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Preliminary Water and Sanitation Assessment for Alappuzha Town

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WORKING PAPER - 1

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This is part of a Working Paper series that came out of studies and action done by CANALPY, an initiative out of the collaboration between Indian Institute of Technology, Bombay and the Kerala Institute of Local Administration.

The major aim of CANALPY is the rejuvenation of canals through decentralised and participatory social and technological interventions. It aims to work with youth and students for an informed understanding of the problems and equip them to reclaim the canal commons from their current state of dilapidation due to free flowing waste water and dumping of solid wastes. The studies done by CANALPY are trans-disciplinary in nature by forging a partnership with local youth, students and especially the municipality so that the data can be readily used for interventions. Every study is followed by presentations, consultations and brainstorming to arrive at solutions and explore the implementation challenges. The initiative started with 18 students from Centre for Technology Alternatives for Rural Areas (CTARA), IIT Bombay and 17 students from the SCMS College of Engineering and Technology, Kerala coming together for a Winter school in November 2017 organised by Kerala Institute of Local Administration (KILA) in collaboration with IIT Bombay. They developed a methodology using open source mobile applications and Geographical Information System (GIS) to undertake technical and socio-economic analysis of the water and sanitation practices and infrastructure of Alappuzha town of Kerala. This report presents the findings of the Winter School.

These are abridged versions of the larger reports. The academic reports may be downloaded freely from the CANALPY website, www.canalpy.com

Working papers in this series:

1. Preliminary water and sanitation assessment for Alappuzha Town.
2. Comprehensive water and sanitation assessment for Alappuzha Town.
3. Rapid flood impact assessment in Kuttanad region.
4. Town level assessment of major polluters and pollutants in Alappuzha Town.

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TABLE OF ACRONYMS

Acronym	**Definition**
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CPS	Centre for Policy Studies
CTARA	Centre for Technological Alternatives in Rural Areas
DEWATS	Decentralized Wastewater Treatment System
DMO	District Medical Officer
DST	Department of Science & Technology
FSM	Fecal Sludge Management
GIS	Geographical Information System
GPS	Geo Positioning System
HPEC	High Powered Expert Committee
IFAD	International Fund for Agricultural Development

IIT	Indian Institute of Technology
IITB	Indian Institute of Technology Bombay
KILA	Kerala Institute of Local Administration
KSCMMC	Kerala State Coir Machinery Manufacturing Company
KSSP	Kerala Shastra Sahitya Parishad
KWA	Kerala Water Authority
ODK	Open Data Kit
OSM	Open Street Map
ppm	Parts Per Million
QGIS	Quantum Geographical Information System
SWM	Solid Waste Management
TDS	Total Dissolved Solids
ULB	Urban Local Body
UNEP	United Nations Environment Programme
WATSAN	Water and Sanitation

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Prof NC Narayanan, IIT Bombay **Dr.Joy Elamon, KILA**

Preliminary Water and Sanitation Assessment for Alappuzha Town

ABSTRACT

Pronounced regulatory failure, lack of waste management facilities and population density have led to rampant pollution of our water bodies. In the Indian context, conventional solutions to this problem fail on two accounts - high capital and energy costs, and lack of technical, financial and institutional capacity for most small and medium towns. Decentralised technology options provide a viable alternative, but they also need a new set of data on water and sanitation infrastructure, services and practices which takes the local context into account. People's Plan Campaign for decentralised local level planning launched in Kerala in 1996 had focussed on this aspect in every aspect of development planning. This has been further proved in Alappuzha for the solid waste management project initiated under the leadership of Dr. Thomas Isaac, the local MLA who is also the Minister for Finance and Coir in Kerala. IIT Bombay has developed a protocol for such decentralised data collection which has been implemented in Alappuzha (Kerala) in the form of a Winter School-2017 involving 36 students organised by Kerala Institute of Local Administration (KILA) in collaboration with IIT Bombay. Alappuzha's canal system has visibly degraded in the past few decades due to indiscriminate dumping of solid and liquid waste. The Winter School sought to develop recommendations for the rejuvenation of the canal system through a set of exercises involving participatory drain mapping, water quality assessment and household survey. The drain mapping exercise tracked the major canals and associated information in an effort to understand wastewater management in the town. The water quality of the canals was analysed to determine the aquatic health and types of pollution. Household level surveys helped in collecting information about access to water services, sanitation practices and public health. The exercise not only highlighted the data gaps in water and sanitation at local level , but it also helped in deciding the future course of the initiative. From the collected and analysed data, it was found that a rejuvenation of the canal system requires strict control of the inflow of solid and liquid waste into the system. However, more importantly it requires a change in the mindset of the public towards the canals, to avert the tragedy of the commons.

