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Comprehensive Water and Sanitation Assessment for Alappuzha Town

Centre for Policy Studies (CPS) and Centre for Technology Alternatives for Rural Areas (CTARA),
Indian Institute of Technology, Bombay

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Kerala

WORKING PAPER - 2

May 2018

This is part of a Working Paper series that came out of studies and action done by CANALPY, an initiative 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. The initiative, led by Kerala Institute of Local Administration (KILA) and Centre for Technology Alternatives for Rural Areas (CTARA), IIT Bombay, 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.

The preliminary assessment of water and sanitation issues in Alappuzha thus identified solid and liquid waste pollution in the sub-canals as the major impediment to the health of the canal system. This called for a comprehensive assessment involving - civil survey of the canals to restore flow, more stakeholders (shops, industries) and the viability of interventions (including the willingness to pay for improved sanitation systems). This was carried out as a Summer School during May 2018 involving 300+ students from multiple disciplines all over India. The main academic partner in this exercise was CUCEK (Cochin University College of Engineering, Kuttanadu). This report presents the findings of the Summer 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
APL	Above Poverty Level
BIS	Bureau of Indian Standards
BPL	Below Poverty Level
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPS	Centre for Policy Studies
CSC	Canal-Shed Committees
CTARA	Centre for Technological Alternatives in Rural Areas
CUCEK	Cochin University College of Engineering, Kuttanad
CWRDM	Centre for Water Resources Development and Management
DST	Department of Science & Technology
GIS	Geographical Information System
GPS	Global Positioning System

IIT	Indian Institute of Technology
IITB	Indian Institute of Technology Bombay
ISO	International Standards Organisation
JICA	Japan International Cooperation Agency
KIEL	Kerala Enviro Infrastructure Limited
KILA	Kerala Institute of Local Administration
KSCMMC	Kerala State Coir Machinery Manufacturing Company
KSCSTE	Kerala State Council for Science, Technology and Environment
KSIDC	Kerala State Industrial Development Corporation
KSPCB	Kerala State Pollution Control Board
KWA	Kerala Water Authority
MSW	Municipal Solid Waste
NEERI	National Environment Engineering Research institute
ODK	Open Data Kit
OSM	Open Street Map
OSS	Onsite Sanitation System

PCB	Pollution Control Board
QGIS	Quantum Geographical Information System
WHO	World Health Organization
WTP	Willingness to Pay
YMCA	Young Men's Christian Association

ACKNOWLEDGEMENTS

The project on Rejuvenation of Canals of Alappuzha was kick-started under the dynamic leadership of Dr. Thomas Isaac, Hon. Minister of Finance and Coir Government of Kerala. We thank him for inspiring us as well as the participants of Winter and Summer Schools by his pro-active participation and unwavering support over the course of the last few months. We express our gratitude to Sri. G. Sudhakaran, Hon Minister for Public Works and Registration or his constant support and the release of the report. Mr. Thomas Joseph, the Chairman of Alappuzha Municipal Council has been an eager partner in this project and we gratefully acknowledge the support provided by him and the councillors in the respective wards. We would like to register our gratitude towards former District Collector Ms. Anupama TV who has motivated and encouraged us with her presence.

Students have been our core strength and we thank all the participants of Winter School 2017 - the students of Centre for Technology Alternatives for Rural Areas (CTARA), IIT Bombay and SCMS College of Engineering for their hard work, perseverance and attitude to work continuously in developing the methodology. We thank Dr Sunny George and Dr Ratish Menon of SCMS Engineering College for their support, especially the water quality analysis during the winter school.

We are indebted to Dr Sunil Kumar, Principal of Cochin University College of Engineering, Kuttanad (CUCEK) for the constant support and guidance in civil engineering survey and its analysis. We also thank Alappuzha Municipal Secretary, Mr. Jahamgeer S for his support and M.R. Prem, the convenor of the project, for his unflinching support at all stages. We are grateful to Mr. K Prasad the Chairman and P.V.Saseendran, the Managing Director of Kerala State Coir Machinery Manufacturing Company (KSCMMC) for opening up their office for the team and as a venue for Summer School. We are indebted to Mr. Biju Balakrishnan, Executive Engineer, Kerala State Pollution Control Board (KSPCB) who simplified many obstacles for the accomplishment of Environmental study in Alappuzha. We thank Mr. Haran Babu, Executive Engineer, Raju Hariharan and Jerome C Yohannan in the Irrigation Department for their keen insights and suggestions to improve the civil engineering survey.

We were greatly benefitted by the stimulating inaugural speeches by Dr. Sunita Narain, Director General, Centre for Science and Environment and Dr. Rajendra Singh of Tarun Bharat Sangh and the presence of best minds in India as panellists of the workshops. We would like to also register our gratitude towards all the enthusiastic participants of Summer School 2018 who played an important and instrumental role in data collection. Unstinting support from our dedicated volunteers from (CUCEK) and Assumption College, Changanacherry helped in smooth conduct of the surveys. It is their hard work, perseverance, and attitude to work zealously in the field for hours which helped us in collecting this large quantum of data within this short span of time. Akhil VS as a local volunteer whole heartedly anchored the Civil Survey team and was instrumental in making the maps and helped during the planning phase and logistics. Latha Raman/Jaigopal and Ritesh Vijay, NEERI, not only shared our philosophy of choice of technology, but shared our passion of saving the Alappuzha canals. It is a joy to continue to work with them.

The efforts put in by our academic team are unmatched. Neelam Rana, Sridhar Ananthanarayanan , Sruthi Pillai , Zachary Burt and Paresh Chhajed formulated the survey designs, reports and training module and analyzed the data and contributed to formalize the recommendations. The volunteers from the School of Planning and Architecture, Vijaywada - Sonam Gurmet, Karun Achintya and Riyanka George prepared the Geographical Information System (GIS) maps that helped enhance the efficacy of the surveys. We are also indebted to Sarat Chandran, Arvind Kartha, Farzeen Mohammed, Ali Akbar, Anugraha, Abdul Rehman and Ruhaim, who volunteered with us during the second phase and helped in co-ordinating the survey teams.

Unstinting support and energy of Rohit Joseph and KILA Research Assistants Nithin Benjamin and Jibin Louis were the lynchpin for the whole event to run on the track. Anoop John efficiently managed food and accommodation arrangements for both the participants and the resource persons. Bai Krishnan handled the responsibility of institution building and communicated with the ward shed committees. Thanks to Ambadi who clicked spectacular pictures throughout the summer school.

A special thanks to our graphic designer Sruthi Das who conceptualized and designed our 'CANALPY' campaign. Apart from designing all the stationary and merchandise associated with the campaign, she has worked with our green event partner 'Light it Up' headed by Anu Karthik and Rishian who provided cloth banners, plastic installations and utility products to the participants and helped us in making this Summer School a green event. Media promotion and awareness campaigns for the Summer School and the Canalpy campaign was done by George Fernandez.

Our interns from Tata Institute of Social Sciences, Mumbai, Mithun Louis and Rupakshi Mathur have been pillars of strength in all aspects of the summer school and we fondly remember their contributions towards the project. We also thank Dr. Vidya Subramanian, Postdoctoral Fellow, Centre for Policy Studies (CPS), IIT Bombay for documenting the expert sessions and for preparing the press reports along with Ambadi and Devika.

Further, we thank Rinu, Roy, Shibin, Benson, and Deepak for logistical support. The food provided by the catering team Snehajalakam, Annam and Shinu was delectable and we thank them for the same. We would like to duly acknowledge the technical support provided by CUCEK College and the civil engineering survey equipment provided by Carmel Engineering College. We thank Mr. Dineshan Achary of CTARA, IIT Bombay, Shri. Jayaraj, Shri. Mathew Andrews, Smt. Girija Devi R and Girish K of KILA for the coordination and administrative support.

We are grateful to Angel King and Socio-Economic Unit Foundation for providing accommodation to the participants, and Pagoda Hotel for accommodating our resource persons. Tony Jose and Jose Nellukaran opened their homestays to us to use as private spaces that made our stay in Alappuzha productive and enjoyable.

Special thanks to Punnapra Jyothikumar and team for enthralling all of us with their folk song performances.

We thank Prof. Satish Agnihotri, Head, CPS and CTARA, IIT Bombay for his support right from the conception of the school and for chairing our valedictory function. We thank the colleagues and staff of CTARA, IIT Bombay and KILA for their support to the Summer School. Finally, we would like to thank the people of Alappuzha, without whose cooperation this exercise would not have seen fruition. We thank them from the bottom of our hearts for their support, suggestions, enthusiasm and warmth with which they embraced our team and participants of Summer School. We dedicate this work to them.

We also thank Sarat Chandran and Jisna Jose for their effort in compiling this working paper from the main report.

