underline the complexity of the challenges associated with the improvement of Coimbatore's environmental water quality in this densely built-up location. And despite the many initiatives undertaken by the many motivated stakeholders in Coimbatore, which have led to various improvements over the years, the overall situation remains challenging. However, we hope that this study supports further initiatives and provides inspiration for any political, scientific, commercial or voluntary activities in the future.

Imprint

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