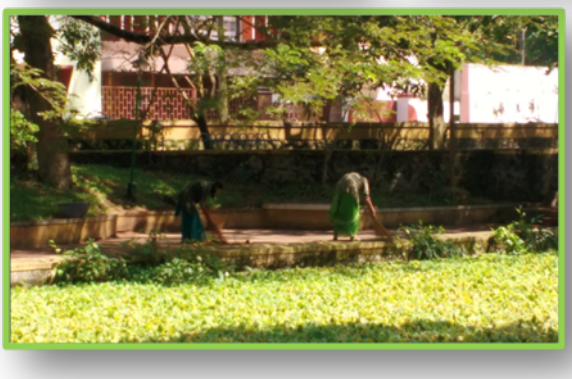
Winter School - 2017

Participatory Water and Sanitation Assessment

for Alappuzha Town

Prilimnary Report and Way Forward



INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

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SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY, COCHIN

SSET

Winter School - 2017

Participatory Wastewater Assessment for Alappuzha Town

Preliminary Report and Way Forward

by

Centre for Policy Studies, IIT Bombay and SCMS College of Engineering &Technology

Supported by

Kerala Institute of Local Administration (KILA)

December, 2017

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Cover photos: IIT Bombay

Contents

Acknowledgements

The trigger and inspiration behind this project is Dr Thomas Isaac, Hon Minister of Finance and Coir and we thank him for spending valuable time with us on three days that helped stimulate students' enthusiasm and sharpen our focus. We thank Mr G Sudhakaran for inaugurating the closing event and his support throughout. Mr Thomas Joseph the Chairman of Alappuzha Municipal Council was present at our opening and closing sessions and was an eager partner in this endeavour with his colleagues and officials. The District Collector Mrs Anupama TV triggered enthusiasm of the students by her presence and motivation from the beginning. Students were our core strength and we thank the students of CTARA, IIT Bombay and SCMS College of Engineering for their hard work, perseverance and attitude to work continuously in the field and into late hours for analysis. We thank Dr Ratish Menon, Dr Aswathi EV , Mrs Merim Mathew and Eldo Abraham of SCMS Engineering College for their support in water quality analysis And Dr Zachary Burt for his presence and help in identifying the appropriate mobile apps. Neelam Rana and A Sridhar of IIT Bombay were our pillars of strength from the planning stage to execution of the winter school. M.R. Prem, Municipal Councillor quickly became our team member and later the official Convener of the programme. He with the unstinting support and energy of Rohit Joseph and Anoop John made the logistics possible. We were amazed by their social capital, especially the way they mobilised more than 20 volunteers to help with the logistics. Without the total dedication of Neelam, Sridhar, Prem, Rohit and Anoop this winter school would not have been possible and we thank them from the bottom of our heart. We thank the employees of the Kerala Coir Machine Manufacturing Company for providing us a space to work and conduct our public meetings. Tony Jose and Jose Nellukaran opened their home stays to us to use as our private spaces that made our stay in Alappuzha productive and enjoyable. We thank Prof. Satish Agnihotri, Head, Centre for Policy Studies and Centre for Technology Alternatives for Rural Areas (IITB) for his support right from the conception of the school. We thank the colleagues and staff of CTARA, IIT Bombay, KILA and SCMS Engineering College for their support to the winter school.

Prof. NC Narayanan, CTARA, IIT Bombay
Dr Joy Elamon, Director, KILA
Dr Sunny George, Director, SCMS Water Institute

Executive Summary

The small and medium towns have huge infrastructure deficit with respect to wastewater management since they lack the technical, financial and institutional capacity for conventional sewerage management systems. The National Urban Sanitation Policy - 2008 questions the sustainability of the conventional approach with respect to cost effectiveness and its ability for universal coverage. The policy recommends cities to use appropriate technology options suiting their need, capacity and context.

To address this challenge the Indian Institute of Technology-Bombay (IITB) has developed a protocol for participatory decentralised data collection for water and wastewater/sanitation infrastructure, services and practices. In this protocol we proposed a replicable approach to a situational analysis of prevailing sanitation and wastewater practices by treating local municipal government as the locus of sanitation interventions and by engaging academic institutions to develop socio-spatial zones as unit of technological, social and governance interventions.

Alappuzha town, situated on the Western Coast of Kerala, has expressed interest and intent to engage in a similar exercise. Intertwined with cross-cutting canals, it lacks comprehensive sewerage network and relies on septic tanks – a primary mode of treatment and soakpits. The partially and untreated wastewater either leads to subsurface soil or drains into the canals. The flat topography and high-water table make it further difficult to establish conventional sewerage network system. The situation presents a challenge and an opportunity to explore heterodox options of sanitation and wastewater management.

As part of the **Winter School (November 27th – December,4th 2017)** the 19 students of Centre for Technology Alternatives for Rural areas (CTARA), IIT Bombay and 16 students of Environmental Engineering of SCMSSET jointly engaged in an academic exercise. IIT Bombay is the knowledge partner to train students on drain mapping using GIS tools,

wastewater mapping and a household survey. SCMS – Water Institute have provided lab support for water quality analysis.

The key **objectives of the Winter School -2017** were to conduct a) drain mapping and wastewater quality assessment of major canals and sub canals; b) household survey to understand water, sanitation and wastewater management practices. The idea was to provide a platform to students to interact with and learn from the experts, practitioners and local people to go beyond classroom learning and understands the complexities of waste water and sanitation issue. It is intended to lead to a participatory sanitation plan inclusive of pollution mitigation for the Municipality.

The three major tasks include (**i) drain mapping; (ii) water pollution sampling and (iii) socio-economic survey** at household level. The school focused on four major canals Vadai, Commercial, east and West Bank Canals and nine inlets. We followed a canal shed approach instead of selecting political boundaries as unit of data collection and analysis. About 17 polygons around four canals (vadai, commercial, east and west bank) along with their respective inlets (forming a canal shed) were targeted.

Drain Mapping: The mapping was conducted using OSM tracker app (an offline GPS tracker) that helps in tracing the canals while taking transects. The exercise resulted into production of 9 major tracks along the 4 canals and key inlets with important point features such as solid and liquid waste dump sites, encroachments and eutrophicated stretches. The output of the exercise is a GIS map of major canals (as polygon features) with pollution issues and/or hotspots plotted on the ward and drain map. The maps are visual representation of key hotspots and problematic areas along / in the commercial, vadai, east and west bank canals, which can be used to design future technological, social and governance interventions. Eg. East bank canal found to have major eutrophication stretches, encroachments and urban sewage release. Similarly, two sub canals (in Zilla Court area) entering into Vadai Canal found to have issues with respect to solid waste dumping and liquid waste discharge.

Water Pollution Sampling: A total of 17 sampling points were selected based on position of drains/sub-canal openings and location of hotspots provided by the

Municipality. Water quality at selected sampling locations was determined using portable kits for critical parameters i.e. dissolved oxygen, Coliform, ammonia, turbidity, pH and phosphates. Presence of Ammonia and coliform bacteria in most of the samples confirms release of human excreta /septage into the canals. Low Dissolved oxygen in almost all the samples indicates that canals are not able to rejuvenate their water. The key issue here is obstructions due to encroachments, waste dumping and eurtophication. All the canal stretches were found to have the presence of faecal coliforms indicating sewage contamination. The water quality parameters indicate that commercial canal receives comparatively higher waste water contamination than Vadai canal. Among the sub canals, Upputty canal and Dock thodu had lesser sewage inflow. Water is stagnated in the west end canal stretches which are also influenced by salinity intrusion. Seasonal analysis is recommended to confirm these findings. Rejuvenation of the canals would require control of sewage inflow, reduction of sewage concentration through pre-treatment (mandatory STPs for commercial establishments, proper septic tanks for households and natural treatment at the end of sub canals) and aeration of canals to increase dissolved oxygen to the safe levels for aquatic fauna. However, a pilot rejuvenation initiative has to be tested before implementing for the entire canal.

Socio-economic survey: Total 476 households were surveyed along 17 polygons. The questionnaire included set of questions relating to services, sanitation infra, solid and liquid management practices, general awareness and public health. The teams were also asked to take geolocation of the functional well and septic tank to ascertain the distance between the two point features. The ODK Collect– a mobile based app was used to collect data, take photos, take geolocations and to send the responses to Google drive. The collated data was then analysed under the four themes i.e. a) Access to services and infrastructure for water supply and sanitation; b) waste management practices ; c) public health ; and d) general awareness. The key sectoral highlights are as follows:

Solid Waste Management: Majority of households segregate the wet and dry waste. Self motivation seems to be the driving force. However, collection is an issue as currently there is no provision of door to door collection. Conflict is visible in people's demand

(door to door collection) and municipality's decision not to provide door to door collection. Interestingly, people of **Alappuzha** are willing to pay for door to door collection. Lack of better option is making the canals and land pollution sinks. The current conflict between accepted solution of need for waste collection by the citizens and municipality's decisions not to has to be negotiated and resolved. Municipality's concern of not allowing piling at landfills and citizen's demands for going beyond individual responsibility to be matched at community level solutions actively taken up by citizen groups to be supported by municipality. The continued in difference from both sides can lead to the loss of already developed decentralised systems of SWM.

Liquid Waste Management: Separate management of grey and black wastewater is a common practice in households – a positive behavioural practice that municipality need to capitalize on. Survey shows high dependence on septic tanks and less on soakpits. However, current toilet disposal methods especially septic tanks and soakpits need town level enumeration supported by better methodological tools in order to assess if septic tanks are scientific or not (elaborated in path ahead section). This is an issue of public health specifically for households that depend on well for drinking water and fail to maintain desirable distance of 6 meters. The survey could not establish causality between septic tank –well distance, well as primary source of drinking water and incidences of diseases at household level. A systematic analysis of this particular aspect is recommended.

Public Health: Few reported occurrences of water / mosquitoes borne diseases. Interestingly, despite reliance on perceived unsafe water resources such as well and public stand posts the water borne disease incidence reportage is low for such cases. This could be due to high dependence on KWA for drinking water and water treatment practice common to Kerala households. The secondary data from District Medical Office presents a worrying picture of increased incidences of dengue fever and leptospirosis in monsoon times.

Environment Health of Alappuzha Canals: People of Alappuzha feel that the environmental health of the town has degraded in past 10 to 15 years. Among many, the

most common issue highlighted is ineffective solid waste management including tourist waste. Related issues are canals being encroached and used as sinks. Hence, canals once a resource currently have no utility for the people. However, majority of the respondents are aware of ("others" using) canals as sinks of pollution.

Recommendations

The Winter School -2017 helped in identifying key sectors eg. solid and liquid waste management and inter-related issue of canal health that need immediate attention. Specific recommendations including key areas identified as future scope of work to obtain better understanding on forward and backward linkages of liquid and solid waste management for the town are:

Liquid Waste Management

- Septic tank Census (Number, Functionality…) on an urgent basis. Need to fix unscientific Septic tanks.
- Cost comparison of septic tank retrofitting with septic tank replacement with better options. Understanding willingness to pay for different options of improved services.
- Use of Local appropriate technology like honey suckers
- Municipal responsibility to schedule and monitor tanks' cleaning, desludging (5 yr cycle)
- Feceal Sludge Management (FSM) and green jobs creation based on quality of sludge generated. Devanahalli , Bangalore an example
- Technological Interventions for bigger/major canals is a black box, which we need further discussions. Cost of DEWATs type of systems for small canals.

Solid Waste Management

- Municipality need to capitalize on the existing positive behavioural practice of solid waste segregation to design suitable interventions such as green enterprises based on compost/biogas.

- Need to institutionalise Kudumbshree or similar self help groups for door-to-door collection for effective management. Effective downstream management of waste is then needed.

- Need interventions to manage tourist waste especially plastic waste. Coir bottles with coconut base can be used to replace bottled water in major hotels and houseboats. This can help in generation of jobs and revenues for the Coir Board.

- Need to assess quantity and quality of solid waste generated from different sources to plan economic interventions, incentives and penalties'. Detailed regulatory recommendations to be workout for this option.

Public Health

- Need to capitalize on existing cultural practices of Kerala especially medicated water on larger scale to manage plastic bottle waste and public health concerns.

- Need to design a scientific study to differentiate septic tanks from Soakpits.

- Need to design a study to establish relationship between public health, drinking water source water logging and toilet waste disposal mechanisms.

- Need to design a study for seasonal analysis of water quality is needed along major canals and their inlets.

- Well water quality analysis (focus on Ecoil and other pollutants responsible for water borne diseases) for houses within permissible limit of distance between soakpit/septic tank and well and for houses outside the limit. Need to collaborate with local institutions.