1. RATIONALE FOR INITIATIVE

Rampant pollution of water bodies is rule rather than exception in large parts of the world. It is worse in urban areas due to population density, lack of space and proper waste treatment facilities where regulatory failure is also pronounced. This calls for a need to assess the issues in the 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 sewage 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 costs. 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 to establish conventional sewerage management systems. The launch of the People's Plan Campaign in 1996 highlighted the need for local level solutions. However, it also requires building capacities in terms of technical, financial and institutional capacities. Kerala Institute of Local Administration (KILA), the nodal institution for capacity building for decentralisation and local governance in Kerala has been working towards this by providing training, hand holding, advisory services, research and establishing linkages with technical and academic institutions to support local self governments.

In the meantime, 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 was developed during an exercise by IITB to map drains (natural and constructed) and household level services and practices in water supply and sanitation in Alibag (Maharashtra) and Nedumangadu (Kerala) with the help of local college students. The project was funded by the Department of Science and Technology (DST), Government of India. The initiative led to the development of tools, survey protocol and methodology for conducting participatory decentralised data collection on water and sanitation infrastructure, services and practices. The protocol proposed a replicable and potentially sustainable approach to a situational analysis of prevailing sanitation and wastewater practices by integrating three aspects.

- First, we regarded the local municipal government (i.e., the Urban Local Body, or ULB) as the locus of sanitation interventions, as no matter what technologies or governance mechanisms are deployed, town-wide scale-up needs the local government support.
- Second, we engaged academic institutions with the help of civic organisations to conduct household surveys to develop analytical capacity in local colleges.
- Third, we developed simple socio-spatial zones of the city by layering wastewater flows and sanitation practices on the GIS platform. Integrating these into city-wide planning can be the first step towards sustainable urban sanitation.

The protocols designed will help the local self governments in Kerala to develop participatory sanitation plan with the collaboration of local academic institutions. This can help harness analytical inputs into sectoral activities of the ULBs and also to ensure accountability of functioning by involvement of students and citizens.

2. INTRODUCTION

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 ability for universal coverage (GoI, 2008). The policy recommends cities to use appropriate technology options matching 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 of the Central Public Health and Environmental Engineering Organisation (CPHEEO). In order to assess the suitability of various technology options 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 two-fold 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.

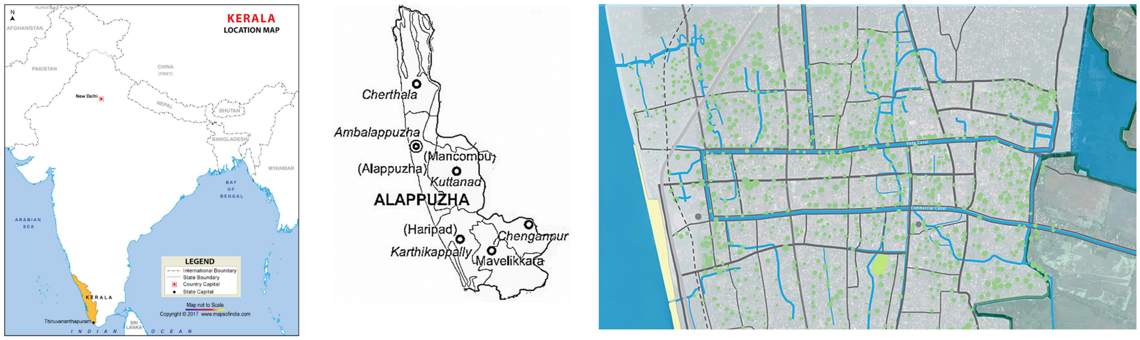
3. SITUATION IN ALAPPUZHA

Alappuzha town, western coast of Kerala, has expressed interest and intent to engage in a similar participatory exercise. It is one of the first planned towns in India. Intertwined with a canal network and backwaters the town lacks underground sewerage network and relies on septic tanks - a primary treatment method. The partially treated and untreated wastewater either leads to subsurface soil or drains into the canals. Flat topography (0-15%) and high water table (3 mts. below the ground) make it further difficult to establish a conventional sewerage network system (GoK, 2013:115). The situation presents a challenge and an opportunity to explore heterodox options of sanitation and wastewater management.

Alappuzha has the great legacy of successfully practicing decentralised solid waste management for the last 4 years. In 2017, the town won the recognition from United Nations Environment Programme (UNEP) along with three other cities in Asia and Europe.

4. WINTER SCHOOL 2017

To broaden the initiative in liquid waste management, IIT Bombay and Kerala Institute of Local Administration (KILA) in collaboration with the SCMS School of Engineering and Technology, Kerala 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 water quality assessment and a household survey.