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

Comprehensive Water and Sanitation Assessment for Alappuzha Town

ABSTRACT

In the Indian context of small and medium towns, lack of technical, financial and institutional capacity mean that decentralised systems of sanitation and waste management offer a better alternative to capital and energy intensive centralised systems. Alappuzha, on the south-western coast of India is now part of an exercise by Indian Institute of Technology, Bombay and the Kerala Institute of Local Administration (KILA) to develop a decentralised, integrated sanitation plan to deal with its degraded canal network. Through Winter School- 2017, an academic exercise involving 36 students, we were able to map the canal network to develop wastewater sheds and hence sanitation zones, understand the water quality of the canal system, and the waste management practices and water services at household level. For Summer School- 2018, this has expanded to a comprehensive assessment of water and sanitation practices in Alappuzha and for revival of the canal network, including civil work to restore flow in the canals, bacteriological contamination of water sources, willingness to pay of households for improved sanitation facilities and environmental study of commercial establishments. The importance of institution building and community participation to revive the canal systems have also been understood.

1. BACKGROUND

Urban India, much like other parts of the Global South, suffers from a chronic degradation of its natural environment, the major brunt of which is borne by its water bodies. The reasons are several, including population density, lack of space and proper waste treatment facilities coupled with pronounced regulatory failures. Viable solutions for these will have to take into account the specific local contexts and multi-dimensional nature of the problems.

Conventional sewerage projects target the problem with a pre-set technology solution without understanding its possible linkages with the local context. This often results in suboptimal functioning of the sewage management infrastructure. The decentralised alternatives to conventional networked approach have been tried and tested in varied contexts by government and non-government organisations across India. The decentralised planning at city level needs a new set of knowledge, tools, institutions and resources. The foremost requirement is to have quality data on the current status of water use and sanitation to identify issues and search for context-specific solutions. This data gap can be filled through crowdsourcing, thus there is a need for increased citizen participation in urban sanitation planning. People's Plan Campaign for decentralised local level planning

launched in Kerala in 1996 had focussed on evidence based context specific local solutions 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.

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 harness this potential resource the Indian Institute of Technology Bombay (IITB) conducted an exercise 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. In the meantime, KILA has been providing training to the urban local governments on integrated waste management as well as was in the process of developing City Sanitation Plans for around 56 urban local governments.

After the successful attempt at bringing science-policy-citizens together, IIT Bombay, and Kerala Institute of Local Administration (KILA) in collaboration with SCMS College of Engineering conducted a Winter School in December 2017 in Alappuzha (Kerala). The town, situated in Southern Kerala, has the great legacy of successfully practicing decentralised solid waste management for the last 4 years. The town is currently in urgent need of an alternate approach in technology and planning to deal with the growing problem of canal pollution. The Winter School-2017, in this context, provided a much-needed platform to explore alternatives in a participative manner with the help of local citizens and students.

About 36 students were engaged in drain mapping using GIS tools, conducted water quality assessment and a household survey. The exercise led to a data base on parameters related to water supply, sanitation, solid waste management, public health, well data etc. for more than 600 households and commercial establishments. It helped in strengthening the protocol to conduct decentralised participatory planning and identifying the scope of future activities including a pilot intervention at Municipal Colony. As a follow-up to the Winter School a series of training programmes were conducted for local youth who later worked as volunteers for the Summer School-2018.

1.1 SUMMER SCHOOL 2018

The Summer School-2018 was conducted from May 6 to May 25. It was conducted by KILA and IIT Bombay in partnership with the Cochin University College of Engineering, Kuttanad (CUCEK). The school received voluntary support from Master in Social Work students of Assumption College, Changanassery. The school consisted of 300 students from multi-disciplinary backgrounds (Civil/Environmental Engineering, Architecture/Urban Planning, Social Sciences/Social Work). The data from about 1500 households and 221 commercial/industrial establishments situated along the project area i.e. canals shed of Vadai and Commercial canals were collected during the duration of the school.

2. STUDY AREA

Alappuzha is one of the first planned towns in India. Intertwined with a canal network and backwaters the town lacks underground sewerage network and sewage treatment facilities. The canals of Alappuzha in the last two decades have shown visible signs of degradation owing to the indiscriminate dumping of solid and liquid waste from residential and commercial establishments. The two canals are part of the huge network of canals (9 main and 104 connecting canals) in Alappuzha.

3. OBJECTIVES

To further our understanding of sources of solid and liquid waste pollution to canal network the scope of Summer School-2018 was expanded from households to commercial and industrial establishments. The key objectives of the Summer School-2018 were:

1. To map civil engineering features, including amount of muck/silt deposited, of canal network as part of the civil survey.
2. To map current infrastructure, services & practices in solid waste and sanitation among different socio economic groups at household level as part of the socio-economic survey.
3. To map the willingness to pay of households for various toilet waste management options as part of the household survey.
4. To map water quality of drinking water sources including wells, Kerala Water Authority (piped water) and public stand posts.
5. To conduct an environmental study of commercial and Industrial establishments to understand solid and liquid waste management practices.
6. To establish linkages between septic tank-well distance and bacterial contamination by on-site measurement.

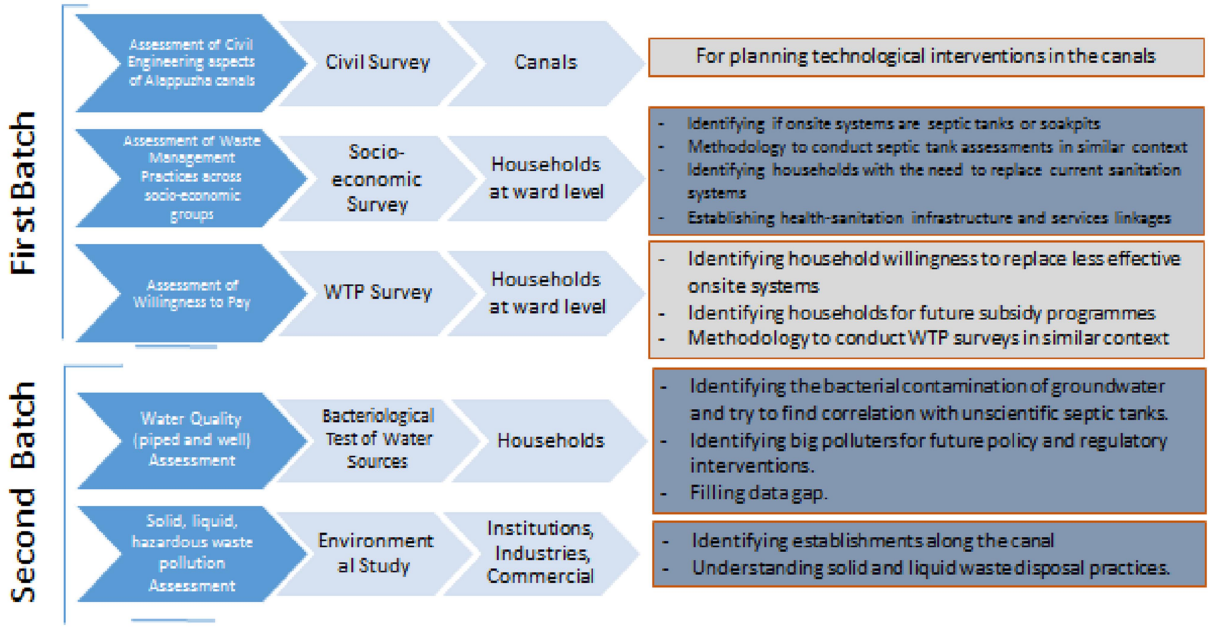


Figure 1: Key components and outputs of Summer School 2018

4. METHODOLOGY

The civil survey, willingness to pay survey and socio-economic survey were conducted by the first batch students. The second batch conducted the environmental study of the commercial establishments, socio economic survey (of Kaappithodu) and bacteriological contamination test of water sources (dug wells,bore wells and KWA public taps). The steps and tools used to carry out the surveys are explained below.