Canals: Moving from sinks to resources

Interventions needed to collect and manage solid waste. Interventions needed to enhance canals' social, ecological and economic value for people of Aleppey.

Path Ahead

Main Message to go: Canals are not wastewater drains, but a heritage to be Conserved

Canals are now considered wastewater drains. 96% of the people see no utility for the canals. This is to be reversed as canals as heritage resources to be conserved. Several inter-related activities to be planned.

1. **Technological Interventions**

a) **Main Canals**: De-weeding, Dredging and Deepening—Needs deeper studies and wider discussions on the technology to be deployed, nature of waste segregation/treatment and economic activities (boating, canal side commercial activities, beautification etc).

b) **Sub Canals and Main Drains:** (i) Cleaning-up the last stretch/outfalls to main canal by suitable treatment mechanisms (natural systems like DEWATS/small STPS/Other technological options?

2. **Averting the Tragedy of Commons**

There is no incentive for the individuals to comply with positive steps in keeping the canals clean. Any personal sacrifice like better septic tanks, onsite treatment of biodegradable waste does not guarantee immediate rewards. This attitude leads to degradation of environment, resources with canal/well/lake pollution in Alappuzha as typical examples. Pollution in canals has to be stressed not only as an aesthetic issue, but a public health and hence social problem It is proven that top down regulation or policing by State seldom works for pollution abatement unless there is a community Consensus Building for Social Regulation[1]. A 'community' with levels of nested institutions has to be built around the canal sheds from small drains to main canals. They have to devise norms/rules/activities of influencing individual behaviour. The structure in which individual behaviour gets enabled or constrained is also important. Most of the people see polluted canals as the responsibility of the municipality. This has to be transformed to make citizens responsible to deal with their wastes and simultaneously to make the municipality accountable.

[1] Positive examples in GW Management – Ralegaon Siddhi, Hiwre Bazar, Pani Panchayat in Maharashtra

3. Students' Campaign: From awareness to Behavioural Change

How does citizen awareness, gets translated into deeper behavioral changes is the challenge? The proposed students campaign is oriented towards making student citizens, who will be given a deeper understanding of the dimensions of the problem, the implications of it and urgent need to take steps to address the issue. They will become sanitation warriors who will reclaim the canal and proclaim that as a resource they are inheriting. The message is that nobody has the right to pollute this precious resource that belongs to the future generation. So, the youth of Alappuzha are going to study this issue and going to collect the information about sanitation practices and start a dialogue with the older generation of how they have degenerated this precious resource and the need to conserve it. The information from winter school is to be compiled and are going to be used in the survey, training and campaign.

Steps in Strategy:

- Student WATSAN Survey

  Identify sources of pollution, quality and quantity at the:

  a. Household level,
  b. Subward/Ward Level- Road side drains, main drains, sub canals and main canals are mapped (making a canal shed).

- The mapping provides a fine-grained understanding of sources of pollution (solid, black/grey water) at the local level.
- After this, the canal sheds can pursue appropriate technical and institutional levels of intervention.
- Activities will be towards strengthening local level governance, through creation of sanitation zones (a combination of socio-economic characteristics, sanitation and cultural practices) laid over each canal sheds. For this a socio-economic survey will be conducted and the sanitation zones correlated with the wards as the basic unit of political boundary for decision-making. Thus sanitation zone committees will be correlated to ward level governance.
- Citizen participation will involve technical training for student citizens to analyze, monitor the problems and actively engage in the solution space.

- The ward councillor, student volunteers, *Kudumbashree* members, Asha volunteers and all concerned citizens who are willing to be part of it will be participating towards action in this mission. The present WATSAN committees created for solid waste management can be strengthened to take these activities forward.
- Shelf of tech options will be developed; such as community biogas, household DEWATS, constructed wetlands, community composts etc.
- Active use of technology like WhatsApp could be used to disseminate information and facilitate local level action like identifying individual polluters and help them. For example, a hotspot identified is under-privileged households on the banks of sub canals who directly open their blackwater into canals. There could be a project that could provide these households with individual/community septic tanks.
- **Faecal sludge management:** The existing soak pits and pit latrines to be converted into septic tanks or toilet based biogas plants. There should be proper collection of septage through efficient septage management devices, transportation and appropriate faecal sludge management and manure conversion. Faecal sludge management units to be installed and the municipalities through the active participation of the Sanitation Committees could regulate these activities. Ways of better septage management at ward/municipality levels to be devised and its compliance for treatment norms to be ensured. Having a database about the cleaning cycles and thus formalize septage management from the municipality side is important.
- **Solid Waste Management (SWM):** The existing systems of decentralized management to be continued and deepened.
- **Green jobs creation:** Proper management of solid and liquid waste can lead to hundreds of green jobs and keeping the canals clean can boost tourism related activities and thus employment too.
- Conservation and enhancement of the canals as a heritage resource to be emphasized and be aligned with the current developmental activities happening in Alappuzha.

4. **Advocacy and Motivation by Demonstration**

There is nothing better than showing and motivating through demonstration. For this, one or a cluster of wards in a canal shed to be taken for doing and demonstrating all the above-mentioned activities. Preliminary work has already been started with a student survey involving 150 students from December 8-9, 2018.

I. BACKGROUND

Rampant pollution of water bodies is rule rather than exception in large parts of the world. It is worse in urban areas due to the population density, lack of space and proper waste treatment facilities, regulatory failure is also pronounced. This calls for a need to assess the issues in local context and to clarify the inter-related issues to explore viable solutions. This is particularly important since conventional 'end of the pipe' solutions like sewerage treatment plants are not working optimally evidenced by the excessive pollution levels in most water bodies. Conventional solutions also have problems like high capital and energy cost. This is more pronounced in small and medium towns having huge infrastructure deficit with respect to wastewater management, since they lack technical, financial and institutional capability of conventional sewerage management systems. To address this challenge the Indian Institute of Technology-Bombay (IITB) has developed a protocol, for participatory decentralised data collection of wastewater/sanitation infrastructure, services and practices. The protocol can be used to train students and practitioners to bring in a fine-grained understanding of sanitation issues taking on board urban local bodies as partners.

Alappuzha town in Southern Kerala has the great legacy of successfully practicing decentralised solid waste management for the last 4 years. It has recently won the recognition from United Nations Environment Programme (UNEP) along with three other cities in Asia and Europe. To broaden the initiative in liquid waste management, IIT Bombay in collaboration with the SCMS School of Engineering and Technology, Kerala has conducted a Winter School from November 27 to December 4, 2017 in selected wards of Alappuzha Municipality. About 36 students engaged in drain mapping using GIS tools, conducted wastewater quality assessment and a household survey. The Kerala Institute of Local Administration (KILA) has supported the initiative. The protocols designed will help the local bodies in Kerala to develop participatory sanitation plan with collaboration of local academic institutions. This can help harness analytical inputs into to sectoral activities of the urban local bodies but also ensure accountability of functioning by involvement of students and citizens. KILA with the technical assistance of IIT Bombay

can use the developed protocol to scale up such initiatives throughout the state. Hence, the Winter School will be the first step towards a fruitful collaboration between KILA and IIT Bombay to improve the water quality, sanitation and thus, public health in Kerala. The exercises like Winter School-2017 can facilitate the process of bridging the knowledge – technology – decision making/implementation gap. It will also contribute to a new pedagogy of field based learning to engineering/science/social science students.

This report presents the preliminary analysis of the findings of the winter school-2017. It starts with the larger issues of the limitations of conventional solutions to waste water management, particularly in small and medium town context. It then elaborates the objectives of the winter school, the methodology and steps in research strategy. The third section is on Alappuzha town – study area for the Winter School-2017. It highlights, based on secondary data, the status of water and sanitation services and key environmental issues that the Alappuzha town is dealing with. The survey findings conducted as part of the Winter School are presented and discussed is subsequent sections under three headings:- major drains and canals: key issues and concerns ; pollution in canals : results of water sampling of major pollution hotspots ; and socioeconomic survey : highlighting access to services , waste management practices, public health and general awareness at household level. The fourth chapter gives major observations, recommendations and path ahead.

II. IDEA OF WINTER SCHOOL

Objectives, Methodology & Approach

The Small and Medium towns have huge infrastructure deficit with respect to wastewater management (HPEC,2011) since they lack the technical, financial and institutional capacity for conventional sewerage management systems. The National Urban Sanitation Policy -2008 questions the sustainability of the conventional approach with respect to cost effectiveness and its ability for universal coverage. The policy recommends cities to use appropriate technology options suiting their need, capacity and context. Still the less capital and energy intensive technological alternatives remain at the firm level (institutions, hospitals, industries etc.). There is no dearth of decentralised technological options and models as stated in the Manual on Sewerage and Sewage Treatment-2013 by the Central Public Health and Environmental Engineering Organisation (CPHEEO). In order to assess the suitability of various technology solutions we need to look beyond the conventional planning and assessment methods that mostly rely on secondary data and 'rule of thumb'. The situation presents a twofold challenge: one to showcase the technical feasibility of such decentralised models at town level, and second to make them part of the municipal decision making process.

To address this challenge the Indian Institute of Technology-Bombay (IITB) has developed a protocol for participatory decentralised data collection for water and wastewater/sanitation infrastructure, services and practices. In this protocol we proposed a replicable and potentially sustainable approach to a situational analysis of prevailing sanitation and wastewater practices by integrating three aspects. First, we treat the local municipal government (i.e., the ULB) as the locus of sanitation interventions, as no matter what technologies or governance mechanisms are deployed, town-wide scale-up needs the ULBs. Second, we engaged academic institutions with the help of civic organisations to conduct household surveys to develop analytical, and possibly implementation, capacity in local colleges. Third, we developed a simple socio-spatial "zoning" of the city by wastewater flows and sanitation practices, as integrating

these into city-wide planning as the first step towards sustainable urban sanitation. The protocol is expected to be used to train students/future practitioners to bring in a fine grained understanding of sanitation issues taking on board urban local bodies as partners.

Alappuzha town, in central Kerala, has expressed interest and intent to engage in a similar exercise. Situated on the Western Coast of Kerala, Alleppey town is one of the first planned towns. Intertwined with canals network and backwaters the town lacks comprehensive sewerage network and has heavy reliance on the septic tanks - a primary treatment. The partially and untreated wastewater either leads to subsurface soil or drains into the canals[2]. Factors such as the flat topography (0-15%) and high water table (3 mts. below the ground) make it further difficult to establish conventional sewerage network system (GoK, 2013:115). The situation presents a challenge and an opportunity to explore heterodox options of sanitation and wastewater management.

As part of the Winter School (November 27th – December,4th 2017) the M Tech students (17) and 2 PhD students of Center for Technology Alternatives for Rural areas (CTARA), IITB and the M Tech students of Environmental Engineering (16) of SCMS jointly engaged in an academic exercise. IIT Bombay is the knowledge partner to train students on drain mapping using GIS tool, wastewater mapping and household questionnaire survey. We developed reading materials, field exercises and protocols before the Winter School. SCMS – Water Institute have a well-developed water quality testing lab. The exercise would lead to a participatory sanitation plan inclusive of pollution mitigation for the Municipality. The study findings might lead to concrete interventions afterwards.

OBJECTIVES

- To impart training to local and IITB students on wastewater quality and quantity and household survey on water, wastewater/sanitation and solid waste management infrastructure, services and practices using smart technologies/Apps (eg: ODKcollect, Open Street Map (OSM), AppSheet etc.).
- To conduct drain mapping for major canals and sub canals and household survey.

[2]The canal water has been found to has high content of E-coli counts (38000 per 100ml), BOD (80mg/l), DO (5-6mg/l) as per the Master Plan-2031 (GoK, 2013: 115).

- To conduct wastewater quality and quantity assessment of major canals and sub canals.
- To provide a platform to students to interact with and learn from the local experts and the practitioners.
- To go beyond classroom learning in order to make students aware of the complexities of waste water and sanitation issue.

METHDOLOGY

The Winter School-2017 involves three major tasks (i) drain mapping; (ii) Water sampling and (iii) socio-economic survey at household level.

i) **Drain Mapping:** The major canals i.e. Commercial canal, Vadai Canals, East and West Bank canals were targeted for the detailed drain mapping. The key inlets to these four canals were identified with the help of Health Inspector. 34 students were divided into eight teams (4 members in each team) and were asked to focus on identified key inlets to the major canals. 4 people team focussed on each side of the canal's bank. The drain mapping exercise was conducted between December,1-2 using OSM tracker app that helps in tracing the canals while taking transect walk. OSM Tracker is an offline GPS tracker to collect points of interest (POI), which can be marked as voice, text, photos or simply as points. The OSM tracker is an open source app and is also customizable based on our requirements. The OSM Tracker app is a freely available app in Play Store[3].

