LINKING URBAN WATERBODY HEALTH TO CITYWIDE INCLUSIVE SANITATION

M.Sc. Thesis

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Linking Urban Waterbody Health to CityWide Inclusive Sanitation

By

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Abstract:

Urban sanitation in developing countries requires systems thinking as there is a plethora different variables which can impact the delivery of adequate sanitation for the people. In the traditional sense, sanitation planning in urban cities focuses on keeping people away from human-waste related pathogens. As cities in India and several developing countries are growing at exponential rates, government agencies are struggling to provide adequate safe sanitation in their cities. In recent years, due to a range of factors such as increasing water stress, recreational needs and biodiversity protection in an urban fabric, urban waterbodies are deemed worthy of conservation. The objective of this research was to systematically understand urban sanitation and how it relates to urban waterbody health. Having understood the system adequately, the aim of the thesis was to answer the research question, can "Citywide Inclusive Sanitation as a planning approach aid in the betterment of urban waterbodies?".

The study adopted a mixed method which comprises of quantitative water quality testing in Kommaghatta lake in Bengaluru city, India and a qualitative analysis at the Bengaluru city level. It included elements of qualitative social research methods such as field observations, informal conversations and semi-structured interviews to answer the research questions.

Water quality results and qualitative analysis suggests that there are three significant pollution pathways into Bengaluru lakes, each carrying different wastewater characteristics and pollution load. The predominant pathway for the pollution of waterbodies in the city is through the stormwater drainage. Additionally, sewer pipes and desludging trucks which dispose faecal waste from on-site sanitation systems also contribute to pollutant load entering into the lakes in the city.

From the semi-structured interviews, a conceptual model of urban sanitation in Bengaluru city and how it relates to waterbodies was developed. From conducting a qualitative analysis, six major system levers were identified. They levers influence the dynamics of urban sanitation in Bengaluru and forms the basis for the pollution pathways that enter into the lake. They six major system levers for Bengaluru urban sanitation are:

1. Rapid urbanization
2. Fragmentation of government entities
3. Sewer infrastructure
4. Feacal sludge management
5. Treated water reuse
6. Citizen group involvement

The study shows that CWIS principles have a significant relevance for solving urban sanitation issues which were identified through the system levers. In addition to solving urban sanitation issues which centres on public health matters, the study also shows that there is also an environmental case for CWIS by arresting waterbody pollution through the identified pollution pathways.
Findings from this research can help to improve decision making in terms of urban sanitation by paying close attention to the cause-effect relationships between variables in the urban sanitation sphere and improve waterbody health in their cities.

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Chapter – 1 : Introduction

1.1 Background

Water, health and sanitation is a basic-need which is crucial for human health and well-being. The fundamental purpose of sanitation is to keep faecal waste away from human contact so that exposure to pathogens can be minimized. Ideally, sanitation infrastructure coupled with adequate treatment facility forms a barrier to limit the transmission of diseases while at the same time, aid in removal of contaminants from the wastewater to facilitate resource recovery and reuse. But in reality, this is still a far-fetched dream for many developing nations in the global south as 85% to 90% of its wastewater is untreated and discharged into the environment (UNESCO, 2017)

Poorly managed sanitation has a disproportionate impact on the health and livelihood of people. In contrast to the developed countries, developing countries where population growth and urbanization are highly accelerated, sanitation issues are often seen to be intractable (Konteh, 2009). According to the World Health Organization, 827,000 people die every year due to inadequate water, sanitation and hygiene in low- and middle-income countries, of which 432,000 deaths are caused by poor sanitation alone (WHO, 2019). Additionally, water and sanitation form the basis for addressing other issues such as poverty, environmental protection and economic development which the Sustainable Development Goals (SDGs) for 2030 aims to tackle (see figure 1). This calls for a need to relook sanitation affairs and decision-making in order to ensure equitable sanitation and sustainable global development.

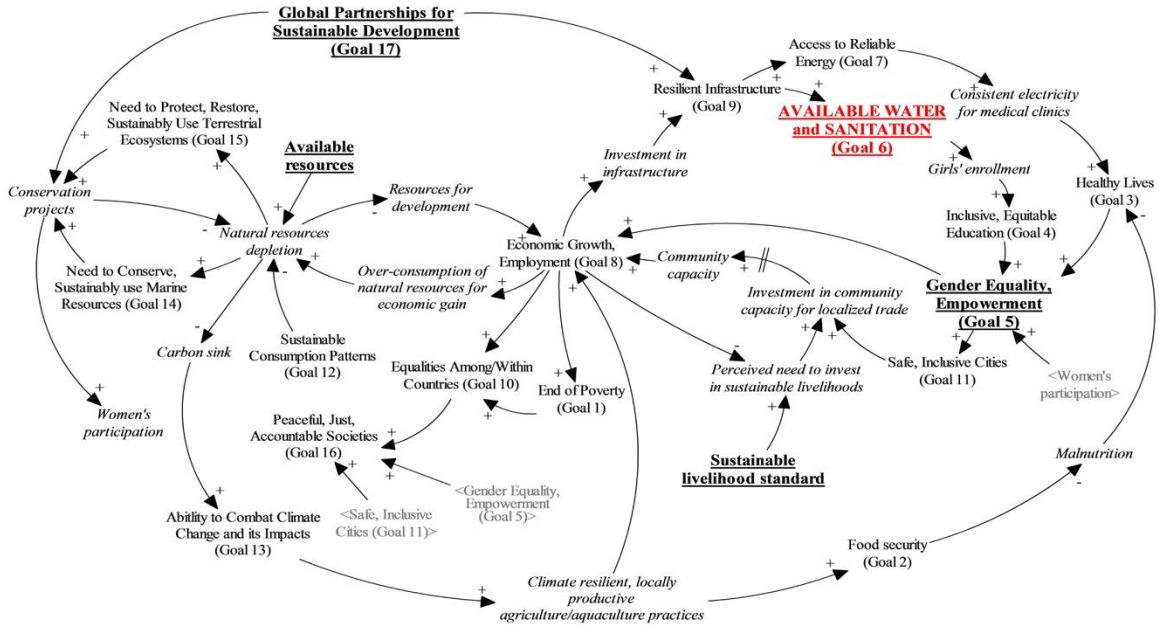


Figure 1 Relevance of Water and Sanitation goals for attaining other sustainable development goals, (source: Naughton and Mihelicic, 2018)

In the past, there has been international programs such as the UN's Millennium Development Goals (MDGs), Global Water Pathogen Project (GWPP) and 'Water for life' decade in order to tackle sanitation issues (Naughton & Mihelicic, 2018). But even if the target to provide "access to basic water and sanitation for all" is achieved, there will still be the issue of treating the wastewater which contaminates waterbodies that

in turn, affects human and environmental health. In this regard, SDG6 has a striking difference in its terminology and its targets. A new category namely, “safely managed” which emphasizes treatment and reuse of wastewater, was added to the sanitation ladder. Hence, one of the targets for SDG6 (target 6.3) is to reduce the proportion of untreated wastewater entering into the waterbodies and reuse. Therefore, the new definition for “safely managed” sanitation meant ensuring both public health and environmental protection. In the recent years, the sanitation value chain is considered to be the base reference for delivering safely managed sanitation in developing nations (BMGF, 2010). This can be seen in figure 2 below:

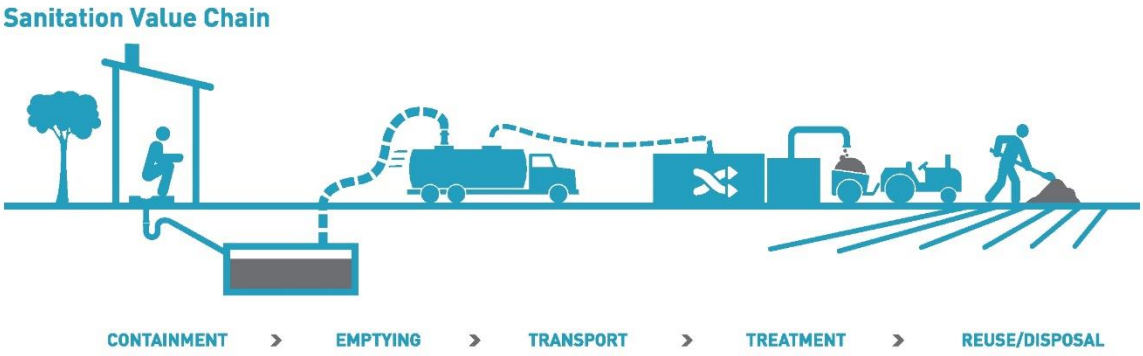


Figure 2 Safely managed sanitation is rudimentary across all elements of the sanitation value chain (Source: BMGF)

As cities growing at an exponential rate, delivery of public services including sanitation tends to lag behind (Osuhor & Essien, 1978). As of 2017, urban areas in India consisted of almost 128 million people without basic sanitation according to the Joint Monitoring Program (JMP, 2017). This number is only going to keep increasing as the population residing in Indian urban areas is expected to be 40.7 percent by 2030 (UNP-Fund, 2007). In addition to that, there is a large inequality across the different classes of income groups who benefit from sanitation services which can be seen in figure 3. In India, only about 15% of the low income group have access to improved sanitation while about 100% of the richest class have access to improved sanitation (JMP, 2017; UNHABITAT, 2016).

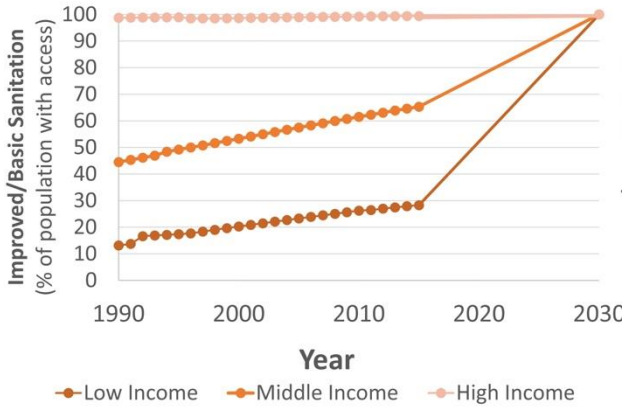


Figure 3 Inequality in sanitation across income groups in India, (source: Naughton and Mihelicic, 2018)

Waterbodies in urban India are grossly polluted due to inadequate sewage treatment infrastructure (Ali & Hussain, 2019; Kankal et al., 2012). Figure 4 shows the sanitation situation in urban India and how unsafely managed sanitation enters into the

environment. Due to rapid urban development, there is a mismatch between the wastewater generated and the existing sewage treatment capacity. Only 30% of the urban areas consists of sewered sanitation with a treatment capacity of just 13.5% of the total wastewater that is being generated (JMP, 2017; Sahasranaman & Ganguly, 2018).

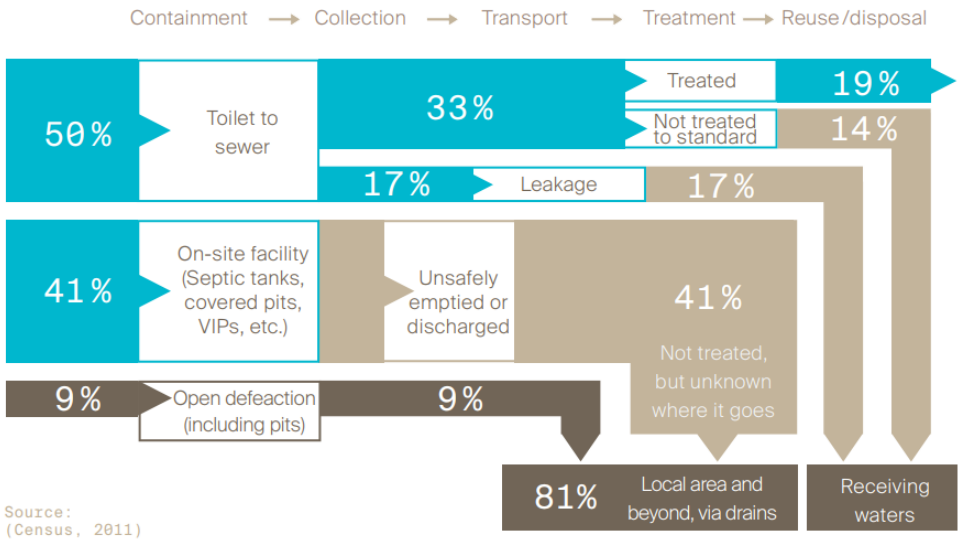


Figure 4 Shit flow diagram of urban India (Source: Census, 2011; Gutterer and Reuter, 2016)

The issue is that, urban sanitation is often related to sewer infrastructures and advanced treatment technologies by decision makers. The conventional approach towards improving sanitation in their cities, is by expansion of sewers and rehabilitation of existing systems (IWA, 2014). But in an urban fabric, specifically in a developing country, there are varied socio-spatial contexts such as informal settlements, peri-urban areas and planned urban areas. Due to issues such as lack of finance, space constraints and lack of enforcement, the conventional approach doesn't perform well in this case and therefore it calls for a need to understand the existing contexts and political regimes to propose appropriate solutions (Abishek S Narayan, 2020; Schrecongost et al., 2020).

1.2 Paradigm shift in sanitation planning:

The existing sanitation planning as followed by cities in India is adhoc and are developed using Central Public Health and Environmental Engineering Organisation (CPHEEO) manuals, which mainly promotes networked sanitation requires heavy investment and longer duration for implementation (Wankhade, 2015). In reality, on-site sanitation systems such as pits and septic tanks are utilized as a temporary solution until a sewer network is realized; specifically, in informal settlements within the city such as slums and migrant communities. Faecal sludge and overflow from these onsite sanitation systems in combination with partially/untreated wastewater reach waterbodies directly by storm water drains or indirectly through the leaks along the sanitation value chain (see figure 2).