4.1 DATA TOOLS USED FOR SURVEY/ANALYSIS

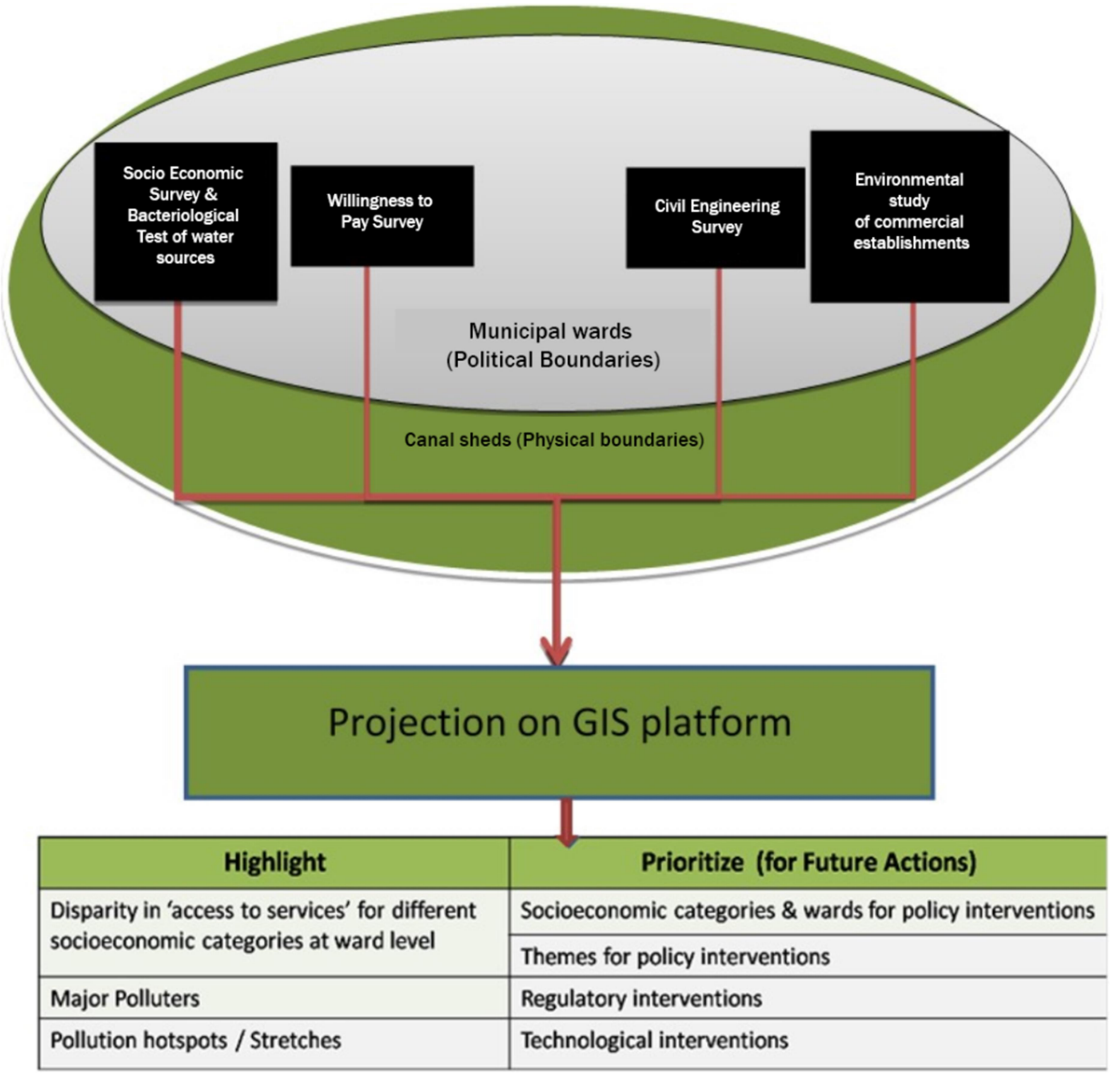
The questionnaire for socio economic survey, willingness to pay survey , civil engineering survey and water quality was designed and developed using Open Data Kit (ODK). The survey was carried out using ODK application in the android phones of the participants. Coordinates of houses and septic tanks were recorded up to an accuracy of 4 meters on ODK collect . The responses were collected in google sheets. The recording of geo coordinates of public tap, hotspots and commercial establishments were carried out using Open Street Maps (OSM) and analysed using QGIS. and ArcGIS Software. Google earth was used in plotting the canals, canal sheds , hotspots and to carry out data cleaning.

4.2 DATA AND MAPPING TOOLS USED FOR LOGISTICS AND PLANNING

The planning and logistics management of surveys was done with the help of Google Maps. The groups were assigned a set of households for the survey and each set formed grids. This helped the students locate grids and parking spots using their mobiles easily. These were also used to carry out examination of the progress made each day by plotting it on google maps. Maps were also used for water sampling in the second batch where they collected samples from the geo coordinate response of the first batch. Parking points were also marked on the map so that the students know where to get down and wait for the vehicle after the survey. In addition, they stuck a CANALPY sticker to identify the households surveyed and to create awareness about the project.

4.3 ANALYTICAL FRAMEWORK

The data collected for different components was collated and analysed at ward and canal-shed level. The data was then projected on to a GIS platform that can be used as a decision support tool to highlight and prioritise areas of policy, technological, governance and social interventions.



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

Figure 2 Analytical framework

4.4 STRATEGY FOLLOWED

The strategy followed for the different components are:

1.Delineation of canal sheds

The first task was to prepare a base map of all the drains and sub-canals leading to the main canals i.e. Vadai and Commercial canals. This was done with the help of maps obtained from government sources. Gaps in information which existed due to lack of maps for drains and sub-canals were filled by volunteers using OSM (Open Street Map) Tracker app. The order of the drains was also marked while tracking which were depicted using different colours.

Using the elevation tool of Quantum GIS Software, the canal-sheds along the drains were delineated. The different canal-sheds were demarcated using the Elevation plugin in QGIS software. The boundaries of each of the canal-sheds were drawn connecting the highest points around each canal.

2. Civil engineering survey

The major aim of the civil engineering survey was to generate data required to prepare an estimate for a primary cleaning of the canal system. This is to ensure the flow of water in all the sub-canals and main canals so that aquatic life could sustain and to tackle the problem of flood in the canals (particularly during the monsoon) due to the accumulation of silt and sludge.

3.Socio economic survey and Willingness to pay survey

The aim was to map current infrastructure, services and practices in solid waste and sanitation at household level and to map willingness to pay of households for various toilet waste management options. Questionnaire was developed using ODK build and data was collected from 1259 households by participants of Summer School -2018. The collected data was analysed using excel. Interviews of masons were conducted as part of the study to understand the way the masons build septic tanks.

4.Sampling of water sources for bacteriological contamination

The geo location of the wells and of the corresponding households were collected by the use of the mobile survey app ODK Collect with a target of 10 houses and 2 public taps a day. From the socio economic survey data collected by the first batch, 756 households were found to have wells while 737 respondents said they had both wells and septic tanks/soak pits in their household. Out of this, water samples from the wells in 503 houses were collected to check for groundwater contamination. 124 public tap samples were also tested and assessed for the bacteriological contamination of the treated Kerala Water Authority (KWA) supply.

5.Environmental study of commercial establishments

An environmental study of the commercial establishments and institutions along the side of the main canals (Commercial and Vadai) was conducted with the second batch of the Summer School-2018 students. The study involved following set of activities:

a) An initial reconnaissance visit with the KSPCB officials along the canals to make a preliminary list of institutions along the canal.
b) In order to identify the institutions along the canal and make a list, official documents and secondary data was examined at the KSPCB office. These documents and data included the consent to establish and operate applications received by the office and the status of those applications. The list was cross checked with the preliminary list prepared in the previous step.
c) Identifying the typology of institutions along the canals.
d) Ascertaining the waste management practices followed by these institutions.

e) Categorization of the commercial institutions under Red, Orange, Green and White categories based on the pollution respective index.
f) Designing of questionnaires using ODK including the geo location of the commercial establishments.
g) Commercial establishments were surveyed by student volunteers as part of the Summer School – Second batch.
h) The survey data was analysed and commercial establishments were mapped on to My Maps.

5. MAPPING CIVIL ENGINEERING FEATURES OF CANAL NETWORK

One of the main problems affecting the canal network is flooding (particularly during the monsoon) due to accumulation of silt and sludge. The civil engineering survey sought to generate the data required to prepare an estimate for a primary cleaning of the canal system which could ensure restoration of flow in all the canals. The major objectives of the survey are:

1. Determination of quantity of desludging and desilting.
2. Correction of canal profile to ensure available gradient for the uninterrupted water runoff.
3. Determination of length of side wall to be protected.

The following is the step-by-step listing of the methodology adopted to map civil engineering features.

a) Drain mapping and the delineation of the canal network into 14 different stretches.
b) Survey Questionnaire developed using ODK build for civil engineering survey.
c) 60 students in 10 groups conducted the survey of each of these canal stretches.
d) All the required features were recorded as part of the survey along with their geo locations.
e) Analysis of data.

A detailed methodology of the civil engineering survey is provided in Appendix A. For detailed maps prepared as the output of the civil engineering survey, refer to the main report - Summer School 2018 available from the CANALPY website.

5.1 LENGTH OF SUB-CANALS

Name of canal	Length (m)
Sadamani canal	2113.76
Ayyappan Pozhi Thodu (near SP Office)	1434.3
YMCA Thodu (from Marthoma Church)	1515.86
Alleppey Company canal	803.9
New Haveli canal	165
Library canal	521.1
Employment canal	153.85
Haveli road canal	179.5
YMCA Thodu – 2 (Canal opposite to private bus stand)	770.2
Thathampally Thodu (Canal near Sisir palace)	436.95
Total Length	**8094.42**

Table 1: Length of sub-canals Source: Civil Engineering surveys carried out during Summer School 2017

5.2 VARIATION OF CANAL WIDTH WITH LENGTH

It is clear from the outset that the sub canals vary abruptly in their width along their topographical layout. It has been observed that much of this variation, more precisely reduction in width is due to encroachment to the canals. This has considerably affected the flow of water in the canals and flooding is the result during monsoon and silting during non-monsoon seasons. The presence of slab covering, encroachments, and compound walls on canal bunds and vegetation on canal side banks affected some of the observations.

5.3 VARIATION OF REDUCED LEVEL (RL) OF CANAL CENTRE BOTTOM WITH LENGTH

Though there are undulations in the canal centre soffit, a natural slope is available. This gradient is generally from the mouth of canal to exit, but with exceptions wherein the canals slope from the mouth and exit to an interior location. The data from this analysis could be employed to fix the available natural gradient in the canals uniformly. Calculations were made to obtain the corrected reduced level.