   We got 9 major tracks along the 4 canals and key inlets with important point features such as solid and liquid waste dump sites, encroachments and eutrophicated stretches. The tracks with the features were exported in GPX format and converted map friendly format i.e. KML. The canals /drain boundaries were then marked on the Google Earth using polygon feature. The point features, using a KML file, were plotted as a third layer on the base map (two layers namely ward boundary and municipal drains/canals) using QGIS platform. The output of

[3] See link:https://play.google.com/store/apps/details?id=me.guillaumin.android.osmtracker&hl=en

the exercise is a GIS map of major canals (as polygon features) with pollution issues and hotspots plotted on the ward and drain maps. The maps are visual representation of key hotspots and problematic areas along / in the commercial, vadai, east and west bank canals.

ii) Water Pollution Sampling

A total of 17 sampling points were selected based on position of drains/sub-canal openings and location of hotspots provided by the Municipality. Water quality at selected sampling locations was determined by assessing three classes of attributes: physical, chemical, and biological. Following basic surface water quality parameters was analysed at various locations along Commercial Canal and Vadai Canal during the winter school.

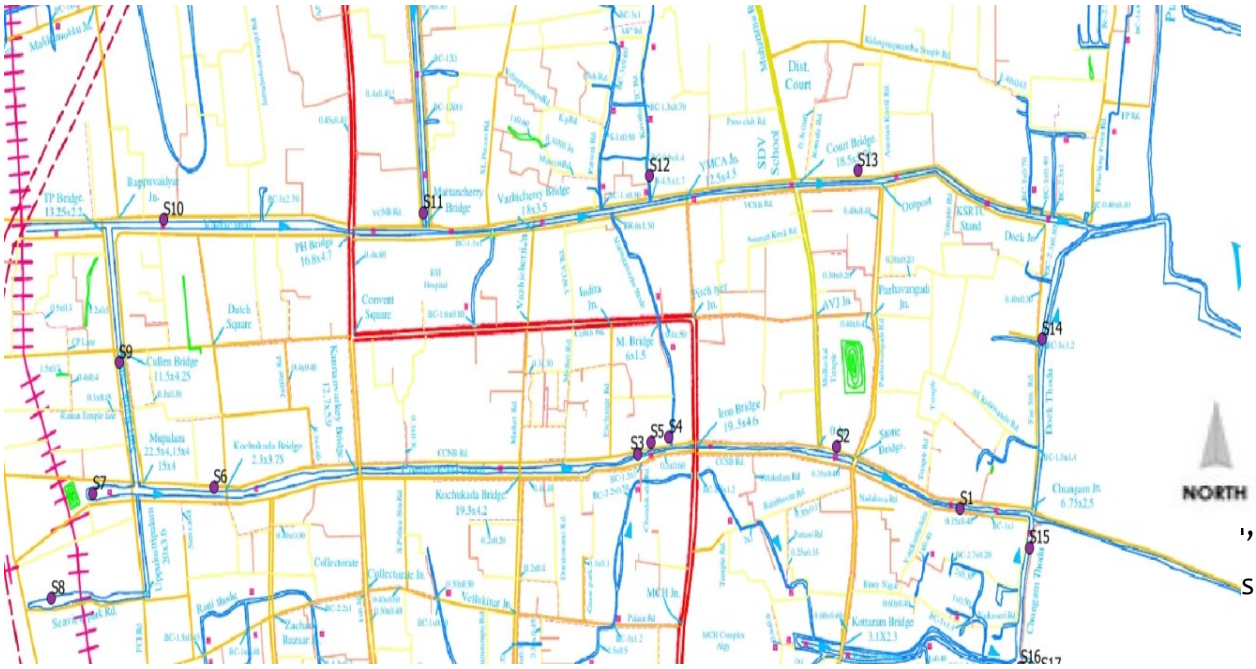
- Turbidity was measured using Nephelometer
- Phosphate was measured using field kits based on colorimetric method.
- pH using a pH meter
- Dissolved oxygen (mg/l) using D.O meters
- Nitrogen parameters were analysed using field testing kits which is basically a colorimetric estimation of concentration of the concerned parameters
- Presence of Coliform bacteria was assessed using H_2S strip test.

Among the total 17 samples collected, four representative samples (S1, S2, S5, S6) were collected from random points along the Commercial Canal (CC), two samples (S10, S13) from Vadai Canal (VC), one sample each from connecting canals (S9 and S14), two samples from the end point of canal near seashore, four samples from sub-canals/drains joining the main canals (S3, S4, S11, S12) and three samples from Chungamthodu (S15, S16, S17) (Table 1).

Table 1 : Sampling Locations

Points	No. of Samples
Commercial Canal (CC)	S1, S2, S5, S6
Vadai Canal (VC)	S10, S13
Connecting canals	S9 , S14
End point of canal near seashore	S7, S8
sub-canals/drains joining the main canals	S3, S4, S11, S12
From Chungamthodu	S15, S16, S17

Figure 1: Sampling points on the map



All the samples were collected in the morning hours between 7:30am and 10:30 am on 28-11-2017. The samples were collected from the top surface without disturbing the

bottom layers. All the samples were collected in air-tight bottles and were immediately transported to lab for further analysis. Annexure 1 for details on relevance of these parameters.

iii) Socio-economic survey at household level

The town has about 52,000 households. The survey covered about 500 households and 100 commercial properties. Instead of selecting political boundaries the survey followed the canal shed approach. Polygons around four canals (Vadai, commercial, east and west bank) along with their respective inlets (forming a canal shed) were targeted (Table 2). The landmarks along the four side boundaries of respective polygons were shared with the 17 teams (2 students in each : each from IITB and SCMS). A polygon might have multiple wards. On the second day of the household survey we realigned our strategy to suit the household density and/or size of the ward and accordingly reassigned the polygons to the student teams.

Table 2: Polygons Names with boundaries

Team	Polygon No	Boundary Landmarks
1	1	Chungam Jn to Stone Bridge Court Bridge to Finishing point
2	9	Chungam Jn to Stone Bridge to Palace Bridge to Mukkavalakkal
3	3	Stone bridge to iron bridge to YMCA jn to Outpost
4	10	Iron Bridge to Chakkarakada Bridge to Vazhicherry Bridge to YMCA bridge
5	4	Kochukada bridge to Kannan varkey brdige to Shavakottai bridge to Vazhicherry bridge
6	5	Bappu Vaidyar Jn to Mattancherry Bridge to Aarattuvazhy bridge to Malikamukku Jn
7	7	Mattancherry bridge to Arattuvazhy bridge to Thondamkulangara Jn to Zilla Court Bridge
8	8	Thondankulangara Jn to Aarattuvazhy Bridge to Popy Bridge to Indira Jn
9	6	stone bridge to kottaram bus stand to medical college jn to iron bridge

10	16	medical college jn to iron bridge to kochukada bridge to vellakinar
11	11	kochukada bridge to kannan varkey bridge to valiyakulam junction to pulayanvazhy jn
12	12	zacharia bazar to kannan varkey bridge to muppalam to upputtipalam to SBI bank to zacharia bazar
13	13	SBI to hospital junction to cassia restaurant to muppalam
14	14	shavakotta bridge to convent square to cullen bridge to TP bridge
15	15	convent square to kannan varkey bridge to muppalam to cullen bridge
16	2	cullen bridge to vijay park level cross to chantha kadavu to bappu vaidyar jn
17	17	cullen bridge to vijay park level cross to hospital jn to SBI to cullen bridge
		kannan varkey bridge to triveni jn ESI raiway bridge to upputtipalam to kannan varkey via muppalam

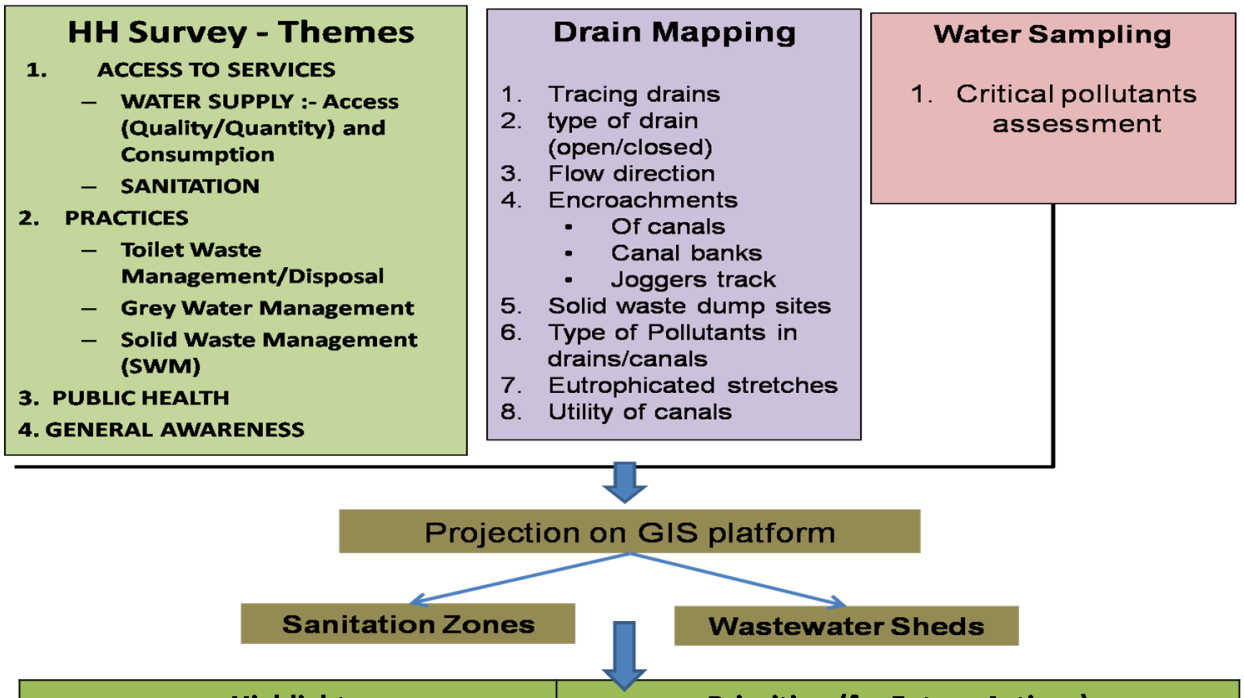
The teams aimed to target each household. The questionnaire included set of questions relating to services, sanitation infra, solid and liquid management practices, general awareness and public health. The teams were also asked to take geolocation of the functional well and septic tank. The ODK Collect (https://opendatakit.org/use/collect/) – a mobile based app was used to collect data, take photos, take geolocations and to send the responses to Google drive. The app does not need internet to collect data. The collected responses then analysed on SPSS and Excel tools.

ANALYSIS APPORCH

The data from three sets of exercise i.e. drain mapping, water sampling and household survey conducted at canal watershed level shall be used to develop wastewatersheds and socio-economic zones. A wastewatershed concept is similar to watershed it is a physical unit. It is an area over which all wastewater or flowing water flows through a single given outlet point. The waste water could flow through either artificial constructed or natural drainage along the natural slopes. The sanitation zones are spatial maps of socio-economic variables, sanitation infrastructure (drains) , public services and practices (household). A sanitation zone is an area which overlays the wastewater sheds on the

socio economic factors of the population understudy. It is an area where sanitation and wastewater practices are likely to be homogenous, thus, similar issues. It could be a basic unit for technological and governance interventions. It could be used to highlight and prioritise areas of technological, social and governance interventions (Figure 3).