Instead of viewing sanitation as a service to be delivered by addressing the entire value chain, current practise is to apply interventions at the conveyance or the treatment level only (Abishek S Narayan, 2020). For instance, “Swatch Bharat Mission” which is country-wide campaign initiated by the Government of India in 2014, heavily focused at the “capture and containment” level which resulted in copious amounts of toilets and on-site sanitation systems, while “emptying” and “treatment level” of the sanitation value chain is currently unaddressed (Ghosh, 2016). It requires a paradigm shift in sanitation planning to provide safe sanitation and at the same time mitigate pollution of urban waterbodies. Consequently, need for ‘systems thinking’ to providing safe sanitation across the sanitation value chain in developing countries has already been introduced in the book “Faecal Sludge Management” (Strande et al., 2014).

Citywide Inclusive sanitation (CWIS) is a new approach for urban planning that is under development with the elements of the SDGs, specifically SDG 6 and SDG 11 amongst others (A S Narayan & Lüthi, 2019a). Research is being conducted in order to develop a methodology of CWIS for the case of Indian mega and secondary cities (Eawag-Sandec, 2018). CWIS promotes inclusiveness of both informal and formal stakeholders, all types of sanitation systems and addressing the entire sanitation value chain. It has received a wide recognition among many nations and several cities that are trying to implement its principles. Its principles broadly suggests, equitable sanitation for all irrespective of several marginalization such as gender, income-class; safe management along the whole sanitation value chain with adequate monitoring and accountability, boosting urban economy through reuse and working in partnerships (BMGF, 2010; A S Narayan & Lüthi, 2019b)

1.3 SFD as a tool to represent sanitation situation:

Owing to the increasing complexity of urban sanitation, attempts have been made to systematically break down sanitation service delivery which follows the flow of wastewater right from its generation to the end use or disposal (Peal et al., 2014). (Peal et al., 2020). A typical SFD with the various possible pathways is shown in figure 5 below:

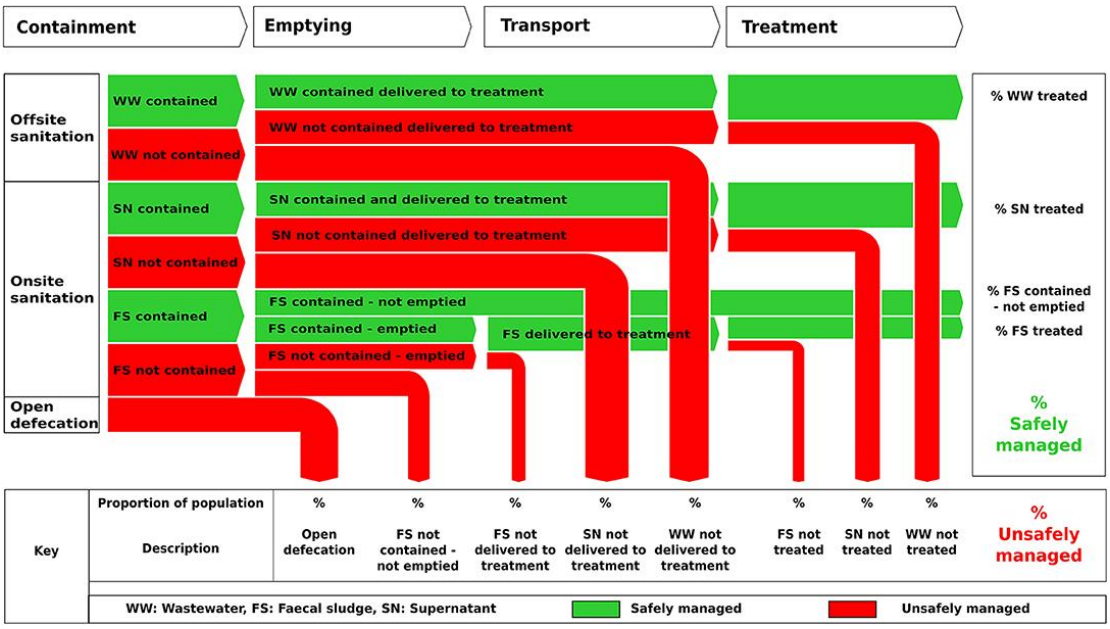


Figure 5 Illustration of an SFD showing the different pathways (SFD-PI, 2018)

Shit flow diagram is a new way of visualizing how excreta flow through the city which is claimed to be beneficial for planning at a higher level. While this is a great conceptual representation, it formed advocacy primarily for investment in infrastructure at the different levels of the sanitation service chain. As seen in figure 5, SFD is good for understanding “what” is happening to the wastewater and “how” it flows through the different arrangement while the “whys” for the red outfalls are missing. It focuses more on indicative percentages and figures while the source of the issue goes unrecognized. Since there is no transparency for the reasons behind the numbers, it limits dialogue among authorities and decision makes.

1.4 Urban waterbodies: A new normal

Urban sanitation in India is focused on providing sanitary living environment to ensure adequate public health, while the quality of water bodies is taking a dive. Almost 70% of the water supply in Indian are contaminated and India is ranked 120 among 122 countries in the water quality index (NITI Aayog, 2019). Almost two-third of the wastewater that is generated are not safely treated and discharged into water bodies which causes a steady decline of urban waterbody health (Bhateria & Jain, 2016; Biswas & Jamwal, 2017).

In the Indian context, waterbodies, specifically lakes and groundwater have been the source of water supply and to meet livelihood needs such as agriculture, livestock rearing and other secondary purposes. But due to urbanization, uses that are derived from a waterbody has been drastically evolving (Biome, 2016). In addition to that, the idea of a catchment for a lake in the urban environment as opposed to a rural lake is distinctly different. This is because, in the built environment, storm water drains are designed not necessarily following the topography but rather with the aim to limit urban flooding by construction of stormwater drain. This created a divide between two lake groups: rural lakes and urban lakes. While rural lakes are still holding to the traditional uses that were derived from waterbodies, urban lakes are still adapting to the it's environment. People in cities view lake as a patch a greenery which can be utilized for recreation.

In the Indian waterbodies’ governance context, the municipal authorities in association with specialized bodies (eg: Lake Development Authority) are the custodians of the lake and the imagination of an “urban lake” is largely controlled by them. The practice is to have civil engineering interventions to reinforce the embankments and desilt with the objective to limit flooding and retain water along with a wastewater treatment infrastructure. In the recent past, there has been a media push to conserve lakes due to heavy pollution, for example the burning lake in Bellandur, Bengaluru (Biome, 2016; Sushmita et al., 2017). This gave rise to active citizen participation in lake related activities for environmental protection and water security.

1.5 Research relevance:

Although there has been attempts such as the shift flow diagram and ‘systems thinking’ for faecal sludge management, there is no instance of systematically understanding the impact of urban sanitation on an environmental proxy such as waterbodies. From literature study, it is clear that the problem with urban sanitation and waterbody health is seen to be interconnected, but it requires a systems approach

Figure 6 Using CWIS as a lens to analyze the synergy between urban sanitation and urban waterbody health

to understand it adequately for providing safely managed sanitation and protect urban waterbodies. This thesis tries to tie the two spheres: “urban sanitation” and “urban waterbody health” using City-Wide Inclusive Sanitation as an inductive lens (see figure 6).

1.6 Research questions and objective:

The objective is to systematically understand urban sanitation system and how it relates to urban waterbody health in Indian cities. Having understood the system, it aims to explore if Citywide Inclusive Sanitation as a planning approach can aid in the betterment of urban waterbodies. Thus, the overarching research question is formulated as:

Can City-Wide Inclusive sanitation (CWIS) planning potentially improve urban waterbody health?

In order to answer this research question, several sub-questions are formulated in a stepwise manner such that they build on each other. It is important to note that sub-questions 1 and 2 are the focus of this thesis, while sub-questions 3 is a derivative-led question to make wholistic conclusions for this study.

As a preliminary step, it is attempted to establish links between urban sanitation and urban waterbodies by understanding how faecal waste flows into urban waterbodies. Therefore, the first sub-question is formulated:

SQ1: What are the faecal waste flows that leak into urban water bodies?

The link between urban sanitation and waterbody health is established in the previous question, but it requires a systems approach to adequately understand the reasons for faecal flows entering into the waterbodies. The “whys” behind the existence of the faecal contaminations are not simply related to the treatment infrastructure but rather multi-layered as descried earlier. Given the lack of theoretical base with respect to the complexities in urban sanitation, it is important to visualize the sanitation system in the city. For this, the causal links between different influencing factors need to be identified thus leading to the second sub-question which is:

SQ2: What the major system levers in the urban sanitation space that influence urban water body health?

Having visualized the urban sanitation system in Bengaluru with the interrelations and how it affects waterbody health, the next step is to analyze the potential of CWIS principles to address the major system levers which were established in the previous question. Therefore, the third sub-question is formulated as below:

SQ3: How are CWIS principles relevant for urban waterbody health?

The overall research approach adopted for this thesis is a mixed method which comprises of quantitative water quality testing and qualitative analysis using a case study in Bengaluru, India. It includes elements of qualitative social research methods such as field observations, informal conversations and semi-structured interviews to answer the research questions. In summary, the research focuses on faecal flows that enter into the lake due to urban sanitation, using systematic analysis to understand the reasons for the failure of urban sanitation and leveraging CWIS principles in order to potentially improve the condition. Figure 7 below represents the summary of the research:

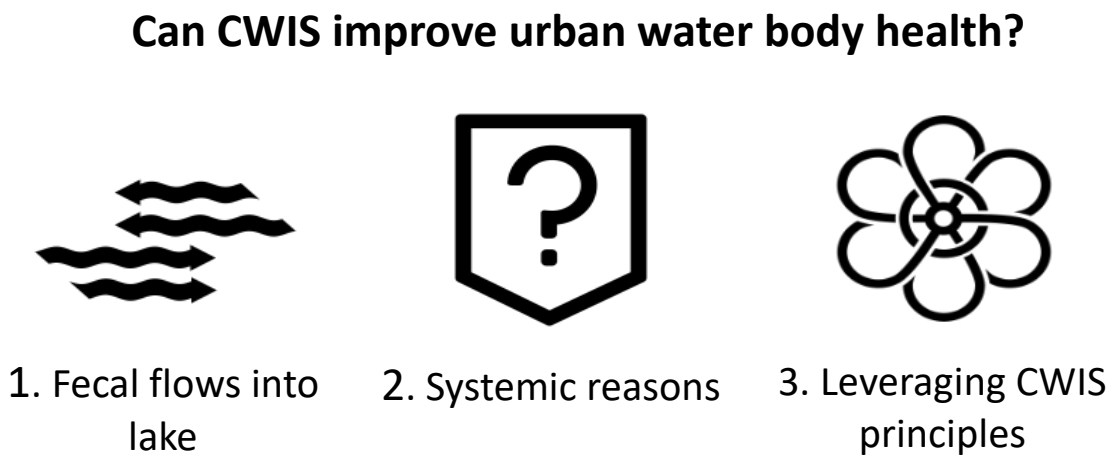


Figure 7 Illustration of the research summary

The rest of this report is structured such that the research methodology is described in chapter 2 and the results are presented in chapter 3. Discussion of the results are covered in chapter 4 and conclusions are organised in chapter 5.

Chapter 2: Methodology

The objective of this research is to systematically understand urban sanitation system and how it relates to urban waterbody health in Indian cities. For studying topics that are complex, contextual and where there is a lack of theoretical base, case studies have proven to be useful (Dul & Hak, 2007). They are also excellent in answering the "why and hows" of the phenomenon under study (Ebneyamini & Sadeghi M., 2018). Choosing a case-study helps in limiting the boundary for the study area, given the timeline of the research. Therefore, the city of Bengaluru in India was chosen for the case study as it fits the developing urban context with over 200 urban water bodies (Biome, 2016). In order to collect the data for the research, fieldwork was conducted in order to collect both primary and secondary data over a period of 16 weeks between February and May 2020.

The approach followed in this study to answer the research questions is two-fold:

(1) **Identifying faecal flows into urban lake using quantitative water quality testing and field observations:**

In order to identify the faecal flows into the urban lakes, the characteristics of the water that flows into the lake through different pathways need to be analyzed quantitatively. The pathways in which water enters into the lake are scoped using the Shit flow diagram and by means of field observations. Escherichia coliform and Faecal coliform are used as a reference parameter along with other wastewater parameters to establish the link between failed sanitation systems and polluted waterbodies (McQuaig et al., 2006). As the existing SFD for Bengaluru is a city-wide representation of faecal flows, it is unfeasible to conduct quantitative water quality analysis at this scale. Therefore, it was decided to investigate the faecal flows into an urban lake within the city using a predefined criterion.

(2) Conceptualizing urban sanitation as a complex multidimensional system using semi-structured interviews:

In order to systematically understand urban sanitation with the casual links and how they influence urban waterbodies at Bengaluru city level, semi-structured interviews were employed. The basis for the semi-structured interviews were largely adapted from the book "Social Research Methods" (Bryman, 2016). In order to conceptualize the system, the interview transcripts were coded and analyzed qualitatively and visualized using Vensim PLE v8.1.1 (Ventana Systems, n.d.). Finally, a Qualitative analysis of the conceptualized urban sanitation system was done using CWIS framework.

Therefore, the study adopted a mixed method which comprises of quantitative water quality testing in Kommaghatta lake in Bengaluru city, India and a qualitative analysis at Bengaluru city level. An overview of the methodology adopted in the study can be seen in figure 8 below. Detailed description of the methods for these steps are expanded in the subsequent sections.