5.4 CORRECTED REDUCED LEVEL (RL) OF CANAL CENTRE BOTTOM

Enlightened from the observations and analysis of the levelling in the previous Section, available gradient of each canal is smoothened to be linearly varying from the mouth to exit, in general or from the mouth and exit to the lowest level as in the cases of YMCA Thodu, Alleppey Company canal and the Library canal. It may be noticed that no filling is proposed in this report, though required, ideally at some locations in the canals owing to expected silting in due course of time with flowing water.

5.5 VOLUME OF DESLUDGING AND DESILTING

Thickness of sludge was observed as the length of sludge sticking on the wooden graduated scale inserted vertically into the canals.The volume of sludge between every two staff locations along the length of canals is calculated as the product of the average width, average depth of sludge and length of the stretch. The total volume of sludge in all the sub canals is close to 5000 m^2.

Table 2 shows the quantity of cutting and desilting required in the canals so as to ensure smooth available gradient for free run-off of water. This is calculated from the positive difference between the existing RL and corrected RL of the canal centre soffit, width and length of canal. The total volume of desilting and cutting is also close to 5000 m^2.

Name of canal	Volume (cu. m.)
Sadamani canal	1402.2
Ayyappan Pozhi Thodu (near SP Office)	1690.4
YMCA Thodu (from Marthoma Church)	958
Alleppey Company canal	260.3
New Haveli canal	129.8
Library canal	82.3
Employment canal	29.6
Haveli road canal	12.7
YMCA Thodu - 2 (opposite to private bus stand)	118.2
Thathampally Thodu (near Sisir Palace)	242.8
Total Volume of Desilting	**4926.3**

Table 2: Volume of desilting required

It was observed during the survey that side walls of total length of approximately 3.5km in all canals are either not protected at all or covered with vegetation or inadequately protected. To rule out the possibility of soil erosion from the sides, canal bunds should be covered with random rubble masonry, ferro-cement slabs or coir geotextiles. Suitable gabion embankment of 15 cm to 20 cm height shall also be proposed at canal banks in order not to let the debris and waste to flow to canals from roads.

5.6 FINDINGS

a) Almost all of the sub canals contribute to the pollutant in the major canals in the town. The encroachments and dumping of waste in the canals reduced the width and depth of the canals and impedes or restricts flow of water.

b) Some of the canals were dry owing to drying up of silt. Many portions are not accessible due to compound walls built on both sides, growth of vegetation, covering of slabs.
c) The civil engineering survey reveals that natural slope of sub canals are from the mouth to exit or to locations other than mouth, particularly in the case of three sub canals.
d) Technology is available for the cleaning of canals, improving water quality via methods like, phyto-remediation, etc., but a comprehensive social behavioural change is the high need of the hour.

6. LIQUID AND SOLID WASTE MANAGEMENT IN HOUSEHOLDS - STATUS AND IMPLICATIONS

The household survey to map the socio economic situation, sanitation practices and environmental services was conducted along the sub canals leading to the two major canals - Vadai and Commercial. The specific objectives were:

1. To map the current infrastructure, services & practises in water, sanitation & solid waste management.
2. To determine if onsite systems are septic tanks or soak-pits.
3. To identify septic tanks not complying with the various regulations.
4. To determine the perceived utility of Alappuzha canals.
5. To identify households having willingness to participate in #Canalpy campaign.

6.1 METHODOLOGY

To map the household practices in solid and liquid waste management, a structured questionnaire was used complemented with semi-structured interviews to get specific details.

- Design of questionnaire: The questionnaire evolved after a series of pilot and actual surveys over the last six months. It included questions related to general household/respondent information, disposal of waste water from toilets, bathroom, kitchen and solid waste management practices. The respondents were asked questions related to water supply, health, perceived utility of the canals and intention to take part in the canal conservation campaign.Although the 'study area' refers to the entire Alappuzha town, the 'project area' is confined to the banks of the sub canal network. Thus the scope of the survey was limited to the two rows of houses along the sub canals. About 1500 households were approached with 83% survey response rate with a Female to Male ratio of 1:1.

- Pilot test: The form was piloted by students of the Master of Social Work (MSW) from 2 to 5 May, 2018. The students were given training on survey protocol and questions related to septic tanks. These included steps like recording the distance between well and the onsite sanitation system (OSS) using a measuring tape. The distance between the two point

features i.e., well and OSS was also recorded as GPS coordinates using ODK collect. The feedback from the students were duly noted and incorporated in the form. The volunteers as team captains led the socio-economic survey during the Summer School.

- Data collection through household survey: The participants were given a training on the data collection tool (ODK collect) and were explained the questionnaire. They were explained about the purpose of the survey, especially the CANALPY campaign and how to approach the households. The participants were divided into a team of two to make a total of 31 teams. Each team was assigned a certain stretch within different canal- sheds and were asked to approach the two rows of households situated along the canals. The finalised forms containing household data were then sent by students from their mobile app (ODK collect) to a host Google drive. The data thus collected was later collated and analysed on excel and QGIS/ArchGIs. Volunteers from the first batch of the Summer School were given a training on analysing certain components of the data and later on helped the team in analysis exercise.

- Desk study and interviews with masons: One of the major objectives of the socio-economic survey was to determine if households have septic tanks or soak pits and how many of those are scientific. A desk study was conducted essentially to find-out if similar studies have been done and if so, then what methodology or tools were used. The desk review indicated a gap in the literature in this area. However, literature does throw light on the fact that most of the septic tanks might be just soak pits (Government of India, 2016). Further, studies did highlight that the perception among households that their OSS is a septic tank has perpetuated from the masons. Taking a cue from this, a series of interviews were conducted with the local masons and sanitary dealers in Alappuzha. The desk review helped in identifying various regulatory requirements to build and maintain septic tanks or soak pits, which were included in the questionnaire.

6.2 SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLED HOUSEHOLDS

With about 45% of the sampled households falling under 3 to 4 family size bracket the average family size is 4.2, which corroborates the Alappuzha Master Plan estimates. With 54.6% of the households having 3 to 4 rooms the average number of rooms per household comes out to be 4.2. Above figures coupled with the higher ownership status of houses (84%) the population seems to be belonging largely to the middle income group.

The sampled population shows higher representation of (71%) APL and non-Scheduled Caste/Scheduled Tribe (SC/ST) households (97%). This is in line with the Census 2011 figures of 2.2% SC/ST population in the town. As far as house ownership is concerned the APL households have better percentage (77%) as compared to the BPL households (~63%). A greater percentage (75%) of APL households have wells within their premises as compared to only 25% of BPL households. This could be related to the plot size of the house (63% are within 1-5 cents) and thus a proxy indicator of household wealth. The average plot size in case of BPL households is 8 cents as that of 12 cents for APL.

6.3 WATER SUPPLY STATUS

Kerala Water Authority (KWA) seems to be the primary source of water to fulfil daily household needs with dependence on wells less than 24%. About 5% of the sampled households stated usage of public taps and stand posts. The overall dependence on wells for drinking (~6%) and other household needs (24%) (Figure 24) is relatively lower. However, it is important to determine the probable relationship between well water usage and water quality because Alappuzha's high population density vis-à-vis toilets and high water table imply risks to public health.

6.3.1 Primary sources of water

Figure 3 below shows the primary sources of water and Figure 4, those of drinking water.

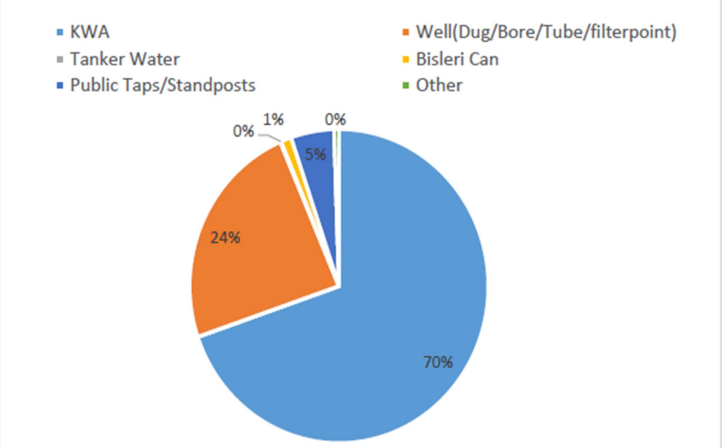


Figure 3: Primary source of water

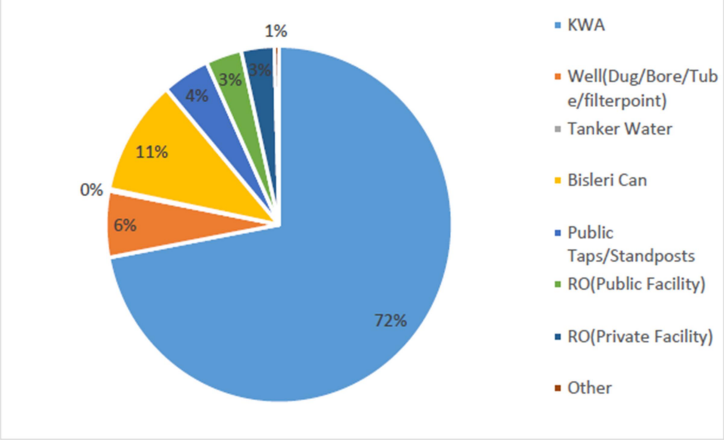


Figure 4: Primary drinking water source

The dependence on KWA water for daily household needs is higher for the APL households (~71%) than that of the BPL (68%) . Accordingly, the public stand posts usage is higher (~9%) for BPL households as compared to APL. The well usage is slightly higher for the APL households than the BPL. Fewer BPL sampled households found to be having wells at home.