Figure 2 : Analytical Framework



Highlight	Prioritize (for Future Actions)
Disparity in 'access to services' for different socioeconomic categories at ward level	Socioeconomic categories & wards for policy interventions
	Themes for policy interventions
Major Polluters	Regulatory interventions
Pollution hotspots / Stretches	Technological interventions

OUTPUTS

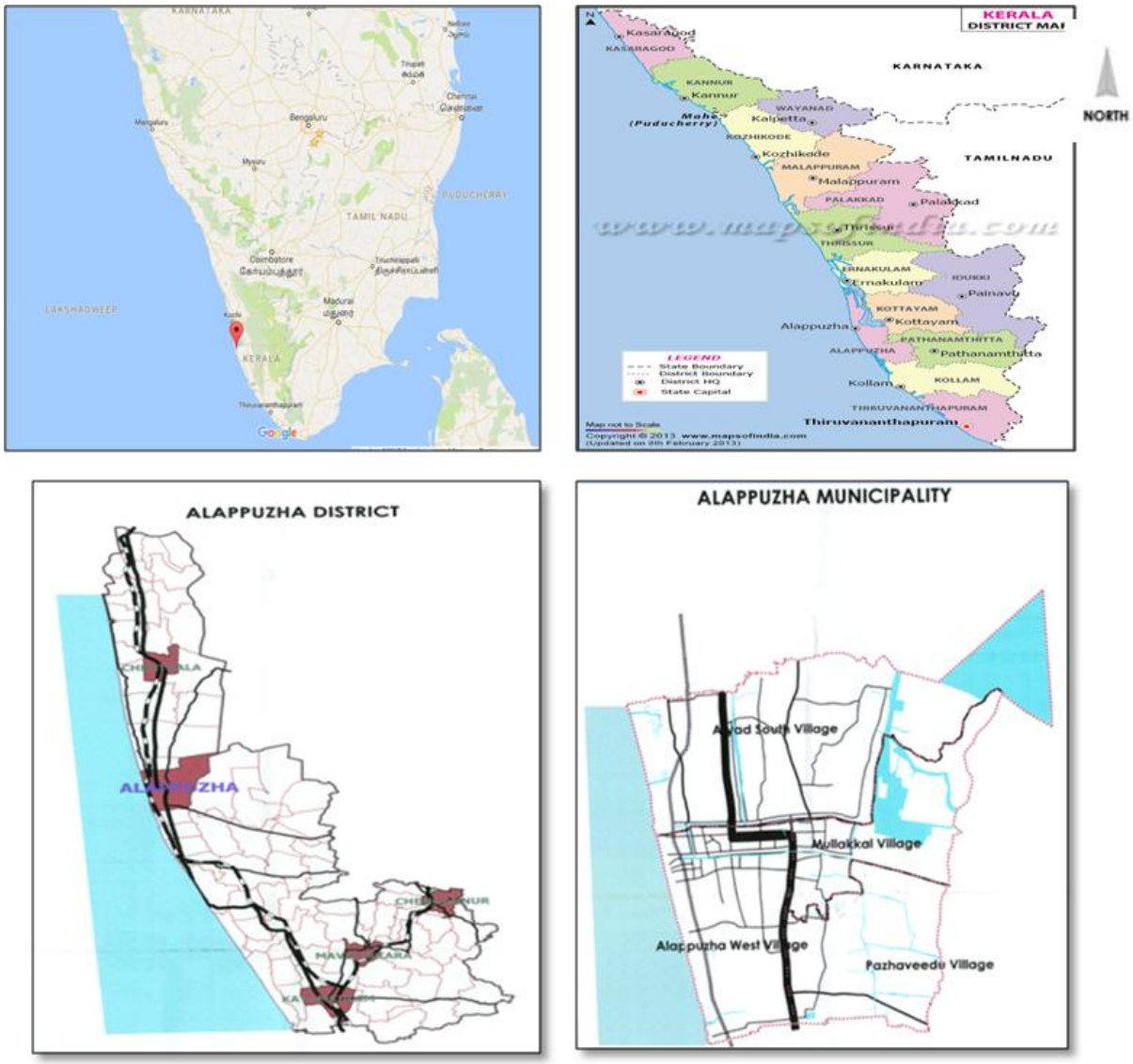
- An assessment report along with the collated data on parameters such as water, wastewater/sanitation and solid waste management on a GIS platform.
- Methodology and a protocol to conduct participative decentralised data collection on above parameters.
- Bridging the gap between the urban local body, academic institutions and local people to device contextually relevant solutions using appropriate technologies.

III. ALAPPUZA TOWN

Winter School Study Area

Situated on Western Coast of Kerala , Alappuzha town (approx area = 46.71 sqkm) is one of the first planned towns of India. It was declared a Municipal Town in 1920. It is a politically relevant place as it is a headquarters of Alappuzha district & Ambalappuzha taluk. Historically speaking it used to have largest sea port and was central hub for coir industry before Kochi developed to be become one. Intertwined with canals network (9 main canals ; 104 connecting canals) and backwaters the town is known as 'Venice of East' and is famous for Nehru Trophy Boat Race. The canals play a crucial role in the heritage and identity of the city. The canals have been dug from the 18th century onwards. The canals were used as navigation routes and to supply the warehouses in the city. The town has Pallathuruthy River flowing on the eastern side and Arabian Sea on the western side (Figure 3).

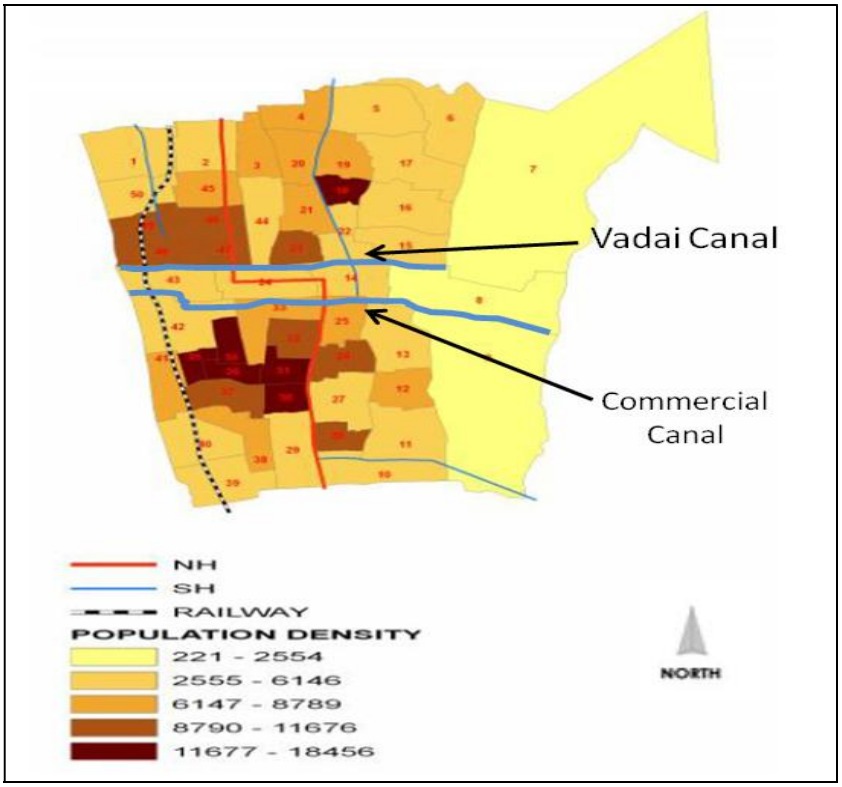
Figure 3 : Map of Alappuzha Town



Source (for last two maps): GoK, 2013.

As per Census 2011 the population stands at 1,74,176. The town has the highest gross density (3992) among the urban centres of Alappuzha district. It has about 42000 households (average house hold size = 4.19) in 52 wards. Vadai Canal, Thumpoly and Civil Station are among the most populous wards (Figure 4). Overall the town is highly urbanised with population primarily dependent on service sector for livelihoods (Figure 13). Other occupations include coir industries and agriculture.

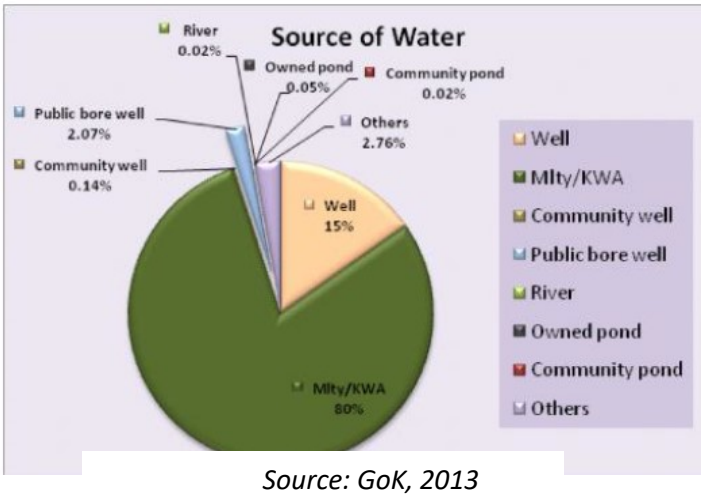
Figure 4 : Ward wise distribution of population density



Source: GoK, 2013

The town has most of the area under residential category followed by agriculture and then water course. There is no forestland and limited vacant land available (0.60 %) in the town. Only 5.09% of the total land area is under municipal area or owned by public /semi public agencies.

Figure 5: Water Sources in Alappuzha Town



Source: GoK, 2013

Status of Civic Services

As per Master Plan Alappuzha municipality 2031 (GoK,2013) the main source of water is tube well by Kerala Water Authority. However, it can meet only 50% of drinking water demand (Figure 5). About 92% of the households face scarcity issues, which is not due to non availability of the water but is due to poor quality of the available water sources. There have been reports of ever increasing fluoride, chloride, iron in ground water. Open wells

are highly polluted due to salinity and bacterial contamination. The situation led to adoption of 18 Reverse Osmosis plants by the municipality.

The network of canals forms the backbone for drainage in the town. The current network of open drains is about 25-30km in length, however, the coverage is not known. The drainage system is inadequate to meet the present needs of the town. The master plan notes that the drains are built arbitrarily without taking into account the run off. Majority of drains are encroached and/or silted up as private premises & public roadside drains do not have silt traps. Moreover, relatively flat topography (slop of ground is in the range of 0-15 %) causing difficulty in free flow. The flat slop along with high water table (3 mts. below the ground) makes the city highly susceptible to water logging.

The town lacks conventional underground sewerage system and relies on primary kind of disposal mechanism i.e. septic tanks. About 83% of the households as per the master plan are having septic tanks and other 15% are having leach pit type latrines. Majority of these septic tanks open through perforated/ disjointed pipes (below the ground level) for absorption into the soil. The high water table and monsoon season cause spillage/leaching from septic tanks and thus causing pollution of canals and ground water. Canal water has been found to have high contents of E-coli counts (38000 per 100ml), BOD (80mg/l), DO (5-6mg/l) (GoK, 2013: 115) and is unfit for human contact.

The town generates about 75 ton/day of solid waste. The major contributors are market, abattoir and households. There is a provision of door to door collection through Kudumbasree Women. The collected waste is taken to a dumping site (7 ha of land at Sarvodayapuram) for final disposal without any sort of treatment or segregation. The key issues with the current arrangement are ineffective collection (only 33% collection) and non processing of the collected waste. The uncollected waste end up into vacant public land, roads, canal and backwaters and thus, causing pollution (Figure 6). A decentralised waste treatment plant through aerobic composting has been tried out in the city.

Figure 6: Places of Solid Waste Disposal – Alappuzha Town

Source: GoK, 2013

The key causes of environmental pollution are irresponsible dumping of untreated solid waste and liquid waste from households in to the drains, thodus, canals and open land. The canal network is encroached, blocked and polluted of weed, solid waste, hospital waste, coir factory waste , rice mills, and sewage disposal .

IV. MAJOR CANALS & DRAINS

Issues of Concern

The process of drain mapping is conducted with a purpose of understanding the wastewater flows in the cities. Typically, in Indian small cities, the storm water drains constructed along the roads also carry the grey water from households and wastewater from commercial units. It is essential to understand and assess the quality and quantity of these wastewater flows for the purpose of planning for wastewater management at a city level. This exercise helps to identify problems and issues in sewage management in surveyed area through delineation of waste-watershed. The procedure followed for data collection included drain mapping by field observations and documentation using OSM Tracker, Google Earth and QGIS software. To do this, the team used OSM tracker to map the characteristics of the drains and to understand the wastewater flows. The concept of waste-watershed could be used to estimate the catchment areas of wastewater, thus, to estimate the quantity of wastewater released at various locations. This could be useful in planning decentralized wastewater treatment units. When this data is overlaid with the sanitation access, practices and socio economic household information, we can get a typology of wastewater management, which can aid planning for wastewater management. This methodology can contribute to developing a protocol for wastewater planning.

Purpose:

The partially and untreated wastewater either leads to subsurface soil or drains into the canals. In Alappuzha, factors such as the flat topography (0-15%) and high water table (3 mts. below the ground) make it further difficult to establish conventional sewerage network system (GoK, 2013:115). Typically, in Indian small cities, the storm water drains constructed along the roads also carry the grey water from households and wastewater from commercial units. It is essential to understand and assess the quality and quantity

of these wastewater flows for the purpose of planning for wastewater management at a city level.