Kerala in India

Alappuzha district

Alappuzha Municipality

Source for first map mapsofindia.com, second map onefivenine.com, third map prepared by authors

Figure 1: Alappuzha and the context

5. Objectives of Winter School

1. To impart training to students on water quality assessment and household survey on water, wastewater/sanitation and solid waste management infrastructure, services and practices using smart technologies/mobile apps.

2. To conduct drain mapping and wastewater quality assessment for main canals (MCs) , sub canals (SCs), main drains (MD), road drains (RD).

3. To conduct household survey on water, wastewater/sanitation and solid waste management infrastructure, services and practices.

6. Methodology

The school involved three major tasks (i) drain mapping; (ii) water quality assessment and (iii) socio-economic survey at household level. Figure 2 illustrates the key activities undertaken during Winter School 2017.

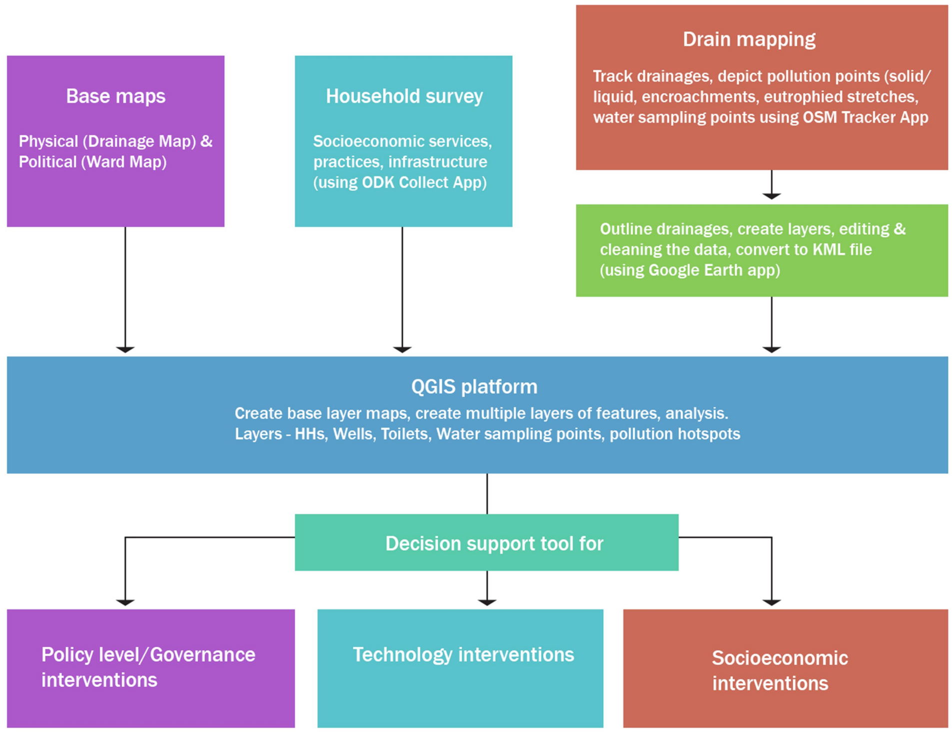


Figure 2: GIS Map and analysis- illustration of the process followed

For the detailed methodology, please refer to the Winter School-2017 Report available on the CANALPY website.

7. APPROACH TO ANALYSIS

The data from three sets of exercises i.e. drain mapping, water quality assessment and socio-economic survey for households conducted at canal watershed level (Figure 3). The information thus collected shall be used to develop waste watersheds and sanitation zones on the GIS platform. Canal watershed is considered to comprise of main canals (MCs), sub canals (SCs), main drains (MDs) and road drains (RDs). A waste watershed, concept similar to watershed, 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, has similar issues. It could be a basic unit to highlight and prioritize areas of technological, social and governance interventions.