It was also found that the primary purpose of the well water is for washing utensils or washing the floor in APL households. The BPL households on the other hand are reported to be primarily dependent upon wells for bathing purpose. Even though, drinking is not the primary purpose for which well water is used in APL and BPL households it could be an issue of concern since the majority of the sampled households found to be having just soak pits for toilet waste disposal and fail to maintain a safe distance (7.5 meters) between the pit and the well.

6.4 SOLID WASTE MANAGEMENT

In order to understand the efficacy of the current model of decentralised solid waste management in the city, we asked a series of questions during the survey including if household is engaged in segregation or not, what are the methods for dry and wet waste disposal and if they are satisfied with the municipal services of solid waste management. Lastly using GIS we estimated maximum distance (approachable road) at which aerobic units are established from a cluster of households. Moving forward from the Winter School-2017 last year, the Summer School-2018 took into consideration assessment of sanitary waste disposal methods. The results are discussed hereunder.

Solid waste segregation: More than 78% of the sampled households reported that they segregate the waste into wet and dry waste, which has been made mandatory by the municipality under its decentralised waste management approach in 2012 when door-to-door collection of unsegregated waste from households were stopped. Interestingly, majority of the respondents (85%) attributed the practice of waste segregation to their own motivation and not to the regulation.

Kitchen waste disposal methods: While 32% use waste from kitchen in garden or as compost, about 17% reported to resort to unhealthy practices i.e., dump the waste in nearby areas or canals. With only 15% of the respondents reported to deposit kitchen waste into the community aerobic units, the utilization of these decentralised units is unexpectedly low.

Dry waste disposal methods: Close to 50% of the households manage their dry waste (plastic, paper, metal etc.) in improper ways i.e., burning, dumping on nearby land or canals. The households seem to be utilizing the community aerobic bins (municipal designated places) disposal mechanism more for the dry waste (21%) disposal than for the kitchen waste (15%). The utilization of infrastructure of decentralised solid waste management is evidently low.

Sanitary waste disposal methods: About 62% of the households resort to burning of sanitary napkins. The burning of sanitary pads is known to release toxins that are dangerous for humans and the environment.

User satisfaction for Municipal services: Even though the waste segregation rate at the household level is impressive, the city has failed to translate it into an effective solid waste management model. Close to 50% of the respondents expressed dissatisfaction with the services as compared to 24% who find the services to be satisfactory. The key issue highlighted during the survey was the inability of the government to provide door to door waste collection. The absence of such a system has led to indiscriminate dumping of waste into the canals and other water bodies turning them into sinks.The Summer School-2018 findings corroborate the results of Winter School held in December 2017 and thus, are a clear indication of larger public opinion on demand of door-to-door collection system in the city.

Efficacy of community aerobic units: The efficacy of the aerobic units was assessed for their availability, affordability, accessibility and utilization. The city has about 23 aerobic units, most of which are located in the project area. The services are free of cost and hence affordable. However, the aerobic unit utilization is very low for depositing both wet (15%) and dry waste (21%). In order to understand why the utilization is lower we determined the maximum distance a household member has to traverse to deposit the waste in the nearest aerobic unit. We conducted the exercise for one ward i.e. Sea View as it has a mix of various social categories. The ward has three micro canal sheds feeding into Vadai and Commercial canals.

We found out that even though the maximum distance to travel to reach near-by aerobic units is well within the 1 km range the utilization is poor. Clearly the local people do not agree with this model of decentralised solid waste management.

6.5 LIQUID WASTE MANAGEMENT

The domestic liquid waste management has three key components: waste from the toilet (solids and water), and waste from the kitchen and bathroom also known as black and grey water respectively. As per various standards like Bureau of Indian Standards (BIS), Central Public Health and Environmental Engineering Organisation (CPHEEO) the black and grey water should be managed separately (BIS, 1995) and (CPHEEO & JICA, 2012). To understand the primary disposal methods for toilet, kitchen and bathroom waste we asked households a certain set of questions during the survey.

Grey water management: To manage waste water from the kitchen and the bathroom majority of the household resort to soak pits. However, there is a considerable number that release waste from both the sources within the household premises or into near-by canals.

The households during the survey were found to be practicing grey and black water separation. However a considerable percentage (63%) releases the two types of waste water

into the same disposal system (septic or soak pit) which impacts its efficacy. To understand the primary disposal methods for toilet, kitchen and bathroom waste we asked households a certain set of questions during the survey.

Black water management: The primary method of toilet waste management as per the respondents is septic tank (63%), followed by soak pits (36%). Very small percentage of respondents (0.007%) however admitted to releasing wastewater into the nearby drain without any treatment.

The higher density of OSS could be a serious threat to ground water quality vis-à-vis public health especially for a city like Alappuzha as it has a high water table and sandy to loamy soil (Alappuzha Municipality , 2016). Thus, it is imperative to determine if the OSS at household level are properly built and managed structures. The specific objectives were:

1. to determine household's perception of toilet waste disposal method
2. to confirm whether OSS is a septic tank or just a soak-pit
3. if it is a septic tank, whether it follows various design standards.

Septic tanks are watertight single storeyed tanks in which sewage is retained sufficiently long to permit sedimentation, without any effluent release as per Bureau of Indian Standards . The main purpose of the septic tank is typically for foul sewage (faecal matter and urine) and sullage (discharge from wash basins, sinks and similar appliances, which does not contain human excreta) is not part of this. In sum, a septic tank is a watertight container with a sealed bottom and an outfall, and should not receive wastewater from other sources. Following the norms, the survey questionnaire was designed to determine the three objectives.

The analysis of household data showed that only 31.2% of the households have proper septic tanks whereas others OSS might be simple pits or soak pits. Further, 81.8% of the households having proper septic tanks failed to maintain a minimum distance of 7.5 m between well and the tank.

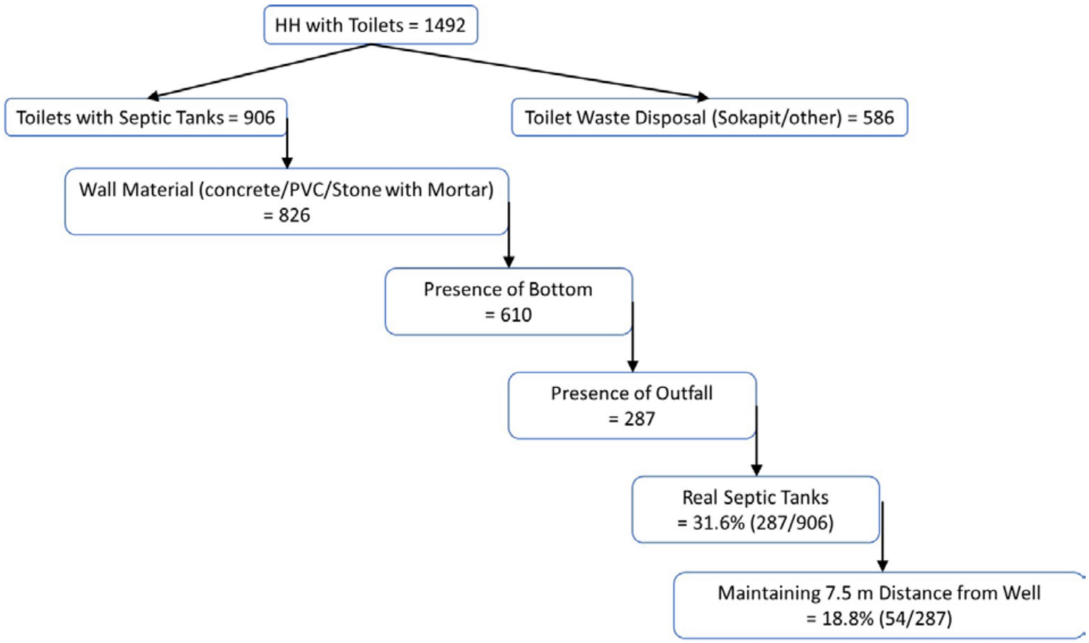


Figure 5: Percentage of households having proper septic tanks

The parameters against which the septic tanks and soak pits were assessed are presented in Appendix B.

Further, the analysis shows that the higher number of BPL households (60.1%) are not complying with the regulatory requirement of 7.5 meter distance between the wells and OSS . This could be due to relatively lower average plot size (~8 cents) in case of BPL households as that of ~12 cents in APL households. Thus, maintaining a safe distance between the well and OSS is difficult for the BPL households.Thus majority of the households might need retrofitting of OSS to eliminate threat to groundwater and humans.

Keeping funds and other resources in mind the prioritization can be done based on criteria such BPL households or households having heavy reliance on the well water etc.

Figure 6 below illustrates the average distance between well and OSS for both APL and BPL households within 3 categories - <7.5m, 7.6-15m and >15m.