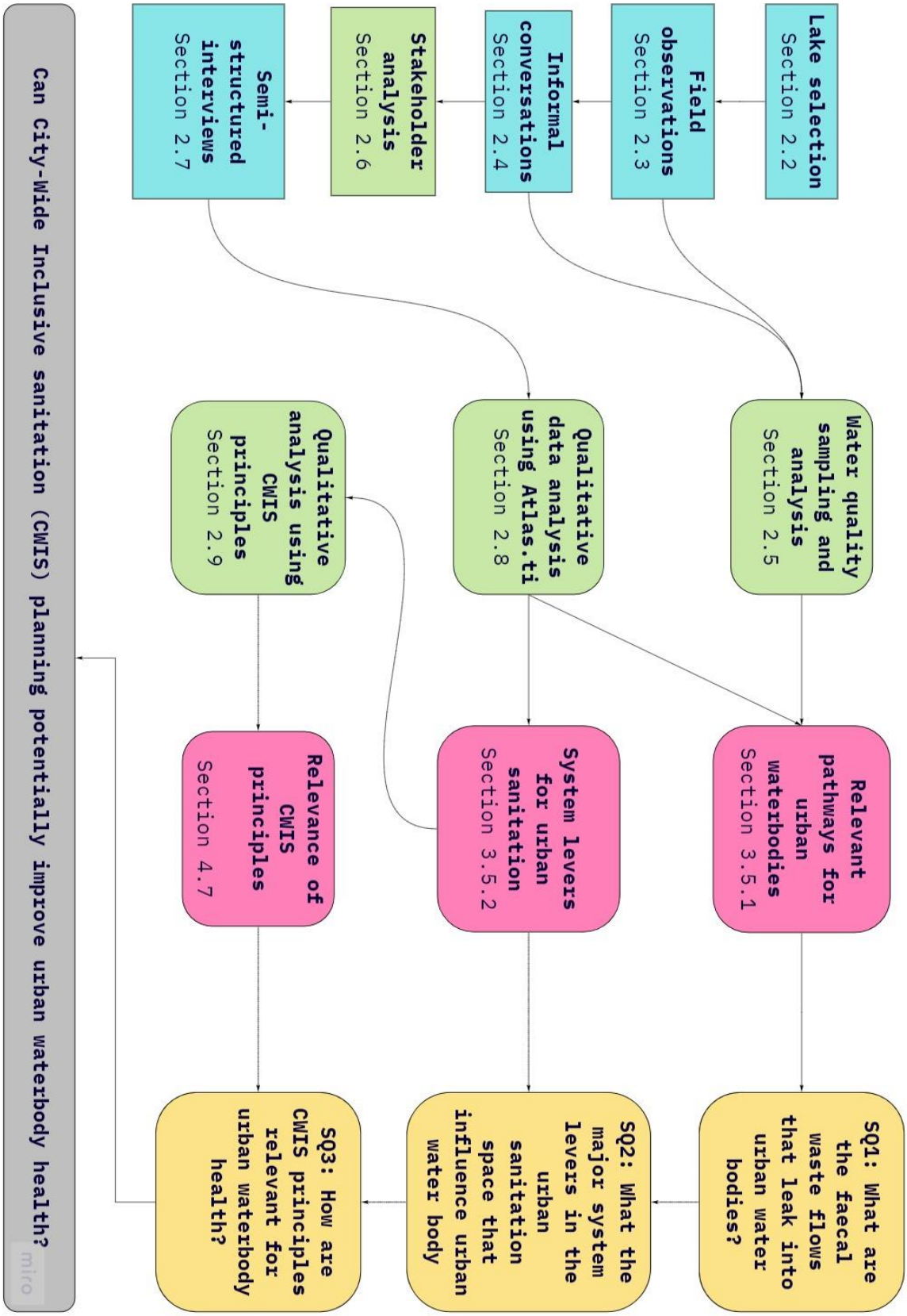


Figure 8 Overview of thesis methodology and how they relate to answering the research questions. The sections numbers where the methods and results can be found are shown inside the box.

2.1 Description of case study area:

Bengaluru is a city located in the state of Karnataka in India which also called the Silicon Valley of India (see figure 8). It has a population of over 12 million and receives an annual rainfall of over 970 mm.

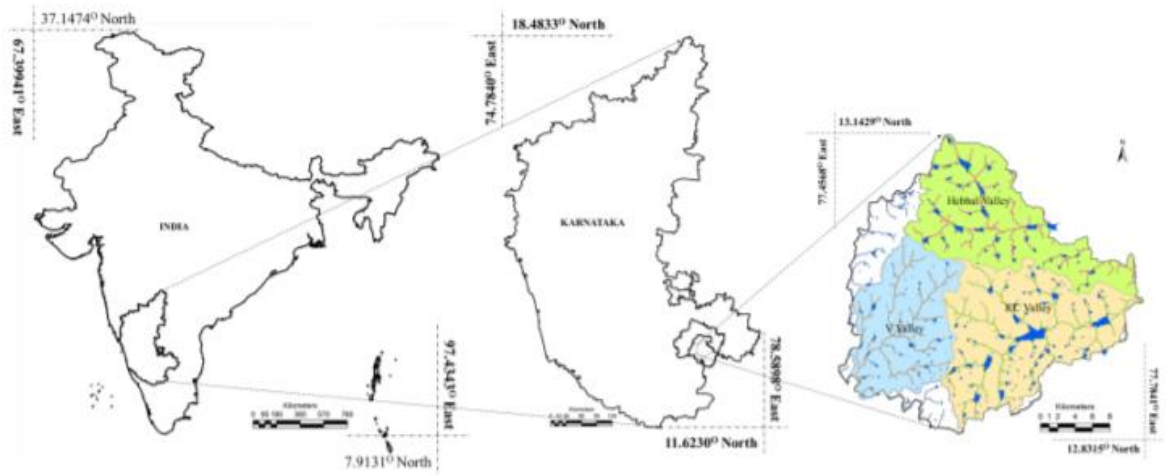
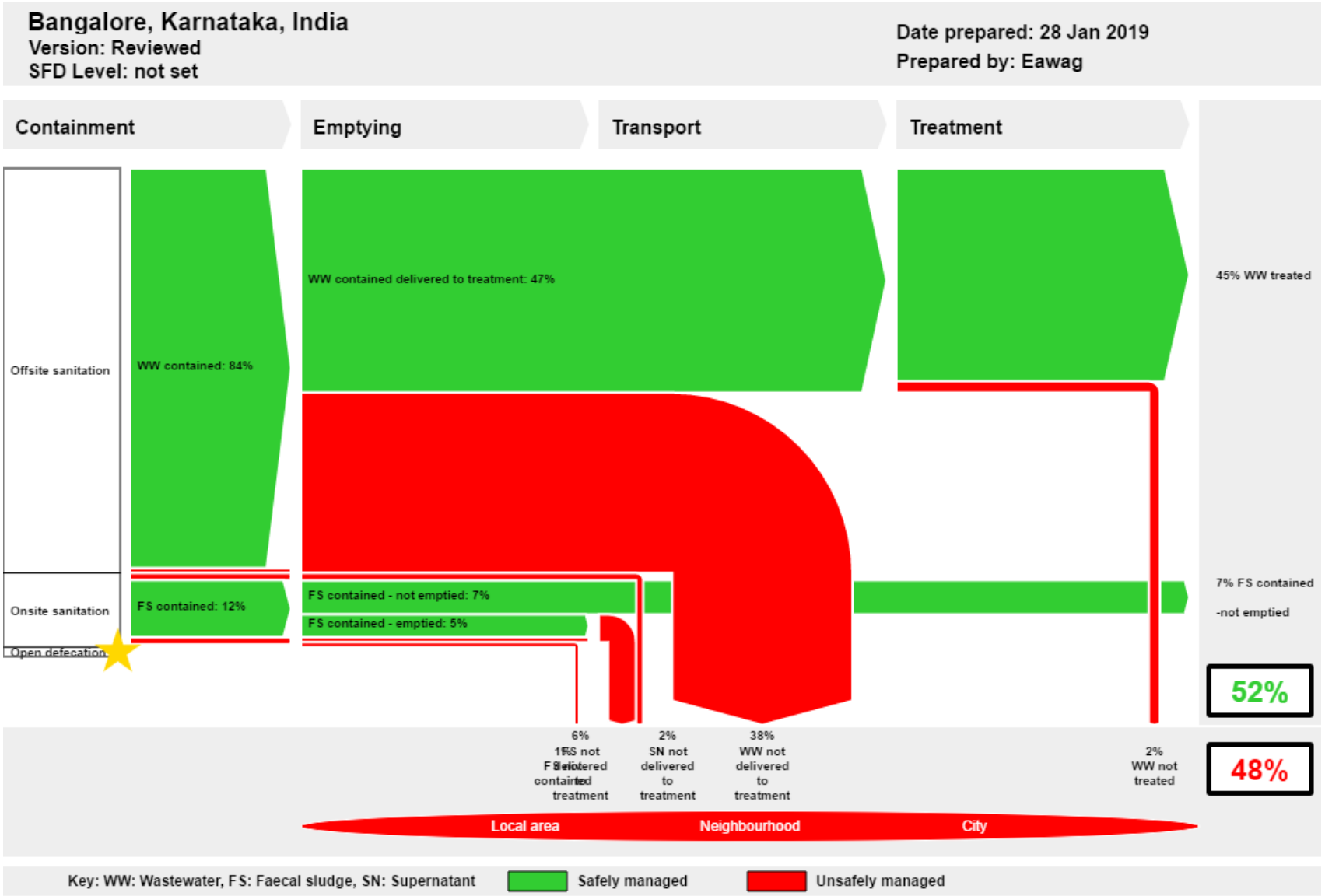


Figure 9 Location of the case study area

Bengaluru has over 200 lakes, most of which were originally artificially made irrigation tanks as build its rulers over the centuries. They are planned in a system of cascading lakes which overflows into each other and finally meets rivers: Arkavathi, Vrishabhavathi and Dakshina Pinakini. Figure 9 above shows the location of case area and the interconnected lake system it encloses. But there has been a steady decline of the number of lakes due to excessive groundwater abstraction from over 400,000 bore-wells (BIOME, 2016).

The lakes in Bengaluru city has been seriously polluted in the last decades due to the rapid urban development, since the bloom in Information & Technology corridor. According to the lake development authority, only 80 lakes are presently in a healthy state while the others are either dried out or heavily polluted with phosphates, nitrates and heavy metals (Ramachandra et al., 2013). Owing to this, there has been an active citizen movement for the conservation lakes through the aid of NGOs and notable environmentalists. Lakes such as Jakkur, Soul kere, Puttenahalli are some of the examples which have been rejuvenated by constructive activities by the local communities which were spearheaded by NGOs (Biome, 2016). This can be attributed to the extensive media coverage which creates awareness and growing social media access by the citizens.

With regard to the sanitation situation in Bengaluru, it has both sewered and non-sewered sanitation systems. While sewerage connection is the primary choice by Bengaluru Water Supply and Sewerage Board (BWSSB), on-site sanitation solutions are prevalent in informal settlements and peri-urban areas. According to the SFD prepared for Bengaluru in 2019 by Eawag, only 52 % of the wastewater generated by the city is safely managed while the rest is polluting the environment through several pathways. The Shit Flow Diagram for Bengaluru can be seen in figure 10.



The SFD Promotion Initiative recommends preparation of a report on the city context, the analysis carried out and data sources used to produce this graphic.
Full details on how to create an SFD Report are available at: sfd.susana.org

Figure 10 SFD for Bengaluru city, (Source: EAWAG, 2019)

2.2 Selection of lake

The selection of the lake was carried out by the process of elimination using predefined criteria as follows:

- a combination of on-site and sewered sanitation in the lake catchment
- minimal exposure to industrial activity and animal husbandry
- existing support from local NGOs and stakeholders

After scoping four potential lakes in Bengaluru city based on the above criteria, the lake situated in Kommaghatta village is selected for further study. Kommaghatta lake is managed by Sulikere gram panchayat (Local community-level authority) which comes under the administrative boundary of Bengaluru South sub-district. Although it doesn't fall under Bruhat Bengaluru Mahanagara Palike (BBMP) which is the city-level municipal authority, most of the catchment area of the lake comes under the BBMP limits. It is considered to be a typical lake as it shares the same climatology, similar topography and is representative of the current situation in Bengaluru city. Given the access to the lake, proximity to lab and availability of data, it was decided to study this lake.

2.3 Field observation

As a preliminary step, several site visits were made to the Kommaghatta lake from 23/01/2020 to 30/01/2020, the activities during the field visits included the following:

- Visual inspection of sanitation arrangements around the lake
- Mapping the inlets to the lake by walking along the drain with geo-tracking device
- Preliminary identification of pollution hotspots (leaks along sanitation value chain) around the lake by visual checks and informal conversations with key informants

2.4 Informal interviews

Informal interviews and conversations were conducted with employees of local NGOs such as CDD Society, Ashoka Trust for Research in Ecology and the Environment (ATREE) and Biome trust since they actively participate in water and sanitation related activities in the study area and work closely with the local government. The responsible government bodies were inaccessible during the data collection process due to local elections and COVID measures. Open questions were used to collect data during the informal interviews. The purpose of the informal conversations was to gather background information, understand the byelaws that exists in the city related to sanitation and for scoping potential participants for the semi-structured interviews.

2.5 Water quality sampling and analysis:

Firstly, in order to understand the uses that can be derived from the lake based on the current health of the lake, it was decided to conduct water quality sampling at multiple points inside the lake. After this, the pathways of pollution into the lake through direct and indirect sources (related to sanitation) are sampled. Using the shit flow diagram for Bengaluru city and the results from field observations in the study area, the major possible pollution pathways which are relevant for the Kommaghatta lake were mapped. These pathways were studied further by means of water quality testing and gathering secondary data from a local NGO namely, CDD Society. The pathways relevant for the waterbody are shown in figure 11.