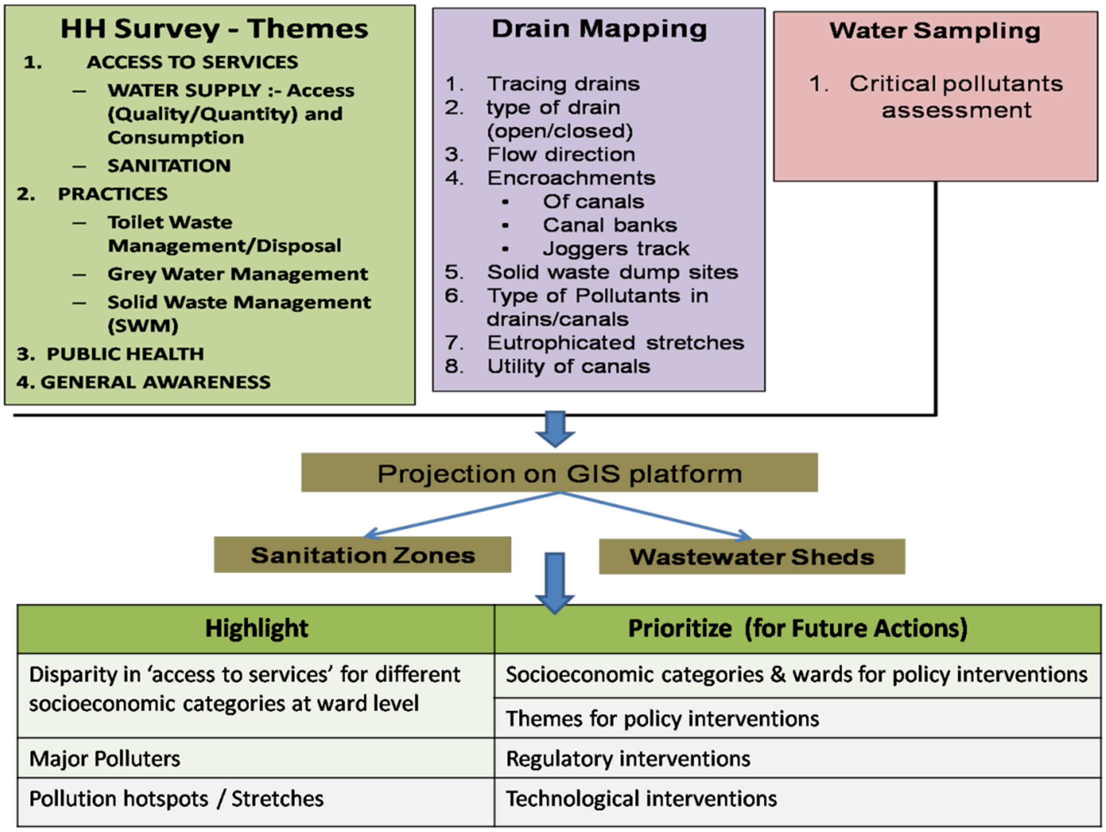


Figure 3 Analytical Framework

7.1 Drain mapping

The process of drain mapping is conducted with a purpose of understanding the wastewater flows in the cities. Typically, in Indian cities, the storm water drains which are 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. To achieve this a set of readily available tools (smartphones) and open data collection tools were used. Training on these tools can equip local people to contribute to local data creation.This approach helps in creating participatory maps which can represent socially and culturally distinct understanding of the landscape and include information which is excluded in mainstream maps. These maps if created by the local communities can depict features which they perceive to be important such as customary land boundaries, traditional practices, commons, sacred areas etc. A participatory way of creating such maps thus aids in depicting local knowledge and information and embracing the diversity in content and presentation. It also serves as a tool for empowerment, decision making and owning the resources for the local communities (IFAD, 2009).

The drain mapping exercise made use of the open data technology to create participatory maps. This exercise also helped to identify problems and issues in sewage management in surveyed areas through delineation of waste-watershed. The procedure followed for this exercise includes tracking along the drains, recording the field observations, map the geo coordinates using Open Data Kit (ODK) Collect and Open Street Map (OSM) Tracker and then plotting and analysing using Google Earth and QGIS software. The team used the ODK Collect app to survey the households and recording geo-coordinates of the households, wells, toilets and liquid discharge points. OSM tracker was used to map the characteristics of the drains and to understand the wastewater flows.

Output is a map showing main Canals (as polygon features) and respective pollution issues / hotspots on the ward boundary and drainage map (base maps). The maps are a visual representation of key hotspots and problematic areas along / in the four main canals (Commercial, Vadai, East and West bank) and sub canals. 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. Figure 4 below illustrates a map projected in Google Earth software showing the tracked canal, as well as important pollution hotspots.

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. The geo coordinates of households, wells, liquid discharge points and septic tanks were mapped as different layers. This will be useful in planning decentralized wastewater treatment units. When this data is overlaid with sanitation access, practices and socio economic household information, it can aid planning for wastewater management.