The process of drain mapping was conducted with a purpose of understanding the wastewater flows in Alappuzha. Currently, since the canals in Alappuzha serve as the wastewater carriages, it was decided to drain map these canal sheds which drains the storm water as well as wastewater into the main canals in Alappuzha, which includes Vadai canal, Commercial canal.

Main Inlets to Vadai Canal	Main inlets to Commercial Canal
a. Near YMCA, Kavitha ITC	Near Iron Bridge
b. Near Vazhichery Bridge	Near Municipal Office (Shadamanithodu)
c. Opposite to (b)	Ranithodu (Muppalam)
d. Near Mattancherry bridge	
e. Near Bappuvaidyarjn	
f.Near North Police Station (Vellapallipalli)	
g. Sub canals inZilla Court Ward	

7 of the drains/canals leading to the main canals were tracked using OSM Tracker and the tracks were opened using Google Earth app. In the Google Earth app, the tracks followed were demarcated with the polygon feature and only the relevant information was plotted in the map.

The main features that have been plotted are Solid Waste dumping in the banks/in the canal/drains", Liquid waste pipes/drains from the households, Encroachments, obstructions to flow,Eutrophicated (with weeds) stretches and also the inlet drains into the canals.

East Bank canal:

The drainage mapping of the East Bank Canal revealed that this canal is highly eutrophicated. This could be due to both the urban sewage coming into the canal from the Mullackal ward and also the agricultural waste from the nearby farmlands in Thirumala ward. There are two inlets, which are largely carrying urban sewage flowing from the Mullakkal ward and joining the East Bank canal. Many of the household drains discharge the liquid wastes into these drains. The tidal effect also influences this canal stretch. The houseboats of many resorts are also parked in here.

Sub canals of Vadai canal in Zilla Court Ward:

Tracking of the sub canals that flows into the Vadai Canal in Zilla Court Ward revealed open pipes and drains discharging effluents into the sub canal. Solid waste is also dumped along the banks/into the sub canal. There are many resorts/hotels along this sub canal, which also discharge the wastes into this sub canal.

Sub Canal of Vadai canal:

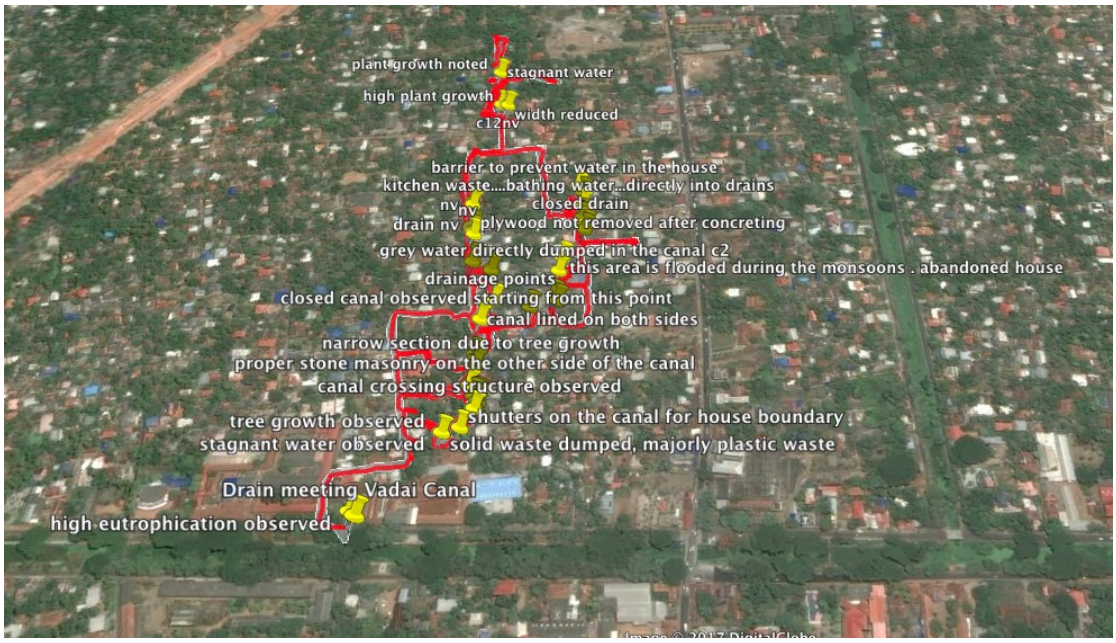
This sub canal flows into the Vadai canal through the Chathanadu, Mannathu and Thondankulangara wards. Liquid waste discharge and the solid waste dumping were found in many places. Obstruction to flow due to solid waste dumping stagnation of water in the sub canal and water logging were also noticed during tracking of this canal-shed.

Uppukuttipallam canal:

Uppukuttipallam connects the Commercial canal at Muppalam to the Ayyappanpozhi and to the sea. It flows in the Civil Station ward and the water is highly saline. Though the density of the households in this locality is less, there is liquid waste discharge and solid waste dump into this canal-shed as well. The drains also have been clogged due to silt deposition, mostly due to the tidal inflow. The accumulation of sand and silt in the mouth of the Uppukuttipallam canal results in water logging and flooding in this region.

Vellapally Canal:

This is a highly dense area with many households in the Powerhouse and Aarattuvazhy wards. Solid waste dumped and liquid waste discharges flow through this canal and then into the Vadai canal. The plastic wastes and the house hold wastes get washed away and clog the place where meets the Vadai canal. This confluence is highly eutrophicated as well.



Sub canal joining Vadai canal:

Solid waste dumping and liquid waste discharge were observed along the sub canal/drain, which joins the Vadai canal. This canal being close to the market area, the waste from there is getting dumped in and along the banks of this sub canal.

Shadamanithodu:

Solid waste dump, encroachment is causing obstruction in the flow of water in Shadamanithodu. This results in clogged drains and water logging in areas close to this thodu.

Table showing the major problems found after the drain mapping exercise:

Canals/Drains	**Flow to which main canal?**	Problems
East Bank canal	Connects Commercial &Vadai canal	Eutrophication, Urban Sewage, Water stagnation, encroached canal.
Zilla Court ward (2 sub canals joining)	Vadai Canal	Solid waste dumping, Liquid waste discharge
Sub Canal of Vadai canal	Vadai canal	Solid waste dumping, Liquid waste discharge, Stagnation of water, Water logging

Uppukuttipallam canal	Commercial Canal	Solid waste dumping, Liquid waste discharge, siltation, water clogging, flooding
Vellapally Canal	Vadai Canal	Solid waste dumping, Liquid waste discharge
Sub canal joining Vadai canal	Vadai Canal	Solid, market waste dumping
Shadamanithodu	Commercial Canal	Obstruction to flow, encroached canals, water clogging, solid waste dumping

V. POLLUTION IN CANALS

Water Quality Assessment

Quality of the water in the canal is an indicator of its aquatic health and extent of waste water contamination. Preliminary investigation of the canals revealed absence of aquatic animals, increased eutrophication and dumping of solid wastes on various stretches of main and sub canals. In order to assess the impact of unplanned urban sanitation on the commercial and vada canals, it was essential to understand the quality of water in these canals. This study selected those water quality parameters which were easy, quick and inexpensive to analyze and at the same time adequate enough to assess the overall health of the canals. Analysis methodology were decided based on the need to make the study more participatory so that it could be replicated by the common people who do not have any formal training in these kinds of analyses.

To have a preliminary understanding of the quality of water from the canal and the adjoining drains/sub-canals, a total of 17 sampling points were selected. The sampling points were selected based on the position of drains/sub-canal openings and the location of hotspots as shown in the drain map of Alappuzha town.

Water Quality Analysis

Water quality was determined by assessing three classes of attributes: physical, chemical, and biological. Table 2.1 shows the surface water quality parameters that were analysed in this study at mentioned locations along Commercial Canal and Vada Canal. The significance of these parameters to the water quality and possible indications are also provided. Analysis of these parameters followed CPCB guidelines[4] except for the parameters analysed with colorimetric testing kits (phosphate, iron, ammonia, nitrite and nitrate). Colorimetric testing kits used manufacturer specific reagents for colour development corresponding to the concentration values of the parameter being tested.

[4] CPCB, Guide manual: Water and waste water analysis

Table : Water Quality Parameters Analysed

Sr. No.	Parameter	Attribute	Analysis Method[5]	Significance[6]	Indication
1	Electrical Conductivity	Physical	Potentiometric Method	Total amount of dissolved ions	some other source of pollution has entered the water
2	Total Dissolved Solids	Physical	Conductometry	refer to any minerals, salts, metals, cations or anions dissolved in water	some other source of pollution has entered the water
3	pH	Chemical	Electrometric Method	Negative log of hydrogen ion concentration	Contaminants or processes within water is making water acidic or alkaline
4	Dissolved Oxygen	Chemical	Membrane Electrode Method	Amount of oxygen molecules dissolved in the water	presence of oxygen consuming contaminants, biodegradation, excessive algal growth
5	Iron	Chemical	Colorimetric test kit	Amount of ferrous or ferric ions	natural deposits, industrial wastes, refining of iron ores, and corrosion of iron containing metals.
6	Ammonia	Chemical	Colorimetric test kit	preferred nitrogen-containing	Fresh waste water contamination

[5] Sawyer, C.N., McCarty, P.L., Parkin, G.F., Chemistry for Environmental Engineering, Tata McGraw-Hill, 2000.

[6] Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed., 1985.

				nutrient for plant growth. It is converted to nitrite (NO_2) and nitrate (NO_3) by bacteria in presence of oxygen	
7	Nitrite	Chemical	Colorimetric test kit	Eutrophication, potential DO reduction	Intermediate state of nitrification process
8	Nitrate	Chemical	Colorimetric test kit	Eutrophication	Final stage of nitrification
9	Phosphate	Chemical	Colorimetric test kit	Eutrophication	phosphate-containing fertilizers, partially treated or untreated sewage
10	E-Coli	Biological	H_2S Strip test	Presence of coliform bacteria	Faecal contamination

3. Results & Discussion

The results of water quality analyses of the canal water samples are provided in table 3.1. The permissible limits of these parameters in surface water as prescribed by various agencies are also provided for reference. Table 3.2 provides details on the sampling location. These results shows that:

1. In general the Dissolved Oxygen (DO) concentration was observed to be very low in most of the samples collected all along the canal. Out of the 17 samples collected, 13 samples had DO concentration below the desirable limit of 4ppm. All the samples collected from dead end of the canals, near to the sea (S6-S10), recorded very low DO concentrations (0-0.2 ppm) as compared to the eastern end connecting to Vembanadu estuary. The water sample from an underground drain opening to CC also recorded very low DO concentration of 0.2 mg/l. Except for

one sample (S6), all other samples collected from CC had DO concentrations above 4 ppm, which could be enough to support the survival of fishes.

2. The electrical conductivity(EC) of the samples collected from Vada Canal and Commercial Canal does not show much variation with values in the range of 495-626 µS, which is within the permissible limits. However the samples collected from locations near to sea (S10, S7, S8, S9) had higher electrical conductivity indicating increasing levels of salinity intrusion in the canal towards the sea.

3. The total dissolved solids concentrations as expected shows similar variation as EC. Samples from stagnated end points near to the sea (S8, S9, S10) had high TDS value (2845 mg/l, 1270 mg/l, 1103 mg/l) due to increased salinity.

4. pH of all the samples collected falls within the range of 6.5 – 8.5. Since the samples were taken from the top layer, the information on variation of pH with depth of canal is not available. There is a chance that canal water is acidic at the bottom due to decomposing algae at the bottom of the canal. The pH normally increases in the top layers with the photosynthesis process that happen due to algae floating on the canal water surface.

5. The iron concentrations show variation among the samples. In general high iron concentration was observed in the samples collected from drain opening (S3, 3 mg/l) to commercial canal and sub-canal opening to vada canal (S12, 3 mg/l). This could be because of the presence of iron in the bore well water which when become waste water, that join the canals through drainage, contribute to the iron concentration in the canal water.

6. High phosphate concentration was observed in all water samples collected from commercial canals. The water samples from sub-canals/drains opening to commercial canal also contain high phosphate concentration (5 mg/l) indicating the contamination of canal water by domestic sewage. The phosphate concentration in the samples collected from vada canal and its sub-canals were relatively lower (1-2 mg/l).

7. All the samples collected reported the presence of ammonia in varying concentrations indicating fresh source of sewage into the canal water. The highest ammonia concentration was observed in the drain opening to commercial canal (S2). This clearly indicates the point of entry of fresh pollutant source in to the main canal.

8. Though we had expected high nitrate concentration in all the samples, surprisingly only four samples showed the presence of nitrates (S2, S6, S8, S17). This low nitrate concentration might be due to flushing out of the nitrified canal water by storm runoff because of the rain on the previous day. Presence of high concentration of ammonia and nitrite validates the assumption that samples contained fresh sewage which entered into the canal after the nitrified waste water got flushed out by storm water.