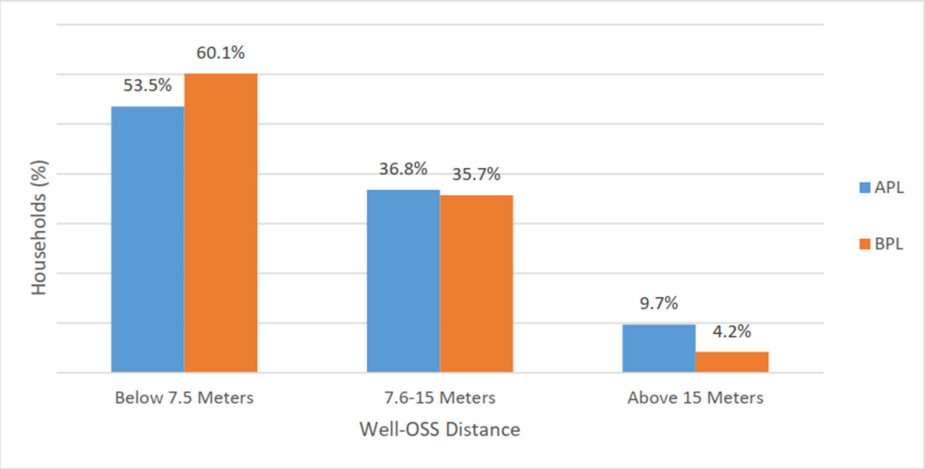


Figure 6: Well and OSS - average distance for APL/BPL households

6.6 PERCEPTION ON CANAL MANAGEMENT

The canals have shown a visible deterioration in the last two decades as noted by Kallelil Raghavan Pillai, a noted historian of Alappuzha. Earlier people used the canals for bathing, washing and cleaning purposes. However over the course of the past few decades, the canals have been reduced to mere navigation channels due to deteriorating quality of the canal water.

The survey showed that people in Alappuzha do not value the canals. About 89% of the respondents do not find any utility in the canals . For respondents who reported to use the canals the most common usage of canals is liquid and solid waste discharge. 70% of the respondents opined that cleaning the canals would definitely improve their business prospects and boost tourism in the area.

As part of the institution building exercise to socially regulate the pollution in the canals, the households were asked if they are willing to participate in different activities of the CANALPY campaign. The three activities are canal shed committees (CSC), mobilization campaign and cleaning drives. The CSC as of now are envisioned to be having supervisory roles with a dynamic structure. The cleaning drives would be a periodical activity which might need people to physically contribute. The mobilization campaign would be intense in the beginning of the Canalpy initiative requiring a lot of ground work and conscientizing people. The response rate was mild as only 44% showed any interest to participate in the campaign. The most and least preferred activities are CSC and cleaning drives.

7. WATER QUALITY ANALYSIS

Many studies have found that the groundwater in coastal district of Alappuzha is vulnerable to bacteriological contamination due to shallow water levels and the existing sanitary practices (CGWB, 2013) (IISc, 2010).

Fecal contamination is present in 90% of drinking water wells in Kerala, with the open character of wells, conventional maintenance habits; soak pits/septic tanks at a distance less than the prescribed distance of at least 7.5m contribute to the bacteriological contamination (CWRDM, 2013)(KSCSTE, 2005). High population density (Alappuzha is one of the most dense districts in Kerala), high well density and with unscientific black and grey water disposal are considered to be the major reasons for the widespread bacteriological contamination of the groundwater aquifers (Karthick et al., 2010).

The water quality analysis carried out during Summer School-2018 had twin purposes of (a) testing the water quality, especially the bacteriological contamination to assess the gravity of the problem and (b) simultaneously making it into a campaign where the problem is demonstrated to households.

The bacteriological contamination is tested using a simple presence and absence (P-A) test to measure the presence or absence of indicator bacteria using Hydrogen Sulphide (H2S) vials. After pouring water sample into the vial and keeping it for about 24-36 hours at 30^{o}C to 25^{o}C, the color of the sample will turn black if there is bacteriological contamination and those which do not turn black are considered to be free from it.[1] This test is used in order to meet water quality standards and guidelines, determine source water quality, treatment system efficacy, distribution system integrity, to come up with water safety plans, risk assessments, management purposes or to encourage, educate and empower local citizens about water quality through community involvement (WHO, 2002).

7.1 METHODS AND TOOLS

The water quality analysis was carried out as part of a socio economic survey , where the geo location of households were collected using ODK collect. Water samples were collected from about 503 wells and 124 public taps to assess bacteriological contamination using H2S vials. Bacteriological contamination in wells was tested to understand the extent of the problem and also to concretise households on the quality of water they are using. Very high percentages (97%) of dug wells were found to be contaminated. Secondary data was collected from the District Medical Office and interview with the District Medical Officer.

[1] To know more about this test: https://www.who.int/water_sanitation_health/dwq/WSH02.08.pdf

7.2 FINDINGS

Alappuzha town has a high number of wells and a very high population density. One of the major observations is the inability of certain households with a low per capita availability of land to maintain a safe distance between the wells and septic tanks due to the small plot sizes. The secondary data analysis of incidence of diseases showed a high and increasing trend of water borne diseases in Alappuzha.

From the socio economic survey, out of the 1043 responses about their water supply source, it was found that while 65% of the households have KWA water as the primary water source, 29% rely on the wells and 5% had to rely upon the nearby public taps.

When asked about the secondary drinking water source, it was found that 379 households also use a secondary water source for their drinking purposes in addition to the primary drinking water source. Out of them, while another 15% said they use KWA water supply as the secondary drinking water source, 24% were relying on wells, while 25% relied upon bottled water and 20% relied upon RO (public facility) for their secondary drinking water needs.

On analysis of the socio economic survey data, 756 households were found to have wells while 737 respondents said they had both wells and septic tanks/soak pits in their household. 691 wells were functional and out of them, 402 were tube/bore wells, 286 were dug wells and 3 were of other type (such as filter point wells).

Out of these wells, 503 well samples were tested for the presence or absence of biological contamination out of which 261 were dugwell samples, 243 were borewell samples. 123 KWA public tap water samples were also tested for checking the biological contamination of the treated water supply. It was found that after 3 days, 93% of dug wells (243 samples), 82% of borewells (200 samples) and 39% of KWA water samples (48 samples) were found to have bacteriological contamination. While the contamination of groundwater sources of dug well and bore well could be due to the unscientific waste disposal mechanisms, the contamination of the treated KWA water samples could be linked to leakages in the water supply as well as due to pressure differences in the network, which allows the contaminated water to enter into the network.

Potability of water, as well as its suitability for other domestic purposes, is affected by its microbiological and chemical qualities. Hence ensuring a particular standard of these is essential to public health.. While poor quality of water due to microbiological contamination can lead to disease outbreaks and result in serious epidemics, deterioration of water quality due to chemical contamination of water is slower but could harm the human health significantly.

With high density of population and environmental pollution, Alappuzha district faces severe drinking water shortages. Many of the farther areas do not get water in adequate quantities and there is contamination of the water supply network due to leakages and pipe bursts. This results in people relying upon other sources which includes wells which are

also contaminated and poses a public health issue. Moreover, during the monsoon, flooding occurs in many parts of the district which further decreases the accessibility to safe drinking water and causes unsafe sanitation thus resulting in outbreaks of various types of water related diseases.

7.3 OBSERVATIONS

One of the major observations is the inability of households to keep the safe distance between wells and septic tanks due to the small plots of households with a low per capita availability of land. Bacteriological contamination in wells was tested to understand the extent of the problem and also to conscientize households on the quality of water they are using. A very high percentage (97%) of dug wells were found to be contaminated. The secondary data analysis of incidence of diseases showed a high and increasing trends of water borne diseases in Alappuzha.

8. PREFERENCES AND WILLINGNESS TO PAY FOR IMPROVED FECAL SLUDGE MANAGEMENT IN ALAPPUZHA, KERALA

Any large-scale intervention aimed at cleaning the canals will need to address the contamination originating from inadequate or inappropriate on-site sanitation. This is a challenge first and foremost because not many local residents know the importance of proper septic tanks; many are contaminating the groundwater and the canals without even realizing it. Some sort of awareness raising campaign will be needed. In addition to raising awareness about how improper on-site systems contaminate groundwater and the canals, some sort of subsidy may be needed, in order to encourage households to upgrade. The first step in setting a subsidy is assessing demand, and characterizing preferences. Ultimately a subsidy aims at managing demand, so the first step towards demand management is to identify the attributes of on-site sanitation that influence demand, and the household characteristics that influence willingness to pay. The preferences of local people were collected using a discrete choice framework to determine a better understanding of local preferences for different types of on-site containment and fecal sludge management. It also included an estimate of the willingness to pay (WTP) for those on-site containment options, and also what are some important household characteristics that influence those preferences and WTP.

8.1 METHODOLOGY

Household Survey was carried out with focus on some of the secondary canals which feed into the two main canals running through the center of Alleppey, the Vadai Canal and Commercial Canal. These secondary canals were mapped, and a designated area of approximately 300 meters on either side. Within this area, every third house was approached for a survey, with a goal of collecting a total of 1000 households. We tried to create a representative sample by assigning sample sizes for each cluster based on overall density and land area covered.