	Containment	Emptying	Transport	Treatment
Offsite sanitation		Sewage not delivered to treatment (Overflowing Manhole Sampling)	Storm water drain entering lake (Lake inlet sampling)	Partially treated wastewater (Effluent quality from Beedi workers colony - Secondary data from CDD Society)
Onsite sanitation	Contamination by onsite sanitation systems (Borewell sampling)		Dumping of faecal sludge (Faecal sludge characteristics - secondary data from CDD Society)	

Figure 11 Relevant pathways for the Kommaghatta lake for further investigation by water quality sampling

2.5.1 Lake water sampling:

In order to understand the current pollution status of Komaghatta lake, grab samples were collect at three points in the lake on 29/06/2020. Kommaghatta lake has an artificial wetland that is present close to the main inlet. Therefore, it was decided to collect:

- one grab sample near the main inlet before the wetland area (Point-1)
- one grab sample at the middle of the lake after the wetland (Point-2)
- one grab sample near the outlet of the lake (Point-3)

The locations of the sampling points are shown in figure 12 below:

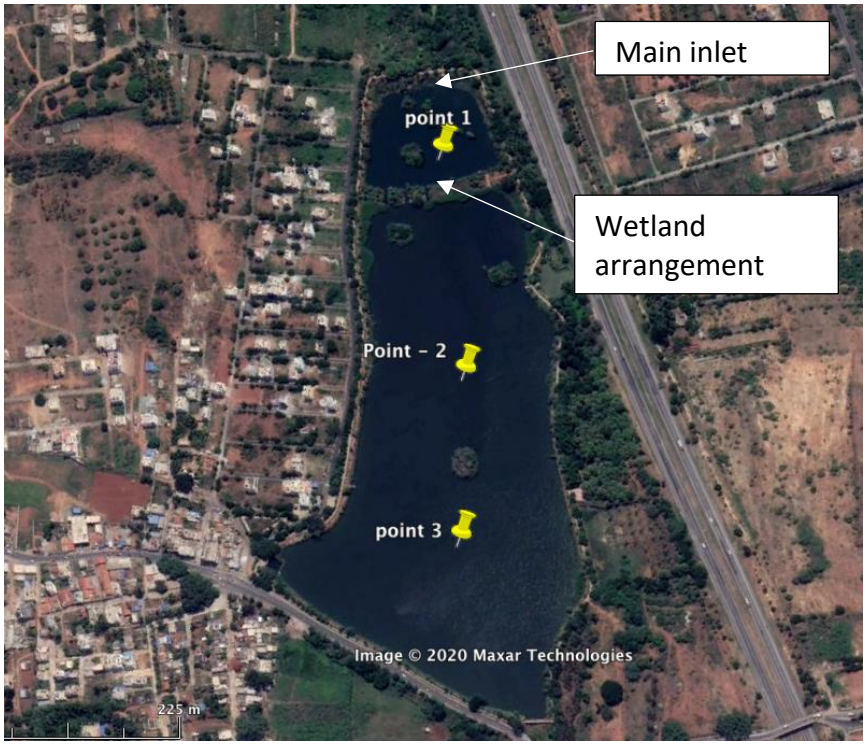


Figure 12 Locations where grab samples were collected in Kommaghatta lake

The lake water samples collected at the three points were sent to the CDD Society for laboratory analysis. The list of parameters and the analysis method is summarised in the table 1 below:

Table 1 List of parameters measured and the analysis method for the lake water samples

Parameters	Analysis method
Colour	
EC	
pH	pH probe
Turbidity	EC probe
TDS	APHA
Ammonium as NH_4^+	Merck test kit
Phosphates	Merck test kit
Nitrates	Merck test kit
BOD (5 day @ 20 deg C)	Oxitop
COD	Closed reflex method
E. Coli	APHA
Faecal Coliform	APHA

It is important to state that the DO was planned to be analysed during the sampling but due to faulty equipment, it rendered erroneous results.

With respect to waterbodies, the quality standards as set by the Central pollution control board under designated “best use water quality criteria”, there are 5 classes which can be seen in figure 13 below.

Designated-best-Use/ Beneficial Use	Classification of water	Criteria
Drinking water source without conventional treatment but after disinfection	A	Total Coliforms Organism 50 MPN/100 ml or less pH between 6.5 and 8.5 Dissolved Oxygen 6 mg/l or more Biochemical Oxygen Demand 5 days 20 °C 2 mg/l or less
Outdoor bathing (organised)	B	Total Coliforms Organism 500 MPN/100 ml or less pH between 6.5 and 8.5 Dissolved Oxygen 5 mg/l or more Biochemical Oxygen Demand 5 days 20 °C 3 mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism 5000 MPN/100 ml or less pH between 6 and 9 Dissolved Oxygen 4 mg/l or more Biochemical Oxygen Demand 5 days 20 °C 3 mg/l or less
Propagation of wildlife and fisheries	**D**	**pH between 6.5 and 8.5 Dissolved Oxygen 4 mg/l or more Free Ammonia (as N) 1.2 mg/l or less**
Irrigation, industrial cooling, controlled waste disposal	**E**	**pH between 6.0 and 8.5 Electrical Conductivity at 25°C (maximum) 2250 micro mhos/cm Sodium absorption ratio maximum 26 Boron maximum 2 mg/l**

Figure 13 Designated best use criteria as prescribed by the pollution control board. (*Source:* CPCB, n.d.)

These classes were also used for lake rejuvenation projects as in the case of Bellandur lake by the expert committee which involved decision makers with respect to the lake (Ramachandra et al., 2013). The results from the laboratory analysis is compared with the aforementioned criteria to establish the present condition of the lake.

2.5.2 Lake inflow sampling:

For understanding the characteristics of the water that was entering the lake at the two active inlets: (a) main inlet (b) stormwater inlet as shown in figure 1, composite sampling was performed from 6 AM until 8 PM on 03/03/2020. Samples were collected and flow measurements were performed every two hours at these two points to prepare the composite sample at the end of the day and refrigerated at 4 degrees Celsius. These composite samples collected from the lake inlets were sent to an NABL accredited laboratory on the following day to be tested for a list of 38 parameters. The sample collection form used on field can be seen in annexure III.

Additionally, two grab samples were taken at these inlets in order to understand the characteristics of the wastewater during the peak flow which was probed to be around 8 AM. The summary of samples collected from the inlets to the lake can be found in table 2 below and the sampling locations can be found in figure 17:

Table 2 Summary of samples collected from lake inlets

Main inlet	1 composite sample 6 AM until 8 PM 1 grab sample at 8 AM
Storm-water inlet	1 composite sample 6 AM until 8 PM 1 grab sample at 8 AM

Flowrate (m^3/h) into the lake through the main inlet and stormwater inlet were measured using a flow meter at two hours' interval when the samples were collected. For the flow measurements, HACH FH950 flowmeter with electromagnetic sensor was employed. It has an accuracy of ±2 % for readings from 0 to 3.04 m/s and ± 4% for readings from 3.04 to 4.87 m/s. The flow measurements were conducted by the technical team from CDD Society under the supervision of the researcher. Figure 15 depicts flow measurement being carried out at the main inlet. There were no rainfall events on the last couple of days before the sampling and flow measurements to ensure the quality of measurements. It is important to note that on the day of sampling, the main inlet seemed to carry green dye which was significantly visible and can be seen in figure 15.

In order to map other sources of inflow into the lake, two other grab samples were taken: (a) One at a stormwater stream which originates from SMV layout neighbourhood and joins the main inlet (b) Overflowing last manhole in the lake catchment. The grab samples collected at these points, were sent to CDD Society for laboratory analysis for a list of 18 parameters. The summary of the grab samples collected apart from the lake inlets are shown in table 3 below and their sampling locations can be seen in figure 14 and figure 17.

Table 3 Summary of grab samples collected around the lake

SMV layout stormwater	1 grab sample
Last manhole – Overflowing sewage	1 grab sample

Figure 14: Stormwater drain from SMV layout meeting the main inlet drain (left) Overflowing last manhole in the lake catchment where grab sample was taken (right)

Figure 15 Glacial blue dye with foaming observed in the main inlet drain during grab sampling (left) Flow measurement at main inlet (right)

Figure 16 Testing of on-onsite parameters during the sampling

The list of the analysis methods for the different parameters are summarized in appendix II. Parameters such as dissolved oxygen, pH, electrical conductivity and turbidity were estimated on-site during the sampling by the researcher (see figure 16).

An overview of locations where the samples were collected and the type of sample can be seen in figure 17 below:

Figure 17 Overview of the sampling locations

2.5.3 Borewell sampling:

In addition to the wastewater sampling two borewell samples were taken on 16/03/20. The households with borewells were chosen which were at the proximity of the lake with the primary intention to see if there is faecal coliform and E.coli contamination pathway that exist in the lake vicinity. For the locations of these borewells, refer to figure 17 above. Borewell 1 is 300 feet deep, situated about 50 meters from the lake periphery and at +5m elevation compared to the lake. Borewell 2 is 500 feet deep and it located 200 meters from the lake periphery. It is at +13m elevation as opposed to the lake.

The collected samples were analysed in CDD laboratory for eight parameters which are summarized in table 4 below along with the analysis methods:

Table 4 List of parameters measured for the borewell samples and the analysis method used

Parameter	**Analysis method**
Colour	Visual
Odour	-
pH	pH probe
Turbidity	Turbidity meter
Nitrates as NO_3^-	Merck test kit
Total Hardness	Merk test kit
Faecal Coliform	APHA
Escherichia Coli	APHA

2.5.4 Faecal sludge and partially treated wastewater characteristics:

Due to the COVID-19 pandemic, it was not possible to sample the following pollution pathways:

1. Faecal sludge dumping in and around the lake
2. Partially treated wastewater discharge into the lake

Therefore, in order to make the data collection wholistic, secondary data on the local faecal sludge and partially treated wastewater characteristics were collected from a local NGO, namely, CDD Society. CDD society who has continuous research and development activities going on with respect to faecal sludge and decentralized wastewater treatment systems (DEWATS). It operates a faecal sludge treatment facility (only for R&D) and a DEWATS in Beedi workers colony (BWC) which is now defunct, both of which are about 1.5 Kilometers from Kommaghatta lake.

2.6 Stakeholder analysis

It was attempted to map the key stakeholder in the city of Bengaluru who are involved in waterbody related activities. This was done by collecting secondary data from online sources and by having informal conversations with experts from NGOs such as CDD Society, Ashoka Trust for Research in Ecology and the Environment (ATREE) and Biome trust. Snowballing technique was used to further identify the participants for the research. Using the social network analysis of Bengaluru for water, sewer and sanitation as a starting point, additional communal stakeholders were mapped specifically for urban lakes in Bengaluru (A S Narayan et al., 2020). Finally, they were classified based on their role with respect to waterbodies in Bengaluru.

2.7 Semi structured interview

The semi-structured interviews were conducted with the key stakeholders from the stakeholder analysis. The purpose of the semi-structured interviews was to capture the perceptions, experiences and expert opinions on urban sanitation and its link to waterbodies. The method of inquiry employed for these interviews was an interview guide (questionnaire) which encompasses probing questions, vignettes and anecdotal examples. It was developed consisting of three key areas, namely: waterbodies and sewage management in Bengaluru and indicators for waterbody health in their perspective. Furthermore, a "why-analysis" was conducted during the interview process which prompts the interviewee to further explain their response in order to bring out the causal links as perceived by the interviewees. The interview guide was not shared with the participant to avoid bias and a sample of the same can be found in the Annexure VI.

COVID-19 had a significant impact on the collection of qualitative data during the research. The interviews were planned to be face-to-face but due to COVID-19 safety measures, it was not feasible. Institutional stakeholders were largely inaccessible during the during this time due to their busy agenda. Therefore, purposive and convenience sampling methods were employed to identify participants within the stakeholder groups. The final mode of interview was telephonic without the video feature owing to the poor internet connectivity in India. The duration of the interviews ranges from 30 to 60 minutes and they were recorded in most cases. In cases where the interviews were not recorded, written notes were made by the researcher. A total of 18 interviews of which 16 were recorded. All the recordings were transcribed extensively and can be found in Appendix VII. Table 5 below summarizes the different cohorts of interviewees and the number of respondents.

Table 5 Different cohorts of interviewees for the study

Cohort	Number of samples
Practitioners	3
Academicians	3
Researchers	3
Citizen groups	3
Institutional stakeholders (Bengaluru city)	2
Urban planners	2
Consultants (Central government)	2

2.8 Qualitative data analysis with Atlas.ti

In order to conceptualize the urban sanitation system in Bengaluru city, the semi-structured interview transcripts were analyzed qualitatively. The software used for the qualitative analysis was Atlas.ti v8. Using Atlas.ti, the interview transcripts were coded based on rules for establishing casual links (Axelrod, 2015). The analysis was carried out until the interview responses were consistent and theoretical saturation was reached. Using the interview data and the casual links between the variables, the conceptual system diagram was created using Vensim PLE v8.1.1 (Ventana Systems, n.d.). Finally, upon creating the conceptual system model, the "major system levers" were identified qualitatively.

2.9 Qualitative analysis using CWIS framework

In order to identify the relevance of CWIS principles for the case study area, the major system levers identified from the previous step are qualitatively analyzed using the CWIS framework. Broadly the CWIS framework is based on six underlying principles which are listed below (Abishek S Narayan, 2020):

1. Equity
2. Environment and public health
3. Mix of Technologies
4. Comprehensive planning
5. Monitoring and accountability
6. Mix of Business models

2.10 Research Ethics:

An informed oral consent was received from each participant before the starting the interview which enabled voluntary participation and right to withdraw anytime. In order to ensure anonymity and data confidentiality, participant identity will be coded, and names will not be mentioned in this report. The interviewees will be addressed only based on their designation or occupation as this information is critical for the research to validate the quality of data. The raw un-coded data will be accessible only to the researcher thus maintaining data confidentiality. This research has met all the compliance requirements by the TU Delft HREC approval committee (ref. no. 1028).