9. All the samples tested for the presence of coliform bacteria showed a positive result, indicating the presence of septage contamination all through the canal.

Water Quality Sampling: Highlights

All the canal stretches were found to have the presence of faecal colliforms indicating sewage contamination. The water quality parameters indicate that commercial canal receives comparatively higher waste water contamination than Vadai canal. Among the sub canals, Upputty canal and Dock thodu had lesser sewage inflow. Water is stagnated in the west end canal stretches such as in Upputty canal, zone near Muppalam , Muppalam to TP bridge stretch and TP bridge to PH bridge stretch. These stretches were also influenced by salinity intrusion even in the monsoon season. The canal stretches such as Chungam Junction to Iron bridge along the commercial canal, AS canal to Dock junction along the Vadai canal, and Dock thodu have better aquatic health compared to other stretches. Seasonal analysis is recommended to confirm these findings. Rejuvenation of the canals would require control of sewage inflow, reduction of sewage concentration through pre-treatment (mandatory STPs for commercial establishments and proper septic tanks for households) and aeration of canals to increase dissolved oxygen to the safe levels for aquatic animals. However, a pilot rejuvenation initiative has to be tested before implementing for the entire canal.

VI. Access to Services, Waste Management Practices & Public Health

Socio-Economic Survey

Survey of Alappuzha town was carried out from 29/11/17 to 3/12/17. Total **476 households** were surveyed. The data collated and analysed to under the four themes i.e. a) Access to services and infrastructure for water supply and sanitation; b) waste management practices ; c) public health ; and d) general awareness.

ACCESS TO SERVICES AND INFRASTRUCTURE

Water Supply: The primary source of water supply is piped water supply (KWA) for 80% of the sampled households. About 15% of the households depend on the well water for daily needs. The primary source to meet drinking water needs is KWA (51%) followed by bottled water (19%). The dependence on perceived unsafe water sources i.e. well and public stand posts is lower (22%) then the KWA. The average water consumption from KWA water could not be found as about 42% of the respondents refused to share the monthly consumer bill details.

Figure: Primary Source of Water

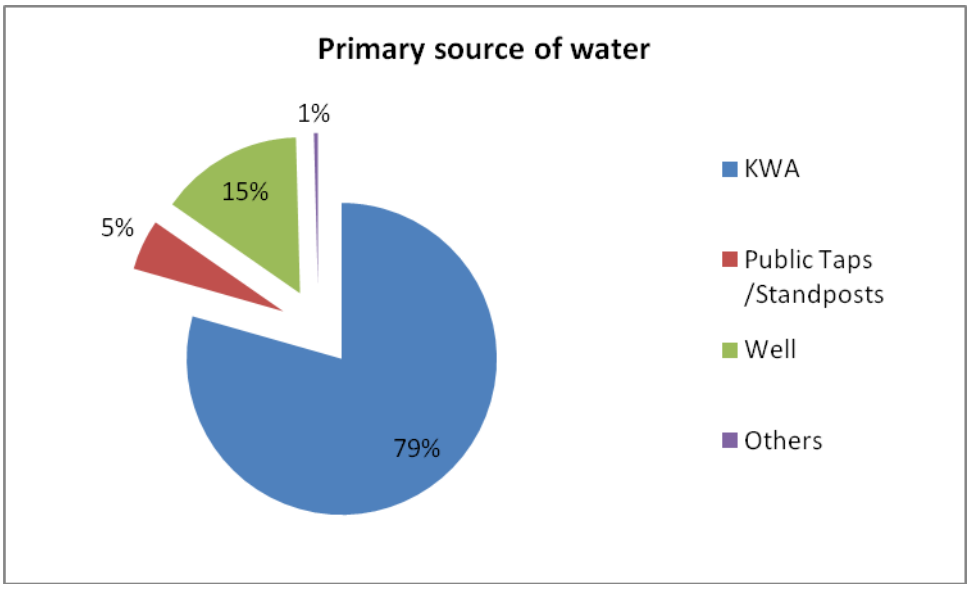
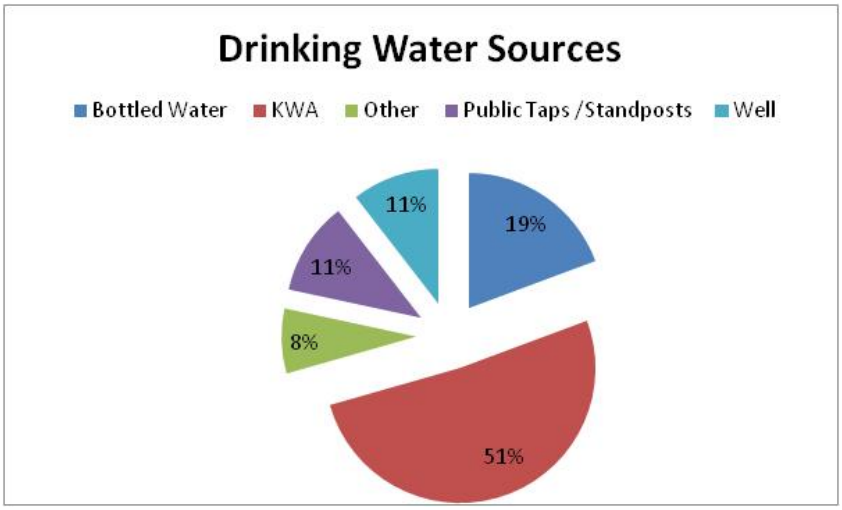


Figure: Primary Source of Drinking Water

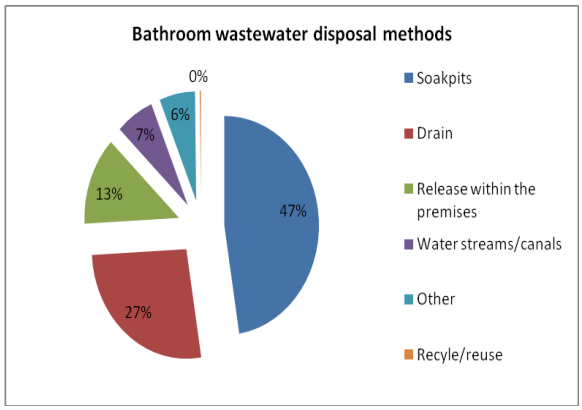


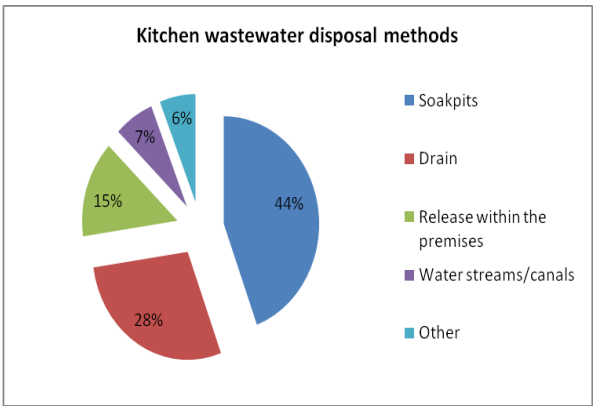
All households had private toilets.

LIQUID WASTE MANAGEMENT

Grey water disposal methods

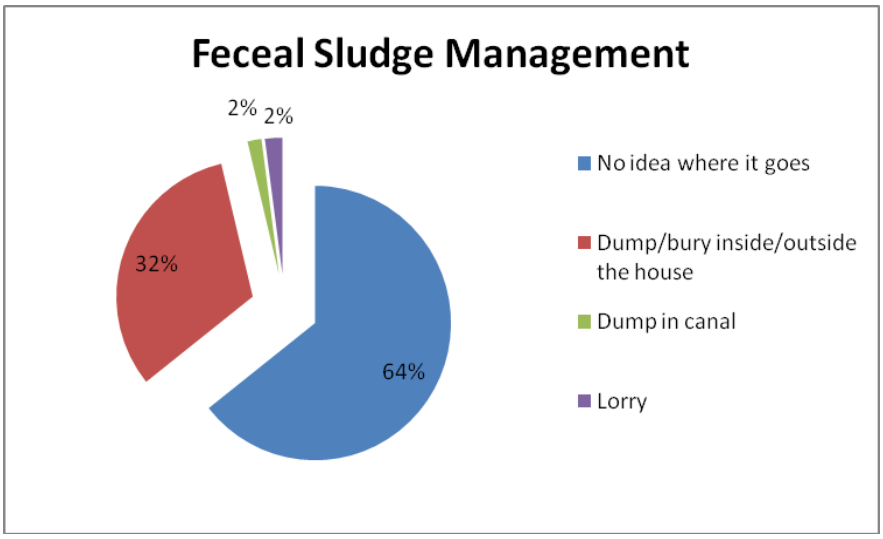
The grey water management includes wastewater from bathroom and kitchen. The preferred mode of disposal for bathroom and kitchen waste is soakpits. About 7% of the respondents admitted to release the bathroom /kitchen wastewater into the water streams /canals.





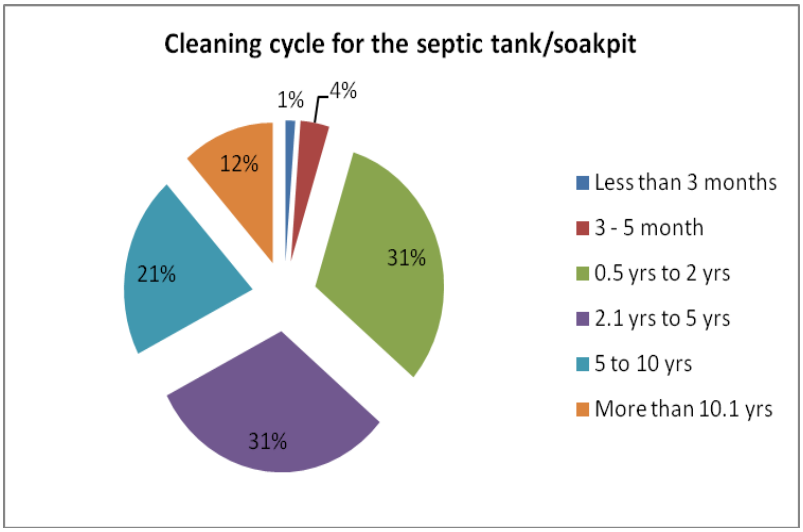
Black water disposal methods

The most common method used for disposing /treating toilet waste or black water is septic tank (90%) followed by soakpits (7%). Very small percentage (1%) of the respondents admitted to releasing black water directly into the nearby drain. A typical cleaning cycle for the septic tank is between 0.5 to 5 years. For cleaning the tanks about

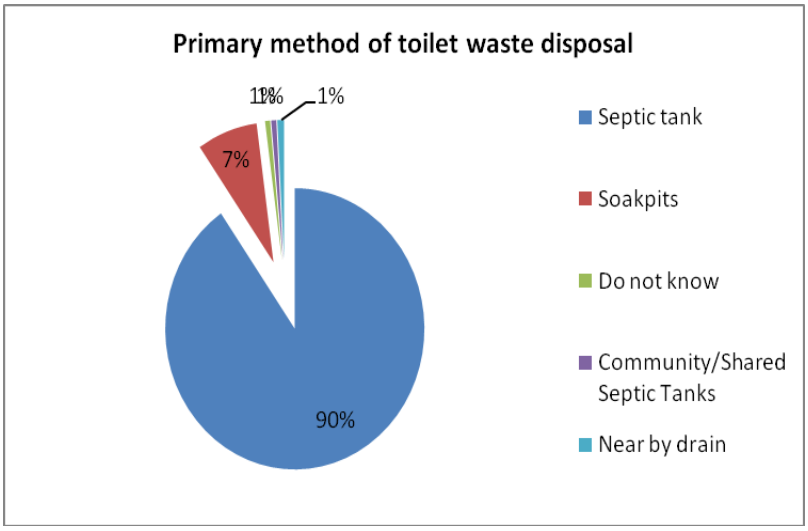


79% of the respondents depend on the private agency and pay on an average 1000 – 5000 INR per cleaning.

The **management** of waste from the septic tank i.e **septage is not scientifically conducted as per the survey.** About 32% of households are involved in unhygienic and unscientific practice of septage management. The common practice is to bury the septage inside/outside the compound.



Majority of the respondents were not aware of how septage is managed once taken out from the septic tank. A very small fraction of the respondents admitted dumping of sludge into the canals during the night by the lorries.