Figure 4 Drain mapping along Uppukuttipallam canal

Analysis of Chathanadu thodu using QGIS: This drain flows through the Chathanadu, Mannathu and Thondankulangara wards of the Alappuzha Municipality. Figure 5 illustrates different layers of the Chathanad canal mapped using QGIS software. The details of the various layers are as follows:

1. The base map (Physical - Alappuzha drainage map sourced from Alappuzha Municipality)

2. The base map (Political - Alappuzha ward map sourced from Alappuzha Municipality)
3. The drainage map (from OSM tracker, outlined based on tracks in Google Earth)
4. Household locations (GPS locations of the surveyed households taken using ODK Collect)
5. Well locations (GPS locations of the wells in the surveyed households taken using ODK Collect)
6. Toilet locations (GPS locations of the toilets in the surveyed households taken using ODK Collect)
7. Liquid discharge point locations (GPS locations of the liquid discharge points collected using OSM Tracker & ODK Collect)
8. Solid waste dumping locations (GPS locations of the solid waste dumping sites collected using OSM Tracker & ODK Collect)
9. Grey water discharge points (GPS locations of the grey water discharge points collected using OSM Tracker & ODK Collect)
10. Hotspots (Municipality specified waste dumping hotspots)
11. Water quality sampling points (GPS locations of the water sampling points)

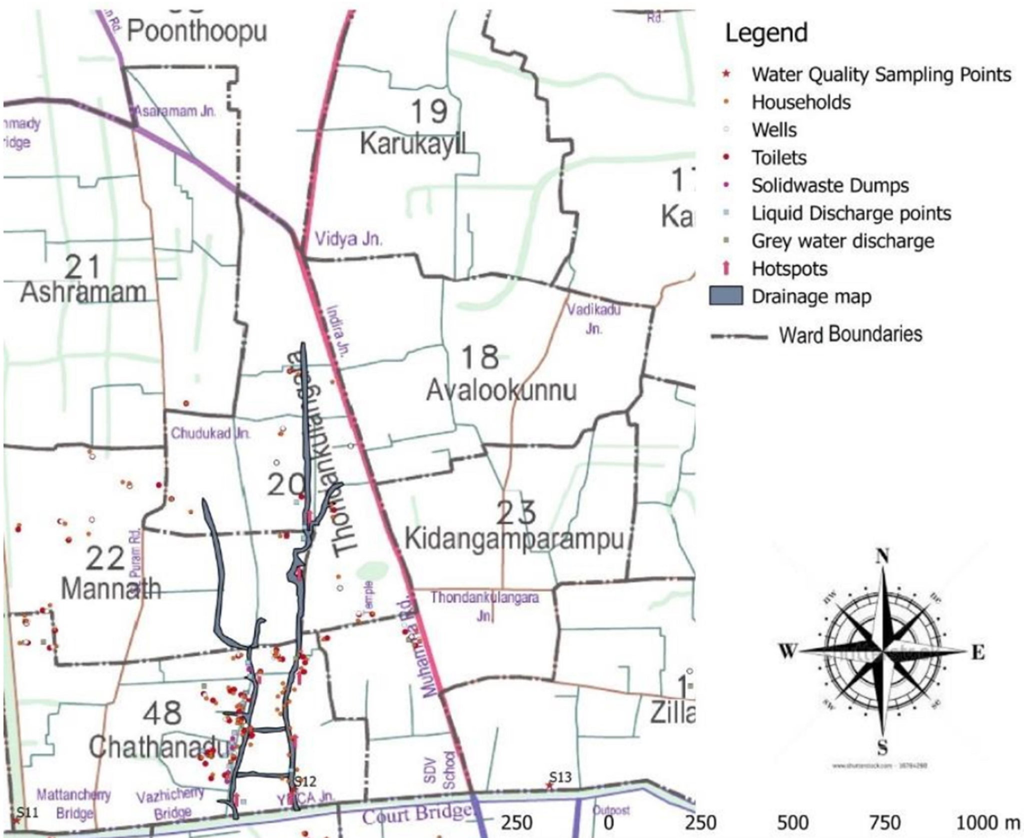


Figure 5 Different Layers in QGIS - Chathanad canal
Base Map: Alappuzha ward map sourced from Alappuzha Municipality

7.2 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 urban sanitation on the Commercial and Vadai canals, it was essential to understand the quality of water in these canals. The 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 was 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.

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 was determined by assessing three classes of attributes: physical, chemical, and biological. 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 andS14), 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)

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 the lab for further analysis. Water quality was determined by assessing three classes of attributes: physical, chemical, and biological. Table 1 shows the surface water quality parameters that were analysed along Commercial Canal and Vadai Canal. The significance of these parameters to the water quality and possible indications is also provided. Analysis of these parameters followed Central Pollution Control Board (CPCB) guidelines except for the parameters analysed with colorimetric testing kits (phosphate iron, ammonia, nitrite and nitrate). The Colorimetric testing kits used manufacturer specific reagents for developing colour corresponding to the concentration values of the parameter being tested.