Chapter 3: Results

3.1 Field observations:

The lake has a total spread of 13.95 hectares and catchment area is shown in appendix I. The primary source of water into the lake are the monsoon rains and flow generated by households from upstream catchment areas. It is jointly taken care of by Bengaluru Development Authority and Sulikere gram panchayat. The lake consists of an artificial wetland which was created during the lake restoration in 2011 (Ramachandra et al., 2015). The main uses of the lake are fishing and for recreational activities such jogging, walking and bird watching by the residents around the lake. During the field reconnaissance, it was noticed that there are three inlets to the lake which were identified of which only two are presently active. They are: (a) Main inlet (b) Storm water inlet.

The main inlet is part of a cascading system which receives water from its upstream lake and households in the catchment which is similar to the lake systems in Bengaluru. It has two primary contributions, which are clusters of households in SMV layout (neighbourhood around the lake with sewer system) and overflow of Ramasandra lake (see figure 19). Predominantly, there is underground sewer provision in the neighbourhoods that contribute to the main inlet, yet visually, the water seems to carry sewage. The overflow of Ramsandra lake is very nutrient rich as there was enormous growth of aquatic macrophytes over the entire drain. Disposal of poultry waste (chicken feathers, dead animals, etc.) was observed at several points along the drain. The storm water inlet was originally thought to be activated during the monsoon but has additional flow which is contributed mainly by a cluster of households in Kommaghatta village. Figure 21 depicts present condition of the lake and the fishing arrangements made at the bank of the lake. Figure 20 shows the main inlet, storm water inlet from Kommaghatta village and the outlet of the lake. There are signs of eutrophication in the lake and it can be seen in figure 22.

Kommaghatta village is mainly covered with on-site sanitation systems which are desludged sporadically. Some of the households had their toilets constructed at the edge of the plot, close to the storm water drain. This can be seen in figure 22. Also, the area has piped water supply by the Sulikere village gram panchayat. It is proving to be inadequate to the needs of the residents, hence few households opt for borewells if they can afford it. Main practices that were observed during the mapping this area were: dish washing, cloth washing, bathing water and overflow pipes from on-site containment systems.

During the field visit, it was observed that the last manhole near the lake vicinity was overflowing and formed a water-logged area which can be seen in figure 18. There was no provision of an STP for the areas covered by the sewer system. It is said that there was a sewage treatment plant planned in a plot near the main inlet which would receive the wastewater from the underground sewage system, eight years ago. A residents complained that there is no clarity as to who is responsible for its provision and that there is no response from the authorities even though they have been actively communicating with the authorities. Visual observations and anecdotal evidences from key informants in the neighbourhood suggest that there could be faecal sludge dumping in this waterlogged area.

Figure 19 Mapped inlets and the connected catchment areas

Figure 18 Water logging created by the overflowing manhole


Figure 21 Kommaghatta lake (left); Fishing practice in the lake (right)



Figure 20 Main inlet (left) Stormwater inlet (middle) outlet of the lake (Right)


Figure 22 Eutrophication observed in the lake (left) Toilet constructed on the stormwater drain (right)

Open defecation was observed in the lake catchment area, even though the village panchayat claims to be “Open Defection Free”. It could be due to the lack of public toilet arrangement in the vicinity for visitors. The practice seemed random rather than organized and consistent. Hence it’s impact is not further investigated in this study.

Based on these observations, five components are deemed relevant for the lake which requires further investigation by collecting water samples and secondary data. They are as follows:

1. At the containment level, the households around the lake in Kommaghatta village predominantly have onsite sanitation systems which are not lined at the bottom. Therefore, borewell sampling is considered to investigate the pollution of aquifer which may be connected to the lake.
2. During the field visit, it was observed that the manhole in SMV layout close to the lake was overflowing and may potentially contribute to the flow into the lake. Therefore, the characteristics of the wastewater from this pollution hotspot is relevant for the waterbody
3. It was seen that the stormwater drain originating from Kommaghatta village and SMV layout neighborhood had visual signs of carrying sewage which eventually enters into the lake.
4. Since there is anecdotal evidence of faecal sludge dumping around the lake inlets, the characteristics of the same is relevant to be studied for accessing the pollution load entering into the lake.
5. From the informal interviews with key informants, partially treated wastewater from inefficient small-scale sanitation systems is said to enter the lake.

Figure 23 below summarizes the pollution hotspots around the lake which may contribute to the pollution of lake and requires further investigation:

	Containment	Emptying	Transport	Treatment
Offsite sanitation		Sewage not delivered to treatment (Overflowing Manhole Sampling)	Storm water drain entering lake (Lake inlet sampling)	Partially treated wastewater (Effluent quality from Beedi workers colony - Secondary data from CDD Society)
Onsite sanitation	Contamination by onsite sanitation systems (Borewell sampling)		Dumping of faecal sludge (Faecal sludge characteristics - secondary data from CDD Society)	

Figure 23 Pollution hotspots identified around the lake which requires further investigation

3.2 Results of water quality analysis

3.2.1 Lake water sampling:

The results of the three samples collected from Kommaghatta lake are summarized in the table 6 below:

Table 6 Results of grab samples collected inside Kommaghatta lake:

Parameter	Before wetland	After wetland	Near outlet	Units
Colour	Green	Green	Green	-
EC	0.9	0.9	0.9	mS/cm
pH	7.7	8.7	9	-
Turbidity	517	133	96.4	NTU
TDS	555	538	503	mg/L
Ammonium as NH_4^+	12.9	4.2	5.5	mg/L
Phosphates	1.8	4.2	3	mg/L
Nitrates	3.8	14	11.5	mg/L
BOD (5 day @ 20 deg C)	60	20	15	mg/L
COD	316	135	110	mg/L
E.Coli	2100	2000	920	MPN/100 ml
Faecal Coliform	1400	1300	680	MPN/100ml

The BOD levels are seen to be higher than 3 mg/L in all the samples, ammonium concentrations are more than 1.2 mg/L and the pH values are more than 8.5. Therefore the lake water does not fall under any of the classes A, B, C, D or E and cannot be used for the respective purposes as mentioned in the criteria. Thus the results suggest that the lake is polluted as they don't meet the designated best use criteria as prescribed by the pollution control board (see figure 13).

From the table it can be seen that near the inlet, before it enters into the wetlands, the BOD concentrations are 60 mg/L with significant concentrations of E.coli (2100 MPN/100 ml) and Faecal coliform (1400 MPN/ 100 ml). But as the water moves through the wetland, there is a significant reduction of the pollution load. The BOD, COD, Ammonium and turbidity are reduced by almost 66.6 %. The reduction in these pollution parameters can be attributed to the treatment by the wetlands.

It is also observed that the concentration of nitrates and phosphates are higher after the wetland. This may be due to the entry of the soap water from the storm water inlet from Kommaghatta village and requires specialized tertiary treatment for the removal of nutrients.

3.2.2 Lake inflow sampling:

The key results of the composite samples collected at the main inlet and stormwater are summarized in the table 7. The complete list of results with all 38 parameters are available in appendix IV:

Table 7 Key results for the composite samples collected at main inlet and stormwater inlet. The values marked in red show that the faecal flow enters the lake.

Parameters	Stormwater inlet	Main inlet	Unit
pH	7.5	7.1	-
Dissolved Oxygen	4.1	4.1	mg/L
Electrical conductivity	1438	1678	µmhos/cm
Turbidity	13.8	45	NTU
Total dissolved solids	1456	1040	mg/L
Phosphates as PO_4^{3-}	6.7	8.4	mg/L
Ammonia as NH_3 - N	9.4	13.5	mg/L
Total Kjeldahl Nitrogen as N	16.2	25.1	mg/L
Chemical Oxygen Demand	122.4	204	mg/L
Biochemical Oxygen demand	63	90	mg/L
Faecal Coliform	3500	5400	MPN/100ml
Escherichia Coliform	Present	Present	MPN/100ml
Total Coliform	16100	9200	MPN/100ml

From the table 7 above it can be seen that the total coliforms that enter into the lake are 16,100 MPN/ 100 ml through the stormwater inlet and 9200 MPN/100 ml through the main inlet. It can also be seen that the BOD and COD in the stormwater inlet (63 mg/L and 122.4 mg/L respectively) and the main inlet (90 mg/L and 204 mg/L respectively) are significantly high which is polluting the lake. The concentrations of the BOD and COD do not meet the discharge standards set by the pollution control board which is 10 mg/L of BOD and 50 mg/L of COD (CPCB, n.d.-b).

It can also be seen that the significant nutrient load enters into the lake through the inlets. For example, hyotal Kjeldahl nitrogen values are 16.2 mg/L in the stormwater inlet and 25.1 mg/L in the main inlet. Similarly, the phosphates values are 6.7 mg/L in the stormwater inlet and 8.4 mg/L in the main inlet. These values are indicative of typical low strength domestic wastewater (CPHEEO, n.d.).

The key results of the grab samples collected at the inlets (at 8 AM), SMV layout stormwater and the overflowing manhole are summarized in the table 8. The complete list of results are available in appendix V:

Table 8 Key results for the grab samples collected at the inlets, SMV layout stormwater and overflowing manhole. The values marked in red show that the faecal flow enters the lake

Parameter	Stormwater inlet @ 8AM	Main inlet @ 8AM	SMV Layout stormwater	Overflowing manhole	Unit
Colour	Grey	Light grey	Dark grey	Dark grey	-
pH	7.5	7.7	7.7	7.4	-
Dissolved Oxygen	8.6	0.5	6.0	1.2	mg/L
Electrical conductivity	1.4	1.8	1.7	1.8	mS/cm
Turbidity	37.7	137	145	141	NTU
Total suspended solids	71	195	214	296	mg/L
Total dissolved solids	1130	1480	1360	1570	mg/L
Phosphates as PO_4^{3-}	54.6	12.9	9.4	36.0	mg/L
Ammonium as NH_4^+	51.6	48.8	37.3	42.4	mg/L
Nitrates as NO_3^-	2.2	3.4	2.5	3.0	mg/L
Chemical Oxygen Demand	209	335	357	489	mg/L
Biochemical Oxygen demand	115	170	170	260	mg/L
Faecal Coliform	24,000	8,500	16,000	10,000	MPN/100 ml
Escherichia Coli	28,000	11,000	43,000	28,000	MPN/100 ml

Presence of Faecal coliform and E.Coli is confirmed in both the inlet samples. The faecal coliform and E. coli concentrations in the stormwater inlet (24,000 MPN/100 ml and 28,000 MPN/100 ml respectively) is seen to be higher than the main inlet (8,500 MPN/100 ml and 11,000 MPN/100 ml respectively). Additionally, the nutrient load such as nitrates and phosphates are seen to be significant in the inlet samples.

Comparing the results from table 7 and table 8 for the inlets, it can be seen that the concentration of BOD and COD at the main inlet is 90 mg/L and 204 mg/L respectively for the composite sample; while the concentration of BOD and COD at the same inlet is 170 mg/L and 335 mg/L respectively for the grab sample collected at 8 AM. Although the results of BOD and COD are higher than the composite samples that were collected from these inlets, it does confirm the inflow of sewage into the lake through the main inlet and stormwater inlet. The difference in the values could be because of the increased concentration of the pollutants during peak flow in the morning when the water usage is high; while the composite samples are influenced by the variation in concentrations over the course of the day.

In addition to carrying sewage, the stormwater inlet which arises from Kommaghatta village carries water from cloth washing, dishwashing and bathing. This could be the reason for the BOD and COD concentrations being lower in the stormwater inlet as opposed to the main inlet. In addition to that, it can also explain the high value of phosphates in the stormwater inlet (51.6 mg/L) which may be due to the use of soap and detergents.

From table 8, it is seen that the grab sample from the area of SMV layout is said to have sewered sanitation, still the SMV layout stream which joins the main inlet seems to have a high concentration of faecal coliform (16,000 MPN/100 mL) and E.Coli (43,000 MPN/100 mL). This could indicate leakage of sewer pipes, failure to connect to STPs and households which still possess on-site sanitation systems. The

wastewater results in grab sample indicate that presence of high ammonia compared to nitrates. According to an expert interview at CDD Society, this might indicate that the wastewater post-anaerobic digestion by the on-site sanitation systems or it may be due to stagnation in the stormwater drains which was noticed at many cross-sections.

Finally, the overflowing manhole is seen to have the highest concentration of BOD (260 mg/L) and COD (489 mg/L). It also has presence of pathogens such as E.Coli (10,000 MPN/ 100 ml), Faecal coliform (10,000 MPN/ 100ml) in the sample. These values indicate that these manholes are leaking untreated raw sewage into the water-logged area.

Based on calculations using the flow data, it was observed that the main inlet discharged around 3000 m^3 during the 14 hours of sampling and peaks at 10 am. The stormwater inlet discharged 70 m^3 during the same period and peaks at around 12 pm. This is the common peak flow time according to the domestic water use practices according to an CDD Society which has implemented several decentralized wastewater treatment plants in Bengaluru. The flow variations in the main inlet and stormwater inlet during the sampling are shown in figure 24.