All surveys were conducted on android phones, using the free application, Open Data Kit (ODK). For each household we conducted a survey which included socio-economics indicators, as well as questions regarding their current on-site containment system, and whether they use groundwater. In addition, they were shown two cards. Two different sets of cards were used in our survey, each with slightly different survey protocols. The first set of cards presented two different hypothetical on-site systems. The whole process was then repeated three times. In the second set, the first card was not chosen randomly; instead, survey questions were used to determine which card described the respondent's current on-site containment system. The first card clearly stated that it represented their current system, and as such, the associated price was zero. The ODK survey was programmed to give the appropriate card number (the levels for treatment and reuse of fecal sludge were still randomly chosen), so that the enumerator would know which card was appropriate to present to the respondent.

Table 3 illustrates the different attributes and levels of each presented during the WTP survey. Every option presented would be a certain combination of each attribute. For example, an option presented would have a lower probability of contaminating groundwater, cost Rs 6000, require emptying >5 years, and so on.

Attributes and Levels	
Prices (₹): ₹ 2,000, ₹ 4,000, ₹ 6,000, ₹ 8,000, ₹ 10,000, ₹ 12,000, ₹ 14,000, ₹ 16,000, ₹ 18,000, ₹ 20,000	Ground Water Contamination: High Probability of Contamination Low Probability of Contamination
Land Requirement 2 m2 (20 sq ft) 4 m2 (40 sq ft)	Frequency of Emptying 2-5 years > 5 years
Construction Method Mason Pre-fabricated	
fecal sludge Management fecal sludge Treated fecal sludge Not Treated	fecal sludge Reuse/Disposal Reused in Farms Disposed in the Canal

Table 3: Attributes and levels included in the WTP Survey

In order to estimate the subsidies necessary to encourage upgrades in on-site sanitation, we collected data from hardware shops and contractors on the costs of installing different types

of septic tanks. In addition, we wanted to know the costs of installing soak pits as well, not to estimate subsidies, but to verify whether or not the WTP estimates corresponded with current market prices.

8.2 FINDINGS

People had a strong preference for septic tanks that do not pollute groundwater, that, on average, people do not seem to have a strong preference for land area or construction type and that a system-wide upgrade that includes treatment and reuse of fecal sludge would increase WTP for septic tank upgrades. A larger willingness to pay was observed for men, home owners and houses with a smaller built area. So, the initial efforts should be focused on men, home owners, and houses that have a smaller built area.

9. WASTE MANAGEMENT IN COMMERCIAL AND INDUSTRIAL ESTABLISHMENTS

In Alappuzha, most of the industries are small scale and fall mainly within the orange category[2]. Since smaller firms face higher cost of compliance, there are routine violations. Before identifying the violators and different types of pollution violation problems happening in Alappuzha and measures to rectify the same, there is a need to identify the industries and commercial establishments in the town. Further in case of Alappuzha, water bodies or canals are mainly being affected by the sanitation practices of commercial establishments in the banks of the canals. Thus, in order to understand the state of the canals, it is imperative to study the waste management practices employed by the commercial establishments and industries along the sides of the canal.

9.1 OBJECTIVES

The key objectives of the study were

1. To identify and map different types of commercial establishments on the banks of Commercial and Vadai Canal.
2. Understand the solid and liquid waste management practices followed by the establishment and Industries.
3. To understand the perception of canals and their perceived utility for the commercial establishments.

[2] The typology used for categorisation of different institutions (commercial establishments and Industries) along the canal sides are according to the revised Classification of industries under Red, Orange, Green and White categories based on their respective pollution index. This is according to the notification no. B-29012/ESS/CPA/2015-16 dated 19/08/2015. Refer http://pib.nic.in/newsite/PrintRelease.aspx?relid=137373

9.2 METHODOLOGY

The main focus of the environmental study was commercial establishments and institutions along the side of the main canals (Commercial and Vadai). The survey was conducted initially with the help of the Kerala State Pollution Control Board (KSPCB) the main regulator of pollution.

An initial reconnaissance visit was undertaken along with KSPCB Assistant Executive Engineer during which it was learnt that most of the commercial establishments were functioning without consent/clearance from KSPCB. Thus it was established that there was an urgent need to fill the data gaps of identifying the typology of institutions along the canals and the waste management practices followed by these institutions.

In order to collect details of these establishments a questionnaire was devised and was uploaded into the Open Data Kit (ODK) Collect platform (https://opendatakit.org/use/collect/) – a mobile based app was used to collect data, take photos, and take geolocations and to send the responses to Google drive. The app does not need the internet to collect data. The questionnaire included sections on general information about the establishment, solid and liquid waste management practices followed perceived utility of canals and awareness on sanitary tax component of property tax. The teams were also asked to take geolocation of the institution and collected responses then analysed using Excel. Initial pilot survey was conducted by student volunteers who targeted selected establishments and industries.

9.3 FINDINGS

In 2016, Central Pollution Control Board (CPCB) released the 'Final Document on Revised Classification of Industrial Sectors'. Commercial establishments in Alappuzha have been classified according to the revised categorisation proposed by CPCB. For those Industries and establishments which are not included in the Revised Classification of Industrial Sectors(B-29012/ESS/CPA/2015-16 dated 19/08/2015), we referred the Kerala State Pollution Control Board Circular Number PCB/T4/115/97 dated 17/03/2017 which included state-specific industries.

Sanitation and waste management practices: Almost 60% of the institutions surveyed did not have toilets and were using toilets of neighbouring establishments or commercial complexes. There were no public or community toilets in the survey area.

Black water disposal: 75% of the respondents surveyed dispose of the black water into septic tanks. However, in 20% of the establishments, black water also was being diverted directly into soak pits.

Grey water disposal: 32% of the respondents are using soak pits for disposal of greywater. Almost 64% of the respondents were disposing off the grey water in the septic tank while 4% admitted that they were disposing it off through drains into canals. This means most of

the establishments (64%) do not segregate the black and grey water streams that might adversely affect the efficiency of the septic tanks.

Solid waste management: 43% of the respondents claimed that they segregate waste into different types. While a majority claimed to do it out of self-interest (52%), almost 23% admitted that they were doing it due to government policy mandating the same. Interestingly, 16% of the respondents are motivated by fiscal incentives from sale of scrap.

10. RECOMMENDATIONS AND PATH AHEAD

10.1 TECHNICAL SOLUTIONS FOR CANAL NETWORK

- Initial cleaning of the sub canals by the irrigation department with de-sludging and de-silting shall ensure gradual and smooth natural slope for water run-off, especially during the monsoon. Actual estimates should be prepared to see how far the student-led exercise was helpful.
- Certain technological interventions such as rubble masonry, ferro-cement slabs or coir-geotextiles along the length of canals can help in protecting the side bunds. Gabion walls of 15 cm to 20 cm height at the canal banks to prevent debris to flow into canals from roads have been proposed.
- A study to understand the seasonal water flow especially during the monsoon is recommended, which will help in prioritising areas for future technological interventions.

10.2 SOLID WASTE MANAGEMENT

- The utilization of decentralised aerobic units is unexpectedly low despite being accessible (walkable distance of 300-800m) and affordable. About half of the sampled households were dissatisfied with the municipal solid waste management services due to the absence of door to door collection, which also explains the lower utilization rate of aerobic units. A thorough study to find out ways and means to enhance the efficacy of the aerobic units is recommended.
- Hybrid model of waste management with equal participation of residents and municipality through the medium of canal shed committees can be implemented. This also helps in creating local jobs. A group of technically skilled youth can work with canal shed committees to ensure the sustainability of household treatment systems like biogas plants and pipe compost units. The potential of activities like collection and processing of solid wastes to generate green jobs is to be assessed.
- A major issue identified was the disposal of sanitary napkins. A study to understand the behavioural practices, users' perceptions, need and demand for eco-friendly cloth based sanitary pads and napkins is highly recommended. Meanwhile, households can be asked to segregate sanitary waste from other domestic waste and label it for segregated collection and safe disposal. The government can install incinerators in

offices, government institutions and improve toilet facilities in such public institutions and commercial establishments.

- In the case of commercial establishments in dense market areas, the municipality needs to provide essential sanitation infrastructure in the form of dustbins and/or aerobic units. The municipality has to put forth regulations and form partnerships with trade unions to ensure that segregation happens in these establishments. Efforts towards improving the business environment for local scrap dealers can increase the rate of segregation in commercial establishments.
- Regulations to facilitate demand side management of the solid waste such as plastic bottles, cutlery, and food wrappers etc. are to be explored.

10.3 LIQUID WASTE MANAGEMENT

- The grey water and black water, though initially segregated in houses end up in the same soak pit which affects the efficacy of waste disposal. Also, there is a lack of scientific septic tanks. Awareness and training programmes for masons & households on proper septic tanks is highly recommended
- Based on the analysis of the sampled population, the majority of the OSS might need retrofitting as these might pose a threat to groundwater and human health. A study to examine the appropriateness of existing design(s) and technological options for onsite sanitation systems at individual household/cluster or community level in Alappuzha context is recommended. Similar study is suggested for treatment and management of grey water.
- Due to high dependence on soak pits, the government can explore installation of faecal sludge management plant for safe collection and treatment of sludge with monitoring to ensure proper cleaning cycles.
- There is a clear need to identify government agencies to regulate and monitor the pollution from onsite sanitation systems. Currently, the division of responsibilities between Municipality, State Pollution Control Board and Kerala Water Authority is ambiguous.