Parameter	Attribute	Permissible Limit	Analysis Method[1]	Significance[2]	Indication
Electrical Conductivity	Physical	300 (mic.moh/cm)	Potentiometric Method	Total amount of dissolved ions	Higher values than the permissible limit indicates contamination
Total Dissolved Solids (TDS)	Physical	2000 (ppm)	Conductometry	refer to any minerals, salts, metals, cations or anions dissolved in water	Higher values than the permissible limit indicates contamination
pH	Chemical	6.5-8.5	Electrometric Method	Negative log of hydrogen ion concentration	Contaminants or processes within water is making water acidic or alkaline
Dissolved Oxygen (DO)	Chemical	4 (ppm)	Membrane Electrode Method	Amount of oxygen molecules dissolved in the water	Low level indicate presence of oxygen consuming contaminants, biodegradation, excessive algal growth
Iron	Chemical	1 (mg/l)	Colorimetric test kit	Amount of ferrous or ferric ions	natural deposits, industrial wastes, refining of iron ores, and corrosion of iron containing metals.

1. Sawyer, C.N., McCarty, P.L., Parkin, G.F., Chemistry for Environmental Engineering, Tata McGraw-Hill, 2000
2. Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed., 1985

Ammonia	Chemical	1.5mg/l	Colorimetric test kit	preferred nitrogen-containing nutrient for plant growth. It is converted to nitrite (NO2) and nitrate (NO3) by bacteria in presence of oxygen	Fresh waste water contamination
Nitrite	Chemical	10 mg/l	Colorimetric test kit	Intermediate state of nitrification process	Eutrophication, potential DO reduction
Nitrate	Chemical	1 mg/l	Colorimetric test kit	Final stage of nitrification	Eutrophication
Phosphate	Chemical	0.1 mg/l	Colorimetric test kit	Eutrophication	phosphate-containing fertilizers, partially treated or untreated sewage
E-Coli	Biological	Nil	H_2S Strip test	Presence of coliform	Faecal contamination

Table 1: water quality parameters and significance

7.2.1 Results of water quality analysis

The results of water quality analyses of the canal water samples are provided in appendix B. The results are discussed hereunder:

- **Dissolved Oxygen (DO)** : In general the Dissolved Oxygen 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 Vembanad estuary. The water sample from an underground drain opening to the commercial canal 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 fish.
- **Electrical Conductivity (EC)** : The electrical conductivity of the samples collected from Vadai 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.
- **Total Dissolved Solids (TDS)** : The total dissolved solids concentrations as expected shows similar variation as EC. Samples from stagnated end points near increased salinity.

- **pH** : 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 the 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 happens due to algae floating on the canal water surface.
- **Iron** : The iron concentration shows variation among the samples. In general high iron concentration was observed in the samples collected from drains opening (S3, 3 mg/l) to commercial and sub-canals of Vadai 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.
- **Phosphates**: High phosphate concentration was observed in all water samples collected from commercial canals. The water samples from sub-canals/drains opening to the 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 vadai canal and its sub-canals were relatively lower (1-2 mg/l).
- **Ammonia**: All the samples collected reported the presence of ammonia in varying concentrations indicating fresh sources of sewage into the canal water. The highest ammonia concentration was observed in the drain opening to the commercial canal (S2) indicating fresh release of pollutants.
- **Nitrate**: 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 fresh release of sewage that entered into the canal after the nitrified wastewater got flushed out by storm water.

- **Coliforms**: All the samples tested for the presence of coliform bacteria showed a positive result, indicating the presence of septage contamination all along the canal.

7.3 Access to services, waste management practices and public health

The town has about 42,000 households and about 659 households were covered in the survey. 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 . 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. The collated data was 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

d) general awareness

Water Supply: The primary source of water supply is reported to be piped water supply (KWA) for 82% of the sampled households. About 13% 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%) than 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.

Solid Waste Management: 74% of respondents claimed that they segregate wet and dry waste and interestingly, self-motivation seems to be the driving force. However, waste collection is an issue of concern as town has no provision of door to door collection currently. Conflict is visible in people's demand (door to door collection) and municipality's decision not to provide the same. In the absence of better options, canals and open lands are slowly turning into pollution sinks and needs urgent attention to retain the gains of the successful decentralised solid waste management experiment here.

Liquid Waste Management: Separate management of grey (kitchen and bathroom) and black (toilet) wastewater is a common practice at household level – a positive behavioural practice that municipality needs to capitalize on. Current methods of liquid waste management using septic tanks and soak pits need town level enumeration for their effectiveness supported by better methodological tools in order to assess if such methods are scientific or not. This is an issue of public health specifically for households that depend on wells for drinking water and fail to maintain the desirable distance of 6 meters between the well and septic tank/soak pit.

Septage Management: The management of waste from the septic tank i.e., septage is not scientifically conducted as observed in 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 lorry/truck. We asked a 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 soak pit. Based on the above set of questions, it was found that though about 61% of respondents perceived their OSS as septic tanks, only 31.2% of them were found to be proper septic tanks, whereas for others, OSS might be a simple pit or soak pit.

Public Health: In the survey, few reported occurrences of water and/or mosquito- borne diseases were reported. Interestingly, despite reliance on perceived unsafe water sources such as wells and public stand posts the water borne diseases incidence reportage is low in such cases. This could be due to high dependence on KWA water and water (boiling) treatment practices common in Kerala households. Most common method of treatment is boiling (63%), followed by water purifiers (17%). Interestingly only 7 % of the households depend on the public Reverse Osmosis (RO) facility setup by the Municipality. The secondary data from District Medical Office (DMO) presents a different and worrying picture of increased incidence of dengue fever and leptospirosis in monsoon times.

Environment health of Alappuzha canals: The 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. 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 highlighted in the survey was mosquitoes menace due to blocked and encroached drain and canal network. Related to the above concern the survey asked questions related to perceived utility of the canal network for the citizens. The canal network of the town currently has no utility for the people (96% of the respondents).

8. RECOMMENDATIONS:

8.1 Liquid waste management

Rejuvenation of the canals would require management of solid waste, control of sewage inflow, reduction of sewage concentration through pre-treatment (mandatory STPs for commercial establishments, scientific septic tanks for households and natural treatment at the end of SCs) and aeration of canals to increase dissolved oxygen to the safe levels for aquatic fauna.

8.1.1 For black water 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 honeysuckers.
- Municipal responsibility to schedule and monitor tanks' cleaning,desludging (5 year cycle)
- Faecal Sludge Management (FSM) and green jobs creation based on quality of sludge generated. Devanahalli, Bangalore an example.
- The survey could not establish causality between septic tanks–well distance, well as the primary source of drinking water and incidences of diseases at household level. A systematic analysis of this particular aspect is recommended.

8.1.2 For initial cleaning of canals:

- Urgent need to examine the suitable solid waste removal options for narrow sub canals (SCs). Need to examine the possibility of waste treatment at outlets of sub canals (SCs) entering main canals (MCs) either by small sewage treatment plants (STPs) or natural treatment methods like Decentralised Wastewater Treatment System (DEWATS) etc.

- Technological intervention for bigger/major canals is a black box, which 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). However, it is clear that the main canals need de-weeding, dredging and removal of solid waste before any technological intervention could be deployed.

8.2 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.
- Municipality's concern of not allowing piling at landfill sites 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 indifference from both sides can lead to the loss of already developed decentralised systems of solid waste management. Interestingly, people of Alappuzha are willing to pay for door to door collection.
- There is an urgent need to institutionalise *Kudumbasree* (Kudumbashree is the poverty eradication and women empowerment programme implemented by the State Poverty Eradication Mission (SPEM) of the Government of Kerala) or similar self-help groups for door-to door collection for effective waste management. Effective downstream management of waste is then needed.
- Need interventions to manage tourism waste especially plastic waste. Possibility of coir bottles with coconut base to be explored to replace bottled water in major hotels and houseboats. This can help in generation of jobs and revenues for the Coir enterprises.
- Need to assess the quantity and quality of solid waste generated from different sources to plan economic/social/governance interventions, incentives and penalties. Detailed regulatory recommendations to be worked out for this option.

8.3 Public health

- Need to design and conduct a study to differentiate septic tanks from soak pits.
- Need to design and conduct a study to establish the relationship between public health, drinking water sources, water logging and toilet waste disposal mechanisms.
- Seasonal analysis of water quality is needed along major canals and their inlets.
- Need to capitalize on existing cultural practices of Kerala especially boiled water on a larger scale to manage public health concerns.
- Well water quality analysis (focus on coliforms and other pollutants responsible for water borne diseases) for houses complying with the permissible limit of distance between soak pit/septic tank and well and for houses outside the limit. Need to collaborate with local institutions.