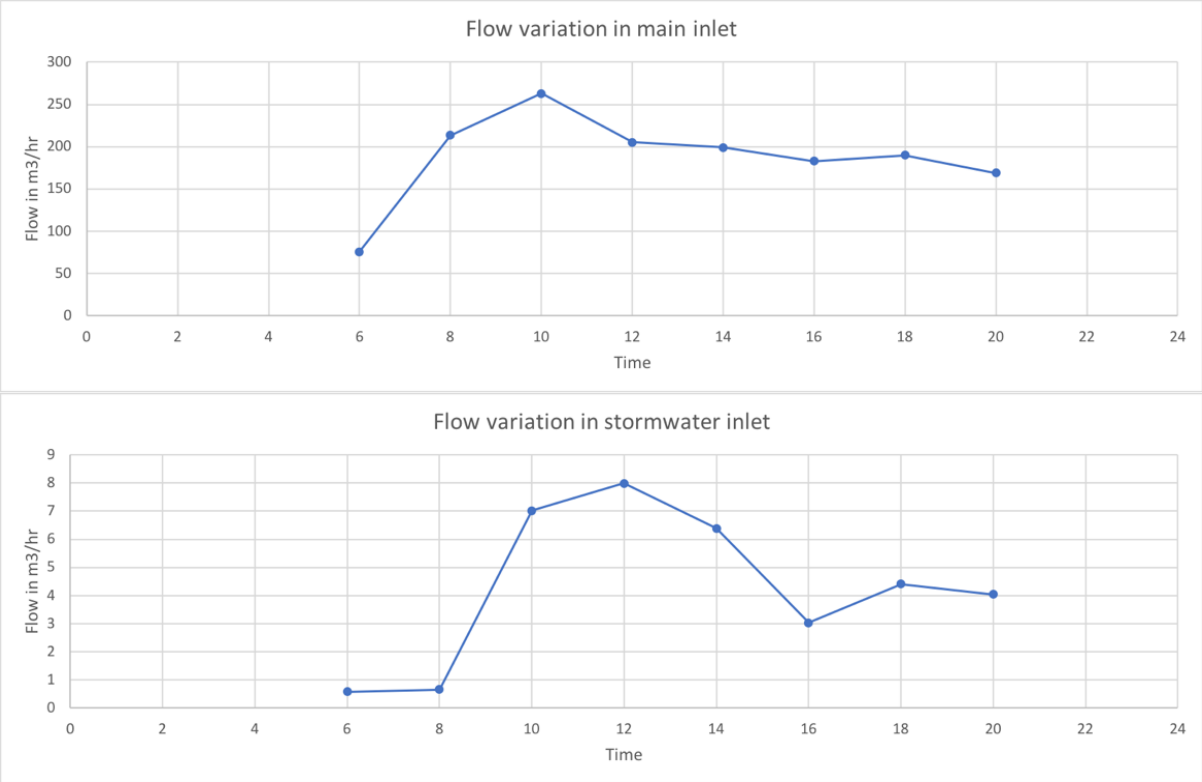


Figure 24 Flow variation during the sampling period at the inlets

Using the concentration of BOD measured during the composite sampling at the inlets, the pollution load into the lake was calculated. It is observed that main inlet contributed almost 270 kilograms of BOD over the period of 14 hours into the lake while the stormwater inlet contributed 4.41 kilograms of BOD over the period of 14 hours into the lake.

3.2.3 Borewell sampling:

The samples were analysed at CDD laboratory and the results are presented in table 9 below:

Table 9 Results of borewell samples. The values marked in red show that there are signs of sewage contamination

Parameter	Borewell-1 200 meters away from lake and 300 feet deep	Borewell-2 50 meters away from lake and 500 feet deep	Unit
Colour	Slight yellow	Colourless	-
Odour	Nil	Nil	-
pH	7.3	7.2	-
Turbidity	7.15	0.72	NTU
Nitrates as NO_3^-	72.5	<4.4	mg/l
Total Hardness	600	470	mg/L as CaCO3
Faecal Coliform	340	40	MPN/100ml
Escherichia Coli	560	420	MPN/100ml

The results from table 9 suggest that both the samples indeed had faecal contamination and presence of E.Coli which is undesirable for domestic water consumption.

The borewell 1 that is in the neighbourhood where on-site sanitation systems are predominant, has a highly concentration of nitrates (72.5 mg/L), Faecal coliform (340 MPN/100 ml) and E.Coli (560 MPN/ 100 ml). The household where the borewell was present had a single pit as the on-site sanitation system which was desludged once in 3 years. It is not lined at the bottom and constructed with 5 concrete rings which has seepage holes. The bore water is pumped to an underground sump from which the water is supplied to the household. Since the household has an underground sump in addition to the on-site sanitation system, there is a possibility of cross contamination of the bore-water.

For borewell 2, the values of faecal coliform is 40 MPN/ 100 ml and the E.Coli concentration is 420 MPN/100ml. As this borewell is located in the part of the study area where there is simplified sewer system with no on-site containment units. Therefore, the presence of E.Coli and faecal coliform indicates pollution of the ground water aquifer.

3.2.4 Faecal sludge and defunct wastewater treatment unit:

Faecal sludge characteristics vary significantly from wastewater characteristics (Strande et al., 2014). This is confirmed as it can be seen in the table 10 where the BOD, COD and total solids concentrations of faecal sludge are much higher than the sludge from Anaerobic Baffled Reactor (ABR) situated which treats wastewater.

There are no faecal sludge treatment plants around the lake area and the closest FSTP is located 40 kilometres away. Key informant interviews around the lake and with CDD Society suggests that they are either dumped into agricultural farm lands nearby or into water-logged area near the overflowing manhole near the lake. As mentioned earlier, the overflowing manhole which created a water-logged area near the lake claimed to be to a hotspot for faecal sludge dumping. If this is true, the faecal sludge from on-site sanitation systems can cause significant in causing pollution to the lake. For example, if one desludging truck of capacity 4000 litres disposes faecal sludge collected from a pit, into the lake, then it will contribute 50.8 kilograms of BOD (12,700 mg/L x 4000 litres). This is because most of the study are is covered with on-site sanitation systems and the fact that faecal sludge has such high concentrations of pollution load.

Table 10 Results of faecal sludge and ABR sludge characteristics in the study area. BOD concentration of faecal sludge from single pit marked in red. (Source: CDD Society)

Parameter	Sludge from ABR @ BWC	Faecal sludge from single pit	Unit
BOD	2200	12700	mg/L
COD	14812	17622	mg/L
pH	7.6	7.8	-
Total solids	29637	32907	mg/L

In terms of a dysfunctional treatment plant near the study area, the performance of the decentralized wastewater system at Beedi Workers Colony shows what could be the pollution load that escapes into the environment and potentially pollute the lake. Table 11 below shows the partially treated wastewater quality that is discharged into the sewer line nearby. This was only because of CDD's intervention in the project while in other cases, decentralized STPs are required to reuse the treated wastewater and discharge the remainder into the stormwater drain or a lake.

Table 11 Characteristics of partially treated wastewater in Beedi Workers Colony, source: CDD Society

pH	Temperature [°C]	Conductivity [mS/cm]	TDS [ppm]	Turbidity [NTU]	Phosphate [PO4-P mg/l]	Ammonium [NH4-N mg/l]	Nitrate [NO3-N mg/l]	Nitrite [NO2-N mg/l]	Alkalinity [mmol/l]	Alkalinity [CaCO3/l]	COD [mg/l]	BOD [mg/l]	TSS [mg/l]
7.3	24.4	3.5	2500	39.7	34	134	25	0.4	15	756	288	170	75

It can be seen from the table that the effluent quality has concentrations pollutants such BOD, COD, phosphates and nitrates which can pose a threat to the lake water quality. Therefore, this partially treated wastewater is also relevant for waterbodies in the area although it does not directly affect the Kommaghatta lake.

3.3 Findings from water quality analysis

In summary, this analysis reveals that several pathways of faecal flows as established using the Shit Flow Diagram does exist in the study area and seen to be relevant for pollution of the Kommaghatta lake but at different scales.

It is found that there is sewage inflow into the lake, which was validated by the characteristics of the inflow water at both the lake inlets. This is from areas with and without on-site sanitation systems as the main inlet covers areas with sewer system and the stormwater inlet covers areas which is mainly covered by on-site sanitation systems. From the flow measurements data and the concentration of the pollutants, inflow of sewage through main inlet is found to be the major contributor for pollution load into Kommaghatta lake. While the stormwater inlet carries lower pollution load compared to the main inlet, it is important to not that the contributing catchment area for these inlets are much different. Nevertheless, both the inlets carry sewage into the lake by means of the storm-water drains that are present in the respective catchment areas. Therefore, storm-water drains are found to be a major pathway for pollution load entering into the lake.

Observing the characteristics of the overflowing manhole and defunct treatment plant helps to affirm the point that they do have a significant impact on the lake on the blind side. For instance, there could be preferential flow through the subsurface into the main inlet as it is only located about 40 meters from the puddle which could then lead to the lowest point (i.e.) the lake. Additionally, defunct treatment plants which is often considered to be working, can eventually pollute the lake due to insufficient treatment. This is comparable to the numerous small scale STPs that are prevalent across the urban areas which discharge the wastewater into stormwater drains or directly to the lake through sewer pipes.

Given that concentration of BOD, COD and total solids in faecal sludge are very high and the fact that these systems are sporadically desludged, like once in 3-5 years, it may act as a pulse loading (sudden increase in concentrations as disposal from trucks are very quick) of pollutants into the lake. Therefore, faecal sludge from onsite containment systems are relevant for Kommaghatta lake. But it is also important to note that, faecal sludge may be dumped into the stormwater drains and it reach the lake indirectly.

The results from the borewell sampling suggest that there is presence of nitrates and coliforms in the borewell water. It is unclear from the analysis, whether the groundwater aquifer is polluted due to onsite sanitation systems or if Kommaghatta lake is contributing to the pollution of aquifer since the nitrates and pathogens in lake water is seen to be high. Nevertheless, on-site sanitation systems may impact the urban waterbodies through groundwater aquifers depending on the lithology under the lake bed. Additionally, since the borewell water has presence of pollutant such as nitrates, after domestic uses, it will further add to its concentration in the wastewater which eventually ends up in the lake.

3.4 Stakeholders analysis:

At the outset, there are several parties involved when it comes to lakes in Bengaluru. All the identified stakeholders were categorized with respect to their roles and presented below:

1. Custodians
2. Regulatory actors
3. Financing actors
4. Beneficiaries
5. Others

3.4.1 Custodians:

Until last year, there were three main bodies, who were responsible custodians for the lakes in Bengaluru, namely:

- Bruhat Bengaluru Mahanagara Palike (BBMP) – Lakes within administrative boundary of BBMP
- Bengaluru Development Authority (BDA) – Lakes in the rural Bengaluru
- Karnataka Forest Department (KFD) – Lakes in the forest reserve areas

In November 2019, the chief minister of Karnataka, Mr. B. S. Yediyurappa announced that all the lakes in Bengaluru were to be handed over to BBMP in order to protect and rejuvenate the same. BDA generally takes care of the civil works in and around the lake areas and they had a “lake and forest department” which was dissolved in 2018. They had claimed to have a lack of capacity to maintain and protect the 25+ lakes under them. Similarly, KFD had eight lakes under them which they couldn't maintain. Thus, a total of 35 active lakes were handed over to BBMP in December 2019.

3.4.2 Regulatory actors:

Some of the regulatory actors that were identified are as follows:

1. National Green Tribunal (NGT)
2. Karnataka State Pollution Control Board (KSPCB)
3. Karnataka Lake Conservation and Development Authority (KLCDA)
4. Bengaluru Water supply and Sewerage Board (BWSSB)

NGT is responsible for judicial matters specially those which involve environmental issues (in an expeditious manner). They are quite a powerful actor when it comes to disposal of waste into the lake and pollution. In the sense that, they can give notice to KSPCB and fine other institutions. They can either independently take up a case or act when a Public Interest Litigation (PIL) is filed by the citizens.

KSPCB is involved in regulating illegal discharges into waterbodies and to conduct routine water quality checks. They can also impose fines, if one were to exceed the discharge standards as set by the KSPCB.

KLCDA is responsible for regulating and approving lake related interventions for the state of Karnataka. They encompass a technical committee made of experts from IIT, IISC and other chief engineers. BBMP and BDA need to present their lake rejuvenation and development plans for approval from KLCDA.

BWSSB is responsible for the water supply and sewerage infrastructure in greater Bengaluru region. They are involved in this network, since they are responsible for the

approval and implementing centralized Sewage Treatment Plants (STPs) and the drainage networks. They are also answerable to KSPCB and NGT when the lakes are fed with untreated or poorly treated wastewater from the centralized STPs.

3.4.3 Financing actors:

The main actors who are responsible for the financing of lake related activities are:

1. Government of Karnataka (GOK)
2. International funding agencies
3. Corporate Social Responsibility (CSR)

Financial budget plans are submitted to GOK by the local bodies such as BBMP and BDA, for lake development and rejuvenation. In light of the handing over process, BBMP has recently requested Rs. 1,253 crores to the state government of Karnataka for rejuvenation activities.

International funding agencies also play an important role in the sanitation systems and treatment units in Bengaluru. They either fund the central/state government or route the funds through local NGO and knowledge partners. Few examples are World Bank, Bill and Melinda Gates foundation, GIZ and Japan International Co-operation Agency.

Private companies mobilize CSR funds through local implementers, NGOs or directly through BBMP. They play a significant role in which lake is being rejuvenated and prefer visibility for the company through the project (eg: Amazon – Mahadevpura lake). Other times, local NGOs play a role in terms of pitching lakes for receiving CSR funds and international funds. They also create awareness among the citizens, channel their actions and build technical capacities.

3.4.4 Beneficiaries:

In this category, the main actors identified are:

1. Resident welfare associations and citizen groups
2. Fishermen

In the recent past, there has been a lot of citizen activism in order to protect Bengaluru lakes and has pushed BBMP to take necessary activities. In this regard, there are mainly four which are noticeable:

1. Friends of Lakes – Pan Bengaluru
2. Puttenahalli Neighbourhood Lake Improvement Trust (PNLIT) – Puttenahalli lake
3. Mahadevpura Parisara Samarakshane Mattu Abhivrudhi Samiti (MAPSAS) – Kasavanhalli, Kaikondrahalli, Soul Kere and Lower Ambalipura
4. Jalaposhan – Jakkur lake

Considering the rigorous citizen activism, BBMP and KTCDA has created lake warden roles and lake watchdog committees. Citizens are exercising their rights by filling PILs and by involving in demonstrations. They are well connected and are seen to be domineering lake rejuvenation activities towards biodiversity protection rather than civil works.

Fishermen are benefitted through the fishing activities in the lake, which is their source of employment and livelihood. The Department of Fisheries tenders out fixed period contracts to interested parties and also maintains the lake for benefit of the fish ecosystem.