10.4 WATER QUALITY AND PUBLIC HEALTH

- Rain water harvesting can be promoted in the Municipality which can considerably reduce the water stress as well as well recharge could improve the ground water quality due to dilution effect.
- The municipality should ensure that the newer establishments comply with the set back distance rule when they seek building plan approval. It has to be ensured with neighbouring houses also.
- Periodic ground water quality checks should be done. The water quality monitoring can be done with wider participation of students and citizens to enhance awareness of the relationship between the toilet waste management, water pollution and health.

10.5 ENVIRONMENTAL REGULATION OF COMMERCIAL ESTABLISHMENTS & INDUSTRIES

- Industries in Alappuzha do not comply with environmental norms due to high costs. As mandated in the Water Act (1974), KSPCB must pro-actively demonstrate cost effective measures for fixing violations in return for a fee.
- Engagement with Industry Guilds and merchant (such as *Vyapari Vyavasayi*) associations is needed in order to understand the reasons for compliance failure and promote green practices.
- KSPCB must encourage industries to have an Environmental Management plan along the lines of ISO 14001 and emulate Maharashtra State Pollution Control Board where this is a mandatory requirement for consent to operate.
- KSPCB must mandate organizations like Kerala Enviro Infrastructure Limited (KIEL), a public limited company promoted by the Kerala State Industrial
- Development Corporation (KSIDC),to collect chemical waste sludge from industries periodically and also release water within the limits prescribed in Surface Water Quality Criteria of CPCB.
- In order to ensure compliance, there is a need to enhance capacity of KSPCB. There is a need for wider citizen participation to identify and monitor pollution points and report it through community institutions such as proposed canal shed committees. This can formalise participation and also ensure transparency and accountability of state institutions for better regulation.
- Formalisation of the engagement between local government departments /agencies and academic institutions is recommended to fill the existing data gap and create a repository of data and information on pollution, water supply and sanitation issues and water quality etc. The data thus collected and collated can be shared with the citizen committees/groups and appropriate government departments for effective evidence-based policy advocacy and social regulation.

10.6 UTILITY OF CANALS AND INSTITUTION BUILDING

The canals are commonly used as dumping place for liquid and solid waste, declining its utility. Socio- cultural interventions are necessary for enhancing life in and beside canals. Some key ideas and concepts have emerged as part of a recent initiative - Alappuzha Heritage Project, by Architect Benny Kuriakose. The project is a comprehensive attempt to revive Alappuzha and regain its 'Golden Age'. Various heritage and industrial structures including canals in the town, will undergo conservation from physical and cultural aspects. Museums, the memory lane walk, canal sidewalk, installation of public art, workshops/activity spaces, guided tours, places to sit and relax on streets, cafes/tea stalls, restaurants along the canals are few of the suggested activities under the heritage project. Such initiatives provide an excellent platform to engage youngsters and children and to make them learn about history in a dynamic manner.

11. CONCLUSION

An alternative approach with new knowledge of disaggregating the town according to wastewater sheds (in the context of Alappuzha it is canal sheds) is taken as a starting point for sanitation planning. The level of services and practice for various socioeconomic groups in a town is overlaid over canal sheds to delineate sanitation zones. These zones, within and across the canal sheds, present a more nuanced understanding of water and sanitation issues and could be a basic unit of technology and policy interventions.The approach also hinges on the idea of social regulations of pollution and actively explores the mechanisms to follow the principles of :

(a) subsidiarity, which seeks management of issues at the lowest possible level
(b) non-invasive technology options, which seeks selection of a particular technology having minimum capital/running costs and negative impact on the environment
(c) building local capacities thus reducing dependence on external expertise,
(d) creating green jobs.

For this approach to work in its entirety the alternative knowledge has to be disseminated, students (future practitioners) have to be trained, citizens have to be made aware to finally develop institutions of collective action for social regulation of pollution. The activities like Winter School-2017 and Summer School -2018 provide a platform to disseminate this alternative knowledge through training environmental/civil engineering, architecture/planning, social sciences students something which is not taught to them in conventional educational programmes. From the point of pedagogy such activities bring engineering students to the field, out of the labs, to think and act on concrete issues on ground. They were not only given an alternative perspective couched on environmental sustainability and affordability but a clear strategy to achieve it through multidisciplinary work and trans-disciplinary stakeholder engagement.

One of the major achievements of Summer School-2018 is an association of a group of students to take forward the protocol and replicate it with context specific alterations. Such initiatives if done with local self government can bring analytical rigour to intervene in local issues and also becomes a tool to bring accountability to the activities of these institutions. Student citizen's who are capable to analyse problems in a context and responsibly engage with it to arrive at solutions can be trained from these sessions.

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APPENDIX A: DETAILED METHODOLOGY FOR CIVIL ENGINEERING SURVEY OF CANAL NETWORK

a) The sub-canal system of approximately 8.1 km was divided into ten separate canals depending upon their topography, location and status of flow through mapping and geo-tagging.
b) Some of the sub-canals were further divided into sub-stretches in view of the convenience to complete the civil engineering survey. There were 14 such substretches (which include the ten sub-canals).
c) The sixty students were divided into ten groups for the survey and they were assigned one stretch at a time. A coordinator was assigned to each group.
d) Each survey group identified their canal stretch and set the Dumpy Level at a convenient location near an established benchmark close to the mouth or exit of the respective canal stretch.
e) The Levelling staff was located at the canal bank over a graduated horizontal scale which was laid across the canal (width-vice) and staff reading was noticed.
f) A vertical graduated scale was inserted into the canal at the left, right and centre along the width close to the horizontal scale, deep into the sludge. The depth of the canal was noticed as the distance from the canal bottom to the level of the horizontal scale. The width of the canal was the distance between the insertion of vertical scale at the left and right of the canal stretch.
g) Thickness of sludge was noted as the length of sludge sticking onto the wooden graduated scale inserted, vertically in the canals.
h) The levelling staff locations were selected after the bench mark at every 25 m or salient points, like, bends, abrupt change of width or depth, change in canal bund protection, encroachment, etc.
i) Other features like, accessibility to the canal stretch, nature and type of sidewall protection, encroachments, presence of vegetation, etc. were also noted as remarks.
j) The benchmarks of all stretches were connected starting from the established benchmark near the railway station, Alappuzha.
k) Reduced Levels (RL) of each of the staff locations was found out with respect to the mean sea level and plots of canal width vs length and RL of canal centre bottom vs length were generated.
l) The undulations in the bottom owing to silting were proposed to be cut-off and plots of corrected RL of canal bottom vs length were generated. The available gradient in the sub-canals are very much evident from these plots.
m) Quantities like, desludging, desilting and length of sidewall to be protected were also calculated.

APPENDIX B: THE PARAMETERS AGAINST WHICH THE SEPTIC TANKS AND SOAK PITS WERE ASSESSED

Design Considerations: Location of septic tank (under or away from the toilet), presence of ventilation pipes, no mixing of waste water from kitchen, bathroom and toilet(Ministry of Housing and Urban Affairs, 2017). Location of the septic tank should be not under the toilet so to have easy access during cleaning. Majority of the septic tanks found to be following the norms.

Construction Considerations: distance between Well- OSS to be maintained at minimum 7.5 meter according to the Kerala Municipal Building Rules (1999) and this is followed by Alappuzha municipality. The Bureau of Indian Standards has stricter norms :- 'soak pit needs to be at least 30 m away from any source of drinking water'(BIS, 1995). Even if we use the diluted state norms, only 19.6% of all OSS and 18.8% of septic tanks were found to be complying with the 7.5 meter regulations.

Size appropriateness: Since it is almost impossible to assess the appropriateness of a septic tank size vis-à-vis family size, we selected a proxy indicator i.e. septic tank cleaning cycle. A typical cleaning cycle of a 4-5 family size household is 2 to 3 years as per various regulations(BIS, 1995)(CPHEEO & JICA, 2012). For our analysis we considered only those households with family size of 4-5 as for the sample population 4.2 is average household size. The analysis revealed that only 30% of the households of family size 4-5 have appropriately sized septic tanks. The rest because of inappropriate size might have ineffective septic tanks.

Sl. No.	Parameters	Results	Relevance	Regulatory Authority
1	Well – Onsite system (min. distance 7.5 m maintained)	19.6%	If not maintained then potential threat to ground water	Government of Kerala, 1999 and Government of Kerala, 2011. Bureau of Indian Standards, 1995
2	Well – Septic tank (min. distance 7.5 m maintained)	18.8%		
3	Septic tanks with ventilation pipes	80%	If not maintained, can affect the efficiency. Important for safety.	CPHEEO (2012) manual on sewage and BIS (1995, pp12).
4	Presence of separate system for grey & black water	39%	If not maintained, can affect the efficiency of tank	Ministry of Housing and Urban Affairs, 2017.
5	Septic tanks not under the toilet	98%	If not maintained, can create obstacle during cleaning	Bureau of Indian Standards, 1993
6	Size appropriateness of septic tanks for 4-5 family size household	30%	If not maintained, can affect the efficiency of tank	CPHEEO (2012) manual on sewage BIS,1995 pp:16

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