Identifying Septic Tanks and Soakpits

We asked series of questions, such as shape, building material, opening, outfall, absence or presence of bottom, to the respondents to ascertain if the septic tank is actually a

septic tank or a soakpit. Based on the above set of questions we can say that about 68% of the onsite installations could be septic tanks and 14 -15% could be soakpits.

It should be noted that it is a crude way to ascertain if the onsite installation is a septic tank or soakpit. However, it is a crucial aspect in black water management as it is related to public health concerns especially for the state like Kerala were significant number of people depend on the well for drinking water. The survey shows that 24.5% of the sampled households (117 out of total 476) do not maintain minimum 6 meter distance between the well and septic tanks. Out of this 117 households only 35 (30%) are using well water as primary drinking source. The survey could not establish causality between septic tank –well distance, well as primary source of drinking water and incidences of diseases at household level. A deeper analysis of this particular aspect is recommended.

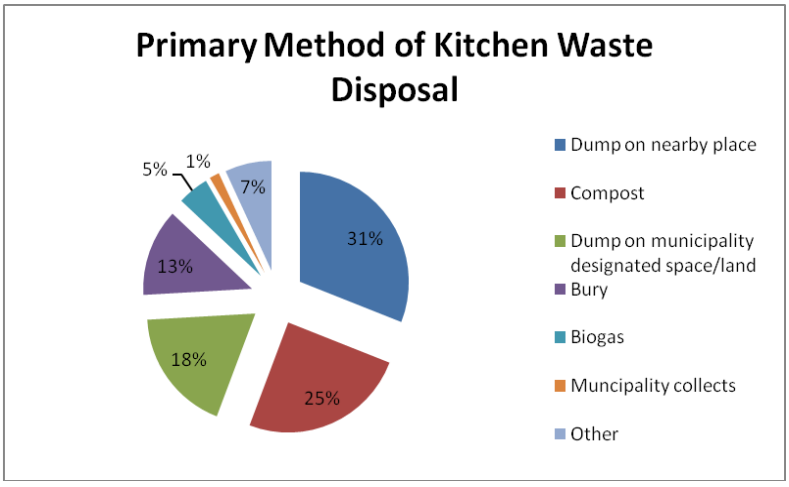
SOLID WASTE MANAGEMENT

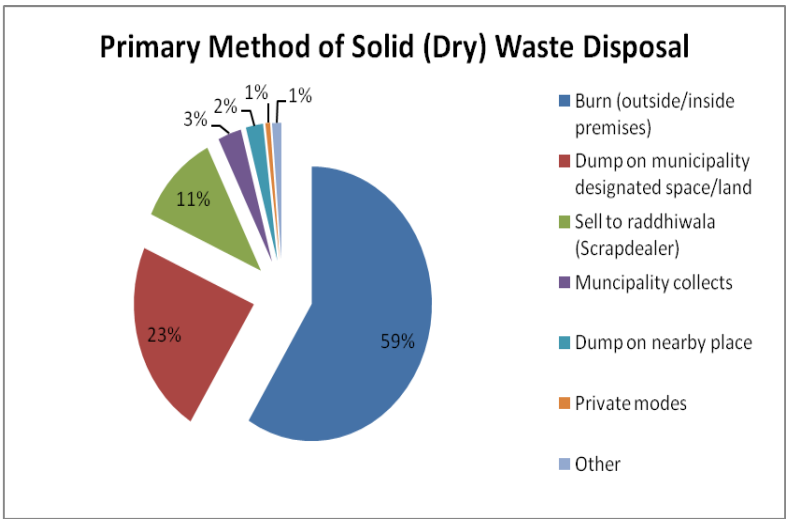
Solid waste segregation: Positive behavioural practices

77.3 % of respondents claimed that they segregate the wet and dry waste. Interestingly, self motivation (own interest) seems to be a major driving force (87%) behind solid waste segregation in sampled households. Rest 13 % segregate the waste as part of the mandatory laws/regulations.

Among the APL and BPL household category the previous seems to be involved in segregation of the solid waste in comparatively larger number. More number (85%) of the APL

Figure : a) Primary Method of Kitchen waste ; b) Solid (dry) Waste Disposal



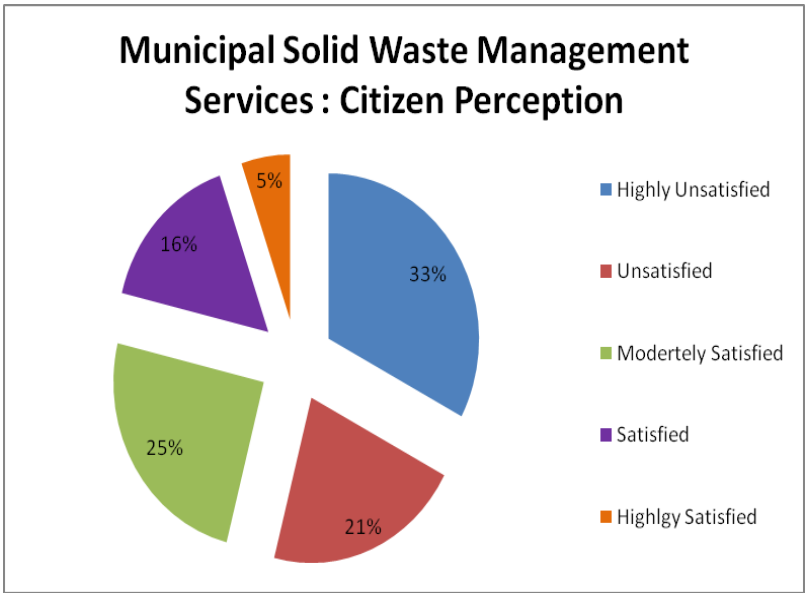


households claimed to be segregating the solid waste as compared to 62% BPL households. The self motivation as a driving force to segregate the waste seems to be higher for the APL households (89%) as that of the BPL households (85 %).

Solid waste disposal: Issues of Concern

Despite of significant proportion of the sampled households practicing solid waste segregation the struggle to disposing it is real. Since collection by the municipality is very low (only from 1% of HHs) in sampled households most of them resort to unscientific disposal mechanisms such as dumping on places nearby the house (31 %) or bury (13 %). There is significant number (25%) of the sampled households that uses compost to dispose of the kitchen waste.

Figure: Municipal Solid Waste Management Services: Citizen Perception



The management of solid dry waste (paper/plastic/glass etc) is no different with 59 % of the sampled households admitting to open burning (inside/outside premises) of waste and 1% admitting to dumping the waste on nearby places.

The solid waste collection by the Municipality is reported to be low (3%) than the stated 33 % in the Municipality draft Master Plan- 2013.[7] The results could be due to the recent norms by the municipality to stop door to door collection. The people are expected to drop their segregated waste in nearby aerobic composting plants. The move by the municipality is expected to make citizens responsible for their waste and instigate behavioural change.

[7] Source: Master Plan Alappuzha municipality 2031 - (draft). http://www.alappuzhamunicipality.in/master_plan

Majority of the respondents feel that the designated aerobic disposal plants are not at a walk able distance. The inefficiency of current collection mechanisms has given a reason to people (more than 50% of respondents) to believe that municipality is not doing enough. Respondents demand door to door waste collection mechanism and are willing to pay if such provisions are made. Under the same decision municipality no more provide dustbins. Respondents raised the issue of poor management of tourist waste. Absence of people accepted collection (door to door) and disposal mechanism (bins) has turned canals and vacant land into sinks. From the survey findings we can conclusively say that the introduction of such coercive measures has certain tradeoffs which were clearly overlooked during decision making phase.

Solid waste generation: kitchen waste generation is lower than the solid (dry) waste generation for the sampled households. The average daily kitchen waste generation per household is about 2.2 kg whereas solid (dry) waste generation is almost double (4.5 kg/hh/day) of it. The daily per capita generation for combined kitchen and other solid waste for the sampled households (avg family size = 4.2) is coming out to be 1.2 kg – higher than the estimates (540 gm/capita/day) provided in the Master Plan-2013. A more systematic analysis is needed for different types of solid waste and sources especially tourist waste.

Solid Waste Management: Highlights

- *77.3% of households segregate the wet and dry waste. About 87% of households claimed to segregate waste out of self motivation.*
- *Municipality to capitalize on the existing positive behavioural practices to design suitable interventions. Such as green enterprises based on compost/biogas from kitchen waste.*
- *Collection is an issue. Conflict is visible in people's demand (door to door collection) and municipality's decision not to provide door to door collection.*
- *People of* Alappuzha *are willing to pay for door to door collection. Need to institutionalise Kudumbshree or similar self help groups for door-to-door collection for effective management. Effective downstream management of waste is then needed.*
- *Need interventions to manage tourist waste especially plastic waste.*
- *Tradoff between effective SWM and dumping in canals: Lack of better option is making the canals and land pollution sinks. The current tradeoffs between accepted solution by the citizens and municipality's decisions give an impression that the decision was not well thought through.*

PUBLIC HEALTH

About 96 % of the HH reported not to have occurrence of water borne diseases in past one year. The most common diseases reported in the survey from rest 4% include mosquitoes borne diseases i.e. malaria,dengue,chikungunya. The secondary data from District Medical Office presents different picture. The low reportage of diseases could be due to the practice of water treatment (72% of HHs) common to typical Kerala household and higher dependence on KWA (51 % of HHs) and bottled water (19%) for drinking water.

Most common method of treatment is boiling (66%), followed by water purifiers (15%). About 10 % of the households depend on the RO facility setup by the Municipality.

Study could not find strong relationship between the perceived unsafe drinking water source i.e. public stand posts (11%) or wells (10.5 %) and water born diseases. In fact, the reported cases of diseases are from KWA water dependent households. The minimum distance needed between the well and supposedly a septic tank is 6 meters. However as per the survey about 25 % of households fail to follow the standard, which might be an issue of public health for households that are using well water for drinking purposes.

Analysis of relationship between drinking water source, susceptibility of the house to frequent water logging and occurrences of type of diseases is needed. The secondary data on public health from DMO can be used to track the household and to find above mentioned cause-impact relationships.

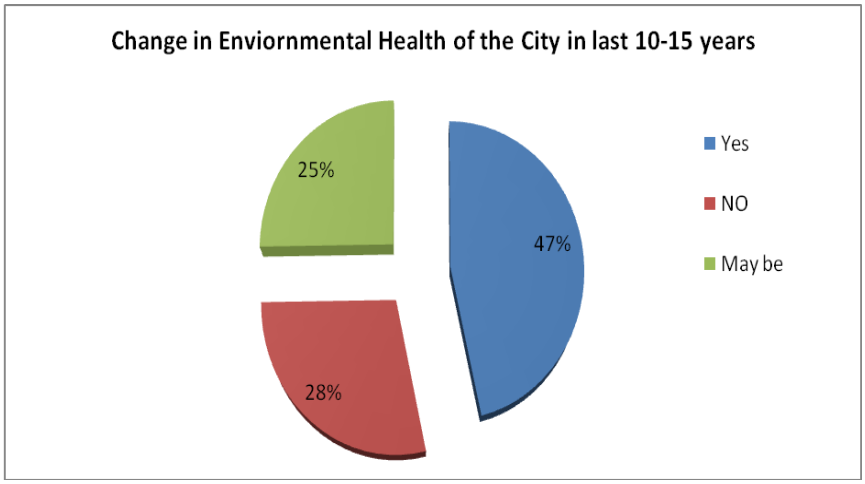
Public Health: Highlights

- *Only 4% of HHs reported occurrence of water / mosquitoes borne diseases*
- *Despite 22% reliance on perceived unsafe water resources the water borne disease incidence is low*
- *72% of HHs treat water before drinking – a common practice in Kerala household. (25 % of households fail to follow the minimum distance of 6 meters between the well and the septic tank. Could be a public health concern for households dependent on well for drinking water.*
- *Differentiating Septic Tanks from Soakpits*
- *DMO's secondary data presents different picture about prevalence of water borne diseases in monsoon times.*
- *Need deeper study of secondary data in Aleppey town is needed*

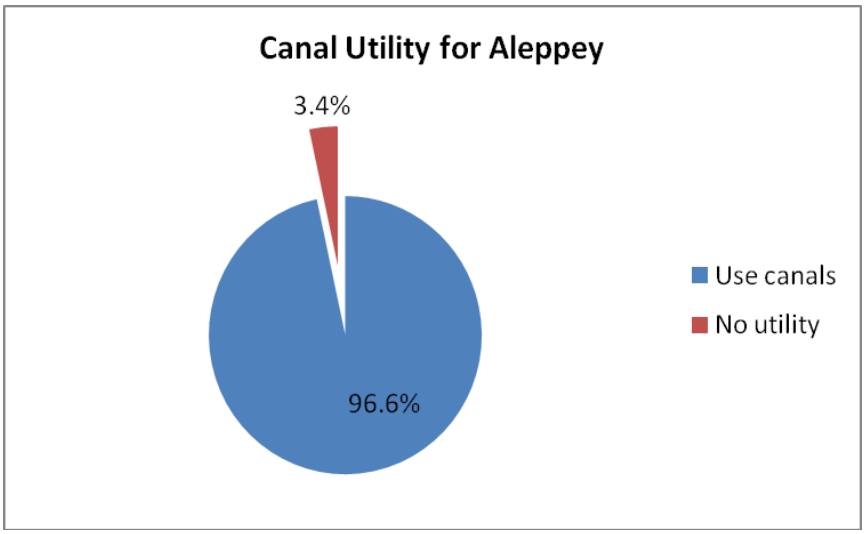
ENVIRONMENTAL HEALTH OF CITY

Figure : a) Change in Environmental Health of the City in last decade ; b) Canal Utility

Close to 47% of the respondents believe that the environmental health of the city has degraded in last 10-15 years. One of the most common response to why do they feel that the environmental health of the city has degraded is inefficient rampant dumping of solid waste, which in turn is related to the canals/drains being used as dumping sites. Respondents seem to be concerned about the quality of the canal water due to solid waste dumping including tourist waste, encroachments and black water release. The related issue highlight in the survey was mosquitoes menace due to blocked and encroached drain and canal network.