3.4.5 Others:

1. Elected representatives
2. Polluters

Local corporators, counselors and Member of Legislative Assemblies play an important role in the choice of lakes that are to be rejuvenated every year. They become the voice of people at times, while during other times, it is claimed to be for personal gain.

Finally, there are polluters such as individual households, small enterprises, apartments STPs and cesspool operators.

3.5 Results from semi-structured interviews:

This section presents the results that were obtained by conducting the semi-structured interviews with the key stakeholders identified from the stakeholder analysis. There were three major results that were obtained from the semi-structured interviews:

1. Pollution pathways for urban lakes in Bengaluru
2. Major system levers which influence pollution of urban waterbodies in Bengaluru.
3. Waterbody health perceptions according to key stakeholders

3.5.1 Pollution pathways for lakes in Bengaluru:

By conducting the qualitative analysis on the semi-structured interview data, the wastewater and faecal sludge flow into urban lakes at Bengaluru city scale was mapped. There seemed to a large agreement among the interview respondents that wastewater ends up into lakes in Bengaluru and that it takes several routes. Figure 20 shows the wastewater flow diagram which was prepared using Vensim PL

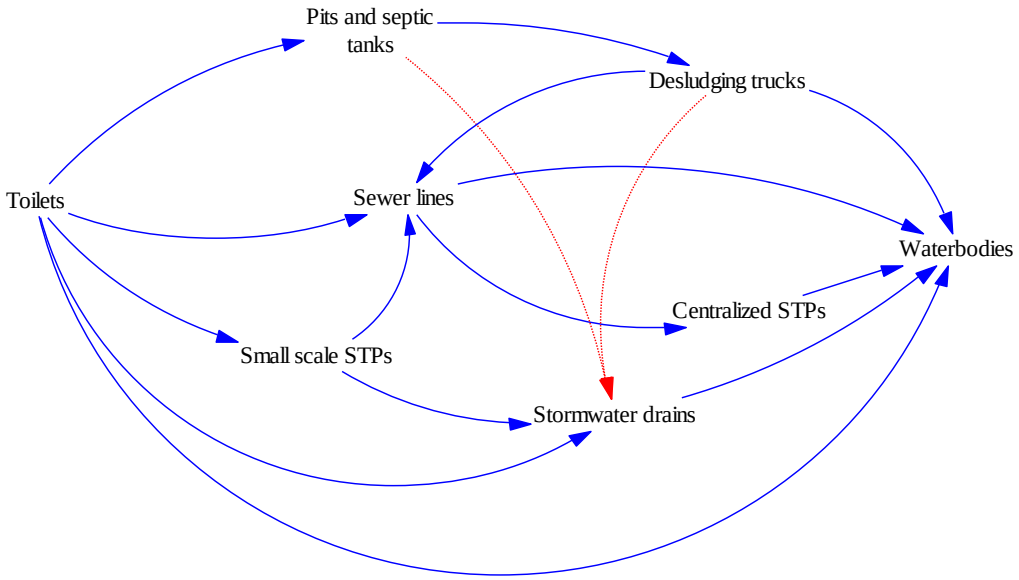


Figure 25 Pathways of pollution load entering into the Bengaluru lakes from semi-structured interviews

As seen in the figure above, the wastewater mainly takes three different pathways before it reaches the lake. This representation only takes into account, the untreated or partially treated wastewater/faecal sludge which can potentially pollute the lake and does not include industrial or chemical wastes that may be discharged into the lake. The three pathways which contribute to more than one source of wastewater are described in the sections below:

Pathway 1: Sewage in storm water drains

The primary pollution pathway into the lake is seen to be through the stormwater drains which flows into the lake. This was observed from the wastewater sampling at the inlets of the lake under study as well as agreed by all the interviewees. As one interviewee puts it, storm water drains have become the catchment for lakes in an urban context (ESI - 07).

Zooming out to the city level, there are thousands of individual STPs as BBMP has imposed the Zero Liquid discharge rule in order to cope with sewer capacities which are being exceeded. Studies and expert interviews suggest that these systems are not operating well (Reymond et al., 2020). They discharge their wastewater into the stormwater drain which also ends up in the lake and thereby becomes very relevant. One of the interviewees who works closely with Jakkur lake said that the BWSSB themselves have laid pipelines for the discharge of treated wastewater from the individual STPs to the lake (ESI-13). The problem occurs only when these STPs start failing and there is no constant monitoring of the performance.

Informal settlement and areas with space constraints not only lead to discharge into the stormwater drain but leads to pipelines directly illegally discharging into the waterbody. This was observed during the fieldwork in two lakes during the scoping for a lake to be studied. One of the interviewees who is involved in implementation of treatment systems in the city mentioned that these are quickly plugged by the authorities and connected to the stormwater drain or the sewer manhole nearby.

Due to the COVID related delays, this pathways was unable to be quantified extensively during the research. But, anecdotal evidences and sampling in the study area suggest that stormwater drains are an important pathway for waterbody pollution and experts interviews confirm that this can be scaled to the city level.

Pathway 2: Partially treated or untreated wastewater discharge through sewer lines

The second most important pathway which is relevant for the waterbody are the sewer lines. In most cases, sewer lines end up in a centralized STP where they are treated and discharged into a waterbody. But due to underperformance, they are partially treated and contributes to inflow of nutrient load into the waterbody. From the interviews, it was observed that most sewer lines are old, leak and polluted the groundwater. Also, experts agree that the capacities are often exceeded leading to discharge of untreated or partially treated wastewater. Additionally, due to rapid urbanization, sewer lines are laid first but it lakes years for an STP to be implemented and the last mile connection is established. Until then, the sewer lines are either leaking into the environment or connected to the stormwater drain which ends up in the lake. This suggests that the absence of adequate and efficient STPs lead to discharge of wastewater into the lake in Bengaluru.

Pathway 3: On-site sanitation systems

The third relevant path is through the desludging trucks which is dumped into waterbodies and the overflow from the on-site sanitation systems which leak into the aquifer and further contaminating the waterbody. All of the interviews who were asked about faecal sludge dumping agreed that it is not monitored well enough and the truck drivers often tend to dispose it into waterbodies or streams that lead to a waterbody. This is reportedly a common practice in several cities in developing countries according to literature (Peal et al., 2020; Strande et al., 2014). This is reinforced by the documentary evidence of the SFD for Bengaluru where 6% of the faecal sludge is not delivered to a treatment plant and 2 % of the supernatant from the on-systems not being treated. Most of the interviewees also agree that faecal sludge is usually dumped into stormwater drains due to the unavailability of faecal sludge treatment plant. Although the field observations and anecdotal evidences suggest that faecal sludge dumping is not consistent in the study area, it is found to be common in other parts of the city (Chitradurga Srinivasa Murthy & Ray, 2019). From the secondary data that was collected from CDD Society, it was seen that faecal sludge has a high concentration of pollutants and if dumped into the lake, it can cause significant pollution.

3.5.2 System levers for urban sanitation

Upon identifying the pollution pathways that are relevant for the waterbody and which ones are significant, it was also attempted to understand the reasons behind why the pollution load enters into the lake through these three pathways. Overall, there was significant convergence as to why waterbodies are polluted in Bengaluru city. The difference in perceptions by the different stakeholders were assessed during the qualitative analysis and based on the frequency of responses, credibility of the respondent and by triangulating the data, some responses were not considered. Based on the responses from the interview, the system of urban sanitation was mapped conceptually using Vensim PLE v8.1.1 and can be seen in figure 26. Positive and negative sign notations are used to indicate if the cause-effect is either positively or negatively reinforcing. It is attempted to integrate the causes for the pathways with the three major pathways of pollution identified in the previous section. As seen in the figure, there are several factors that influence the urban sanitation in Bengaluru. This is a result on conducting the why analysis during the interview process to capture the casual links between different influencing variables.

The system levers which play a role in impacting waterbody health are identified from this conceptual representation based on its centrality and significance. It was seen that there are six major system levers which influence the dynamics of urban sanitation in the city of Bengaluru. They are as follows:

1. Rapid Urbanization
2. Fragmentation of government entities
3. Sewer Infrastructure
4. Faecal sludge management
5. Treated water reuse
6. Citizen group involvement

These system levers are discussed in detail in the discussion chapter as to how they influence the pollution pathways into the lake and highlighting various perceptions by interviewees.

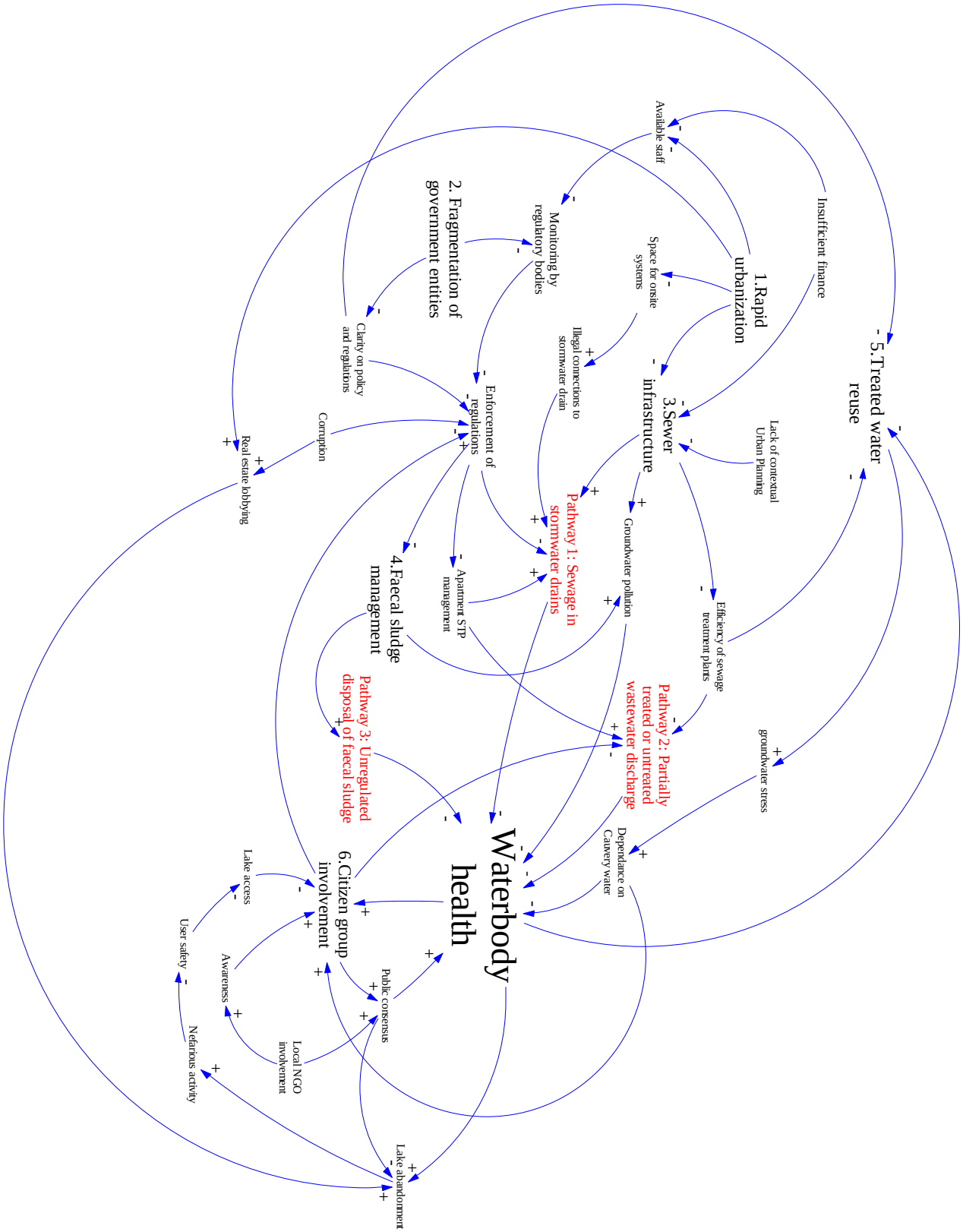


Figure 26 Conceptual representation of urban sanitation in Bengaluru city. Positive and negative sign notations are used to indicate if the cause-effect is either positively or negatively reinforcing. The pollution pathways are highlighted in red. System levers are numbered and shown in larger font size.

3.5.3 Waterbody health perceptions:

When it comes to the term waterbody health, there seemed to be a lot of disparity in the understanding by different stakeholders. But the concept of “lake health” in an urban context is differently understood by different stakeholders. In the urban context, lakes have been constantly evolving and what the lake needs to perform is rather unclear (ESI – 05). As one respondent puts it, “We need to reimagine what is an urban lake. Getting back to the once pristine condition of the lake might not be practical and it needs an adaptive way of looking at lakes in an emerging context” (ESI - 02).

When asked about the roles that lakes play in the city of Bengaluru, there was a mix of interesting answers from the respondents ranging from, it just being a place to hold treated wastewater to the city’s main source of water as in the traditional sense. Consequently, the idea of a healthy lake as perceived by the stakeholders also tends to vary a lot. It was attempted to identify what a healthy lake is according to key stakeholders and mapped in figure 27:

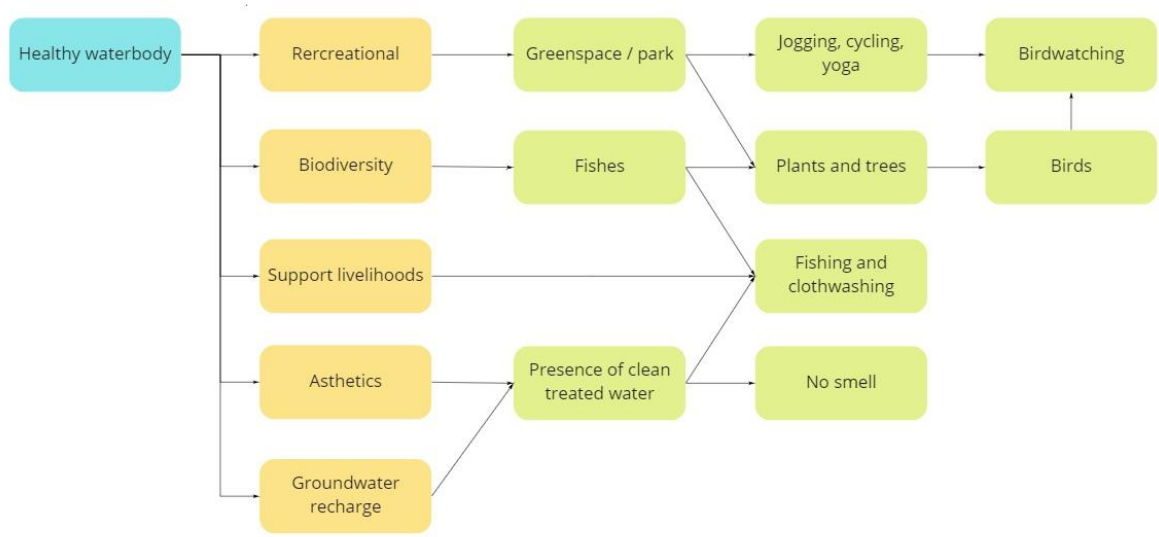


Figure 27 Perceptions of different stakeholders of a healthy waterbody and how it is related to each other

They are mainly classified into five major categories:

- Recreational
- Thriving biodiversity
- Supporting livelihoods
- Visual and aesthetics
- Groundwater recharge

In the figure they are organized according to the responses from the interviews in the order of their significance. Most of the interviews agree that lakes play a huge role for adding aesthetics and act as a recreational zone. It incentivizes the people to care more about the lakes and acts as a gateway to create awareness on other avenues such as conserving the biodiversity and protecting the environment. While experts agree that it is ok to concentrate on the recreational and aesthetic aspect of the lake, they stress that lakes should continue to support different livelihoods that are dependent on the lake. Fishing and cloth washing as practiced by different

communities for generations need to thrive in a controlled manner such that all stakeholders can be benefitted from the waterbody.

Regarding groundwater recharge, citizen groups feel that it is important and very much relevant for the future water crisis that is imminent for the city of Bengaluru. Therefore, it is also considered as one of the important roles that a healthy lake is supposed to play according to the citizens. There has also been anecdotal evidence from studies conducted by the local NGOs which suggest that lakes can help in recharging the groundwater aquifer. This further reinforces the motivation of civil societies and NGOs to create an aware among the people and push for filling the lake with treated water. This is mainly because lakes are usually full only during the monsoon season while at other times it turns out dry since the authorities has started diverting wastewater from entering into the lake due to media pressure (ESI – 05, ESI – 06, ESI- 09).

It is reported by many that residents don't care about the quality if the water in the lake and that they only want a lake which is aesthetically appealing and can be used recreational purposes. Therefore, government official is motivated to create quick fixes such as desilting, removing solid waste and strengthening the embankment (ESI – 02, ESI – 03, ESI – 04, ESI - 09). On the other hand, the representatives of the citizen groups see much more than just the recreational uses that can be extracted out of the lake. They consider lakes to be a haven for biodiversity in a concrete jungle such as Bengaluru city. They are constantly educating the citizens about the environmental benefits that can be realized by protecting the lake. One interviewee said that, "Authorities don't realize the amount of money lost in terms of environmental damage. They just want to create a nice park with greenery around the lake" (ESI- 07).

Based on the different perception on waterbody health and how it varies from each of the stakeholder, it was agreed by the interviewees there is no one set of lake health index that can applied for all the lakes in the city. They agree that it needs to be worked out contextually for each lake along with the involved stakeholders after having a vision for the lake (ESI -02, ESI – 09, ESI - 16).

Chapter 4: Discussion

4.1 System lever 1: Rapid urbanization:

Urbanization plays a pivotal role in the sanitation dynamics of the city. It is an external factor which is beyond the control of city planners and decision makers. From the interviews it was the primary cause for lake pollution as the city of Bengaluru is expanding at an exponential rate. Due to rapid urbanization and the IT bloom in the city, peri-urban areas are growing at an exponential rate which leads to increase in the generation of wastewater while the sewer infrastructure is still not in place (ESI - 06). Therefore, it is discharged into stormwater drains which eventually ends up in the lake.

Real-estate agencies play a huge role in developing the areas near the lake and often claimed to be the primary reason for lake deterioration and encroachment. One of the interviewees said that real-estate agencies and builders often fill up empty lake areas with construction waste and eventually occupy the land for construction (ESI-08). Since there is not enough data about the lake boundaries and the lack of enforcement in terms of the buffer distance from a waterbody, new buildings are eventually constructed close to the lake with no adequate wastewater management. When builders implement new apartment complexes, a basic non-contextual small-scale treatment plant is incorporated to cut down on the capital costs. In addition to that, apartments are often named as “Lake-view” as a marketing strategy such that the residents feel that the lake belongs to the apartment facility. Therefore, they restrict the other users of the lake such as fishermen and cloth-washer whose livelihoods depend on the lake. Therefore, the development priorities are more inclined towards enhancing luxuries and not about adaptation and problem-solving (ESI-07).

In terms of the administration and regulation of the sanitation systems, it is difficult for the pollution control board and other regulatory bodies when the city is expanding at an exponential rate. These regulatory bodies are not funded enough and often understaffed and therefore it is hard to track the performance of the various small scale STPs across the city. Additionally, the provision of sewer infrastructure also suffers as the funds for this come as lumpsum amounts and takes several administrative procedures before it is implemented (ESI - 05). As one BWSSB official puts it, “If we make a plan for sewer system and an STP today, it would 10-15 years before it gets implemented” (ESI - 10). Thus, there is a huge lag between the rate at which the city grows and the provision of adequate sewer infrastructure.

Urbanization also leads to the generation of different types of sanitation solutions such as temporary or on-site sanitation solutions due to lack of adequate planning (ESI - 15). Therefore, authorities struggle to monitor, regulate and serve these different types of solutions. In the year 2007, 110 villages were added to BBMP city limits and the construction water supply and sewerage system is still underway. In the meantime, on-site sanitation systems are the means to manage the wastewater while there is no desludging service provided by the city administration even though 30% of the city population is reliant on it (ESI-15). The faecal sludge from these systems also requires special treatment as the characteristics are different from typical wastewater which is usually not provide as most of the funds are going to implementing sewer lines and centralized STPs. Additionally, slum areas are often located at the inlet or outlet of lakes where there is not enough space for sewer connections. It is difficult for

authorities to enforce and regulate the illegal discharge of wastewater into the lake, since they are poor and marginalized. They are also heavily supported by local politicians who promise better living conditions in exchange for their votes.

4.2 System lever 2: Fragmentation of government entities

Urban governance in a developing city such as Bengaluru is a multilayered issue as it ranges from lack of funding, inter-agency cooperation, skill and corruption (ESI - 01). It is also reported to be at different levels starting from, lake management, provision of sanitation infrastructure, enforcement of regulations and sanitation planning.

Urban governance is a well-known problem in the Indian context but from the interviews there seems to be a difference in opinion as to who is responsible for the lack of urban governance. While the authorities claim that they are doing their best in terms of improving the sanitation situation, citizen groups and local NGOs claim that there is no collaboration by the authorities with the actual users of the system. It is often seen as a top-down approach and puts more emphasis on infrastructure than the social aspects (Chaplin, 2011). They claim that there is a lack of accountability, transparency and inclusivity in their activities. As one representative of a citizen group puts it, “We want to be involved right from the planning stage until the implementation and maintenance of the systems”. It is reported that this is slowly changing in the recent years, mainly due to the intervention of the public for lake related activities by filing public interest litigations. As one of interviewees states, it takes a dynamic bureaucrat to collaborate and work with the citizens. But it was also mentioned that the authorities only co-operate within their institutional framework and very much influenced by politics and other power dimensions (ESI – 06).

Another reason for the failure of urban governance is that there is a lack of ownership as to who is responsible for what among the several agencies that are working in the urban space (Jamwal et al., 2016; Reymond et al., 2020). For example, BWSSB is responsible for the sewerage and treatment of wastewater while BBMP manages the lakes in the city for lake rejuvenation. Unless there is a cooperation between these two agencies, the chances of the lake being in a healthy state is very low (ESI - 07). In addition to that, the pollution control board and lake development authority is responsible for monitoring the pollution into the lake. But the pollution control board is said to focus more on the industrial pollution aspects while BWSSB imposes blanket fines on neighbourhoods who they think are polluting the lake (ESI - 15). On the other hand, the local citizens are deemed responsible by BBMP to be watchdogs for the lake and enforce the by-laws as set by the municipality. This just shows the complexity of lake regulation in the city and reinforces the tendency of authorities to show a blind eye until the lake is polluted heavily.

In terms of wastewater bylaws and regulations, the pollution control board has the authority to formulate and enforce it at the city-level and the municipality monitors it. But in the case of India, there are different agencies coming up with recommended discharge standards which are blindly endorsed which causes confusion as to which is applicable (ESI - 12) (Jamwal et al., 2016; Klinger et al., 2019; Schellenberg et al., 2020). This was confirmed by most of the interviewees and the constantly changing wastewater discharge standards has caused tension among practitioners and the authorities as the standards are seen to be too stringent. As one Pollution Control Board official mentioned to one of the interviewees, “Only if we set 10 mg/l BOD then

we will at least get the citizens to treat it until 30 mg/l". This mindset by the PCB officials is confirmed by several other interviews and in literature (ESI – 04, ESI -11, ESI – 12, ESI - 16) (Jamwal et al., 2016; Schellenberg et al., 2020). In combination with the lack of ownership, capacities and disparity in the understanding of which standards are applicable, it is a big challenge to regulate wastewater disposal quality across the city. This forms the basis of the statement by an interviewee, "Everything is on paper, but nothing is enforced or regulated by the authorities" (ESI - 12) (ESI - 01). Finally, there is a lack of data in terms of the efficiency of the existing treatment plants and even if there data available which can be useful for other agencies, there is no transparency by the responsible agencies (ESI - 09).

4.3 System lever 3: Sewer Infrastructures

The capacities in terms of infrastructure and skill are another major system lever which links to waterbody health. The interviews indicate that the sewer systems are running under capacity due to the constant expansion of the city limits and centralized sewer systems being the primary choice by decision-makers. This is due to the fact that these systems require huge investment, time for implementation and a highly skilled labour for operation and maintenance. Lack of finance and being understaffed influences both the implementation of sanitation solutions and the monitoring of the existing systems (Jamwal et al., 2016; Klinger et al., 2019). Additionally, the city planning authorities are mostly civil engineers or urban planners and do not include other relevant disciplines such as ecologists, sociologists and environmental engineers (ESI - 07).

The existing sewer pipes are reported to be old and leaky which were established several decades ago. This leads to high groundwater levels in the core part of the city and contamination of the shallow aquifer (ESI – 015, ESI - 09). Due to the exceeded capacities and poor condition of the sewer pipes and STPs, BBMP imposed the Zero liquid discharge limit which forced apartments with more than 30 households to treat their own wastewater and reuse the same (Klinger et al., 2019). This gave rise to more than 4000 such small-scale treatment plants of which are 80 to 85% are reported to be underperforming and discharging partially treated wastewater into the stormwater drain or into the lake (ESI - 13).

The sewer pipes are often overloaded and the design capacity of the sewage treatment plants are exceeded (NITI Aayog, 2019). This leads to inefficient treatment of the wastewater and therefore the discharged water has a high amount of pollutant load. There were instances where the STPs at the inlet of the lake diverts the wastewater directly into the lake due to high amounts of inflow into the treatment plant (ESI - 04). On the contrary, newly established STPs are not getting enough wastewater inflow since sewer lines which are still under construction. For instance, the STP at Kengeri is said to be underloaded by a large factor for over a year due to the lack of last-mile sewer connectivity (ESI- 14).

In terms of the skill required to operate the sewage treatment plant, there seems to be a lack of trained operators (Klinger et al., 2019; Narayanan et al., 2017). One interviewee said that, most often the operator makes poor choices to shut down certain treatment modules depending on visual checks of the inflow quantity and quality (ESI - 08). It is said that when the system is built by a different agency than the one that operates it, it often leads to poor management and inadequate treatment performance

(ESI - 14). This is also seen in small scale treatment plants at the apartment level where operation and maintenance agency try to reduce the costs for running the plant. When residents move into newly built apartment complexes, they are unaware of the treatment systems and their efficiency. Eventually, the residents aim to cut down on the operational costs of the system by shutting down certain parts of the treatment unit and diverting the wastewater (ESI - 12).

Finally, there is a lack of skill and capacity by the decision makers to choose appropriate solutions for the situation. Experts claim that there is a tendency by decision makers to opt for high investment, large infrastructure projects as opposed to the contextual solutions (Hawkins et al., 2013). One interviewee suggests the decision-makers need to unlearn what they have learnt during their technical studies which heavily endorses design of sewer and centralized treatment technologies while the best practices and working models in a developing context is ignored. This gave rise to intense capacity building campaigns by the central government and NGOs to help decision-makers take informed steps in their cities (ESI - 11).

4.4 System lever 4: Faecal Sludge Management:

Faecal sludge management has been gaining a lot of attention over the past years since the announcement of the Swatch Bharath Mission in 2014 (SBM, 2019). As mention earlier, due to the rapid urbanization combined with the increased provision of household toilets made faecal sludge very much relevant for Indian cities. But due to several gaps along the sanitation value chain, there are many issues which hinders the safe management of faecal sludge in the city.

Due to an inclination towards provision on sewer systems, there is not enough funding to build faecal sludge treatment plants in the city. There are also no desludging trucks operated by the city corporation which makes it hard to monitor and regulate disposal of faecal sludge into stormwater drains and waterbodies. Interviews suggest that only two STPs in the city was permitting the disposal of faecal sludge into their facility which was then discontinued to the increased concentrations of