9. PATH AHEAD: AVERTING THE TRAGEDY OF COMMONS

96% of the respondents see no utility of the canals except as waste dump sites and wastewater drains. This is to be reversed as canals to become heritage resources and to be conserved. For this to happen several interrelated activities can be planned starting with making citizens aware of self and social regulation. 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 the State seldom works for pollution abatement unless there is a Community Consensus Building for Social Regulation. 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. For Alappuzha this is not new as there are existing Water and Sanitation (WATSAN) committees for solid waste management. These have to be activated to take-up intermediate management of solid and liquid waste. As part of the making citizens aware a students' campaign will be conducted (post Winter School - 2017) with a hope that this will provide a trigger to behavioural change.

The findings/observations from Winter School-2017 are to be compiled and to be used in the survey, training and campaign.

To accomplish the task following steps will be taken:

- Conducting student WATSAN survey to identify potential sources of pollution and waste management practices at the:

  a. Household level,

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

- The mapping provides a fine-grained understanding of sources of pollution (solid, black/grey water) at the local level.
- The canal sheds thus can pursue appropriate technical and institutional level 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 shed. 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, Kudumbasree members, Asha workers 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 technology options will be developed; such as community biogas, DEWATS, community composts etc.
- Social media tools such as 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 underprivileged households on the banks of sub canals who directly open their black water 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 which 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.

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Appendix A: Drain mapping process followed (protocol)

1. Procured available maps from the Alappuzha Municipality. Two maps are found to be useful. One is the map with the ward numbers, which provided the administrative boundaries and another is the physical map with the drains in Alappuzha Municipality.

2. These two maps are geo referenced using QGIS software and are used as base maps. Though the maps don't mention any scale, the maps are found to be made based on a scale and hence could be geo referenced and used as base maps. Maps which are made not based upon a scale cannot be used for QGIS analysis.

3. In the survey form (ODK Collect or Appsheet), the location of each household, wells, septic tank/soak pits and liquid waste disposal points are also recorded as Latitude and Longitude. These recorded points can be mapped in the base map as different layers.

4. The household locations are copied into an excel sheet and made into a kml file and is formed as a layer in QGIS.

5. Similarly QGIS layers are formed with the wells, septic tanks/soak pits and liquid waste disposal points.

6. OSM Tracker is used to track along the inlets to the main canals and record the hotspots, i.e, the liquid discharge points, encroachments, eutrophicated patches, solid waste dumping sites etc. The tracks are plotted in Google Earth and the drainage channels are drawn using the polygon feature.

7. Once the drainages are drawn using polygon features, the recorded hotspots (of liquid discharge points, encroachments, eutrophicated patches, solid waste dumping sites) are depicted in the map and they are saved as a kml files. The kml files are then mapped as a layer in QGIS.

8. The photos and the notes mentioned in the recorded points in OSM Tracker help in selecting the points to be mapped.

9. A layer with the water quality data was also formed so that further analysis based on the water quality in the drains.

Appendix B: Water quality testing results , Alappuzha town

Sample No.	DO (ppm)	Conductivity (mic.moh/cm)	TDS (ppm)	pH	Iron (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Ammonia (mg/l)	Coliforms
Permissible	4 ppm	300	2000	6.5-8.5	1 mg/l	0.1 mg/l	10 mg/l	1 mg/l	1.5mg/l	Nil limits - >
Standard->	IS-10500	WHO (2004)	IS-10500	IS-10500	IS-10500	USEPA	USEPA	USEPA	WHO (2004)	IS-10500
S1	6	610.5	355.4	6.9	1	5	0	0	3	Not tested
S2	5.9	534.5	308.2	6.8	0.3	5	10	0.5	3	Present
S3	0.2	604.3	349.6	6.9	3	5	0	0	5	Present
S4	4.5	561.5	323.9	7.0	1	5	0	0	3	Present
S5	5.2	607.2	349.7	7.1	3	5	0	0	3	Not tested
S6	0.1	623.6	362	7.2	0.3	5	5	0	3	Present
S7	0.1	858.7	494.4	7.4	0.3	2	0	0	3	Not tested
S8	0.1	2845	1636	7.8	0	1	5	0	1	Present
S9	0	1270	714.6	7.4	0	1	0	0	3	Not tested
S10	0.1	1103	636	7.4	0	2	0	0	3	Present
S11	3.2	602.8	338.6	6.8	1	2	0	0	3	Present
S12	2.8	576.9	337.8	6.9	3	2	0	0	3	Present
S13	3.1	496.1	286.2	6.8	1	1	0	0	3	Not tested
S14	3.1	225.3	128.2	6.8	0.3	0.5	5	0	1	Present
S15	2	537.4	309.2	7	1	1	0	0	3	Not tested
S16	2.4	541.4	311.6	7	1	1	0	0	3	Not tested
S17	2	546.9	315	7	1	2	0	0	3	Not tested

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Preliminary Water and Sanitation Assessment for Alappuzha Town

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