Related to above concern the survey asked questions related to perceived utility of the canal network for the citizen. The canal network of the town currently has not utility for the people (96% of the respondents).



Environment Health of Aleppey Canals: Highlights

- *47% of the respondents feel deterioration in environmental health of the town*
- *Most common issue highlighted is inefficient solid waste management including tourist waste*
- *Related issues are canal network encroached and polluted*
- *Canals have no utility for 96% of the respondents. However, majority of them are aware of ("others" using) canals as sinks of pollution*
- *Interventions needed to collect and manage solid waste*
- *Interventions needed to enhance economic and social utility of the canals : the heritage structures*

VII. RECOMMENDATIONS & PATH AHEAD

Winter School-2017 was conducted during November 28 to December 4, 2017 – a collaborative exercise between local urban body, local engineering collages and IITB to understand liquid waste management at canal shed level for Alappuzha town in Kerala. The school facilitated the process of bridging the knowledge – technology – decision making/implementation gap. Under the school three main tasks were carried out i.e. drain mapping, water sampling and household survey at the canal watershed level. Under the school a team of students (local and Mumbai) covered about 500 households, 4 major canals (with 9 inlets) in 17 polygons falling in multiple wards.

The exercise although incomplete helped in identifying key sectors eg. solid and liquid waste management and inter-related issue of health of the canal that need immediate attention. The current section discusses some of the specific recommendations. The Winter School -2017 helped in identifying key sectors eg. solid and liquid waste management and inter-related issue of canal health that need immediate attention. Specific recommendations including key areas identified as future scope of work to obtain better understanding on forward and backward linkages of liquid and solid waste management for the town are:

Liquid Waste Management

- Septic tank Census (Number, Functionality…) on an urgent basis. Need to fix unscientific Septic tanks.
- Cost comparison of septic tank retrofitting with septic tank replacement with better options. Understanding willingness to pay for different options of improved services.
- Use of Local appropriate technology like honey suckers
- Municipal responsibility to schedule and monitor tanks' cleaning, desludging (5 yr cycle)

- Feceal Sludge Management (FSM) and green jobs creation based on quality of sludge generated. Devanahalli , Bangalore an example

- Technological Interventions for bigger/major canals is a black box, which we need further discussions. Cost of DEWATs type of systems for small canals.

Solid Waste Management

- Municipality need to capitalize on the existing positive behavioural practice of solid waste segregation to design suitable interventions such as green enterprises based on compost/biogas.

- Need to institutionalise Kudumbshree or similar self help groups for door-to-door collection for effective management. Effective downstream management of waste is then needed.

- Need interventions to manage tourist waste especially plastic waste. Coir bottles with coconut base can be used to replace bottled water in major hotels and houseboats. This can help in generation of jobs and revenues for the Coir Board.

- Need to assess quantity and quality of solid waste generated from different sources to plan economic interventions, incentives and penalties'. Detailed regulatory recommendations to be workout for this option.

Public Health

- Need to capitalize on existing cultural practices of Kerala especially medicated water on larger scale to manage plastic bottle waste and public health concerns.

- Need to design a scientific study to differentiate septic tanks from Soakpits.

- Need to design a study to establish relationship between public health, drinking water source water logging and toilet waste disposal mechanisms.

- Need to design a study for seasonal analysis of water quality is needed along major canals and their inlets.

- Well water quality analysis (focus on Ecoil and other pollutants responsible for water borne diseases) for houses within permissible limit of distance between

soakpit/septic tank and well and for houses outside the limit. Need to collaborate with local institutions.

Canals: Moving from sinks to resources

Interventions needed to collect and manage solid waste. Interventions needed to enhance canals' social, ecological and economic value for people of Aleppey.

Path Ahead

Main Message to go: Canals are not wastewater drains, but a heritage to be Conserved

Canals are now considered wastewater drains. 96% of the people see no utility for the canals. This is to be reversed as canals as heritage resources to be conserved. Several inter-related activities to be planned.

1. **Technological Interventions**

c) **Main Canals**: De-weeding, Dredging and Deepening—Needs deeper studies and wider discussions on the technology to be deployed, nature of waste segregation/treatment and economic activities (boating, canal side commercial activities, beautification etc).

d) **Sub Canals and Main Drains:** (i) Cleaning-up the last stretch/outfalls to main canal by suitable treatment mechanisms (natural systems like DEWATS/small STPS/Other technological options?

2. **Averting the Tragedy of Commons**

There is no incentive for the individuals to comply with positive steps in keeping the canals clean. Any personal sacrifice like better septic tanks, onsite treatment of biodegradable waste does not guarantee immediate rewards. This attitude leads to degradation of environment, resources with canal/well/lake pollution in Alappuzha as typical examples. Pollution in canals has to be stressed not only as an aesthetic issue, but a public health and hence social problem It is proven that top down regulation or policing by State seldom works for pollution abatement unless there is a community Consensus

Building for Social Regulation[8]. A 'community' with levels of nested institutions has to be built around the canal sheds from small drains to main canals. They have to devise norms/rules/activities of influencing individual behaviour. The structure in which individual behaviour gets enabled or constrained is also important. Most of the people see polluted canals as the responsibility of the municipality. This has to be transformed to make citizens responsible to deal with their wastes and simultaneously to make the municipality accountable.

3. Students' Campaign: From awareness to Behavioural Change

How does citizen awareness, gets translated into deeper behavioral changes is the challenge? The proposed students campaign is oriented towards making student citizens, who will be given a deeper understanding of the dimensions of the problem, the implications of it and urgent need to take steps to address the issue. They will become sanitation warriors who will reclaim the canal and proclaim that as a resource they are inheriting. The message is that nobody has the right to pollute this precious resource that belongs to the future generation. So, the youth of Alappuzha are going to study this issue and going to collect the information about sanitation practices and start a dialogue with the older generation of how they have degenerated this precious resource and the need to conserve it. The information from winter school is to be compiled and are going to be used in the survey, training and campaign.

Steps in Strategy:

- Student WATSAN Survey

  Identify sources of pollution, quality and quantity at the:

  c. Household level,

  d. Subward/Ward Level- Road side drains, main drains, sub canals and main canals are mapped (making a canal shed).

- The mapping provides a fine-grained understanding of sources of pollution (solid, black/grey water) at the local level.

[8] Positive examples in GW Management – Ralegaon Siddhi, Hiwre Bazar, Pani Panchayat in Maharashtra

- After this, the canal sheds can pursue appropriate technical and institutional levels of intervention.
- Activities will be towards strengthening local level governance, through creation of sanitation zones (a combination of socio-economic characteristics, sanitation and cultural practices) laid over each canal sheds. For this a socio-economic survey will be conducted and the sanitation zones correlated with the wards as the basic unit of political boundary for decision-making. Thus sanitation zone committees will be correlated to ward level governance.
- Citizen participation will involve technical training for student citizens to analyze, monitor the problems and actively engage in the solution space.
- The ward councillor, student volunteers, *Kudumbashree* members, Asha volunteers and all concerned citizens who are willing to be part of it will be participating towards action in this mission. The present WATSAN committees created for solid waste management can be strengthened to take these activities forward.
- Shelf of tech options will be developed; such as community biogas, household DEWATS, constructed wetlands, community composts etc.
- Active use of technology like WhatsApp could be used to disseminate information and facilitate local level action like identifying individual polluters and help them. For example, a hotspot identified is under-privileged households on the banks of sub canals who directly open their blackwater into canals. There could be a project that could provide these households with individual/community septic tanks.
- **Faecal sludge management:** The existing soak pits and pit latrines to be converted into septic tanks or toilet based biogas plants. There should be proper collection of septage through efficient septage management devices, transportation and appropriate faecal sludge management and manure conversion. Faecal sludge management units to be installed and the municipalities through the active participation of the Sanitation Committees could regulate these activities. Ways of better septage management at ward/municipality levels to be devised and its compliance for treatment norms to be ensured. Having a database about the

cleaning cycles and thus formalize septage management from the municipality side is important.

- **Solid Waste Management (SWM):** The existing systems of decentralized management to be continued and deepened.
- **Green jobs creation:** Proper management of solid and liquid waste can lead to hundreds of green jobs and keeping the canals clean can boost tourism related activities and thus employment too.
- Conservation and enhancement of the canals as a heritage resource to be emphasized and be aligned with the current developmental activities happening in Alappuzha.

4. **Advocacy and Motivation by Demonstration**

There is nothing better than showing and motivating through demonstration. For this, one or a cluster of wards in a canal shed to be taken for doing and demonstrating all the above-mentioned activities. Preliminary work has already been started with a student survey involving 150 students from December 8-9, 2018.

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Annexure – Water Pollution Sampling Results , Alappuzha Town

Sample No.	Latitude	Longitude	Location	DO(ppm)	Conductivity (µS)	TDS (ppm)	pH	Iron (mg/L)	Phosphate (mg/l)	Nitrate (mg/L)	Nitrite(mg/L)
Permissible Limits (for effluent discharge)				**4 ppm**	**1200 µS**	**2100 ppm**	**5.5 - 9**	**3 mg/l**	**5 mg/l**	**10 mg/l**	**1 mg/l**
1	9.49401	76.3469	In front of KSCMMC	6	610.5	355.4	6.946	1	5	0	0
2	9.4953	76.3431	After Stone bridge	5.9	534.5	308.2	6.797	0.3	5	10	0.5
3	9.49516	76.33372	In front of Saukar Masjid(Fresh overflowing drain)	0.2	604.3	349.6	6.889	3	5	0	0
4	9.4955	76.3381	Drain next to Iron bridge	4.5	561.5	323.9	7.064	1	5	0	0
5	9.4954	76.336	Intermediate point in commercial canal	5.2	607.2	349.7	7.123	3	5	0	0
6	9.49447	76.3245	Next to Kochukadavupalam	0.1	623.6	362	7.185	0.3	5	5	0
7	9.49433	76.3209	End point of Commercial Canal (Swimming pool)	0.1	858.7	494.4	7.431	0.3	2	0	0
8	9.49216	76.397	Pump house - near to beach	0.1	2845	1636	7.795	0	1	5	0
9	9.49705	76.3217	Intermediate point in Cullen canal	0	1270	714.6	7.393	0	1	0	0
10	9.50002	76.323	Near Idukku Road	0.1	1103	636	7.386	0	2	0	0
11	9.50016	76.3308	AS canal(bridge top)	3.2	602.8	338.6	6.8	1	2	0	0
12	9.50092	76.3376	Connection drain from left (overloaded with plastic)	2.8	576.9	337.8	6.9	3	2	0	0

13	9.50103	76.348	Boat jetty	3.1	496.1	286.2	6.76	1	1	0	0
14	9.49754	76.3493	Dock Thodu	3.1	225.3	128.2	6.8	0.3	0.5	5	0
15	9.49321	76.3489	ChunkamThodu	2	537.4	309.2	7	1	1	0	0
16	9.49073	76.3487	ChunkamThodu near bridge	2.4	541.4	311.6	6.97	1	1	0	0
17	9.49057	76.3493	ChunkamThodu towards Kuttanadu	2	546.9	315	6.97	1	2	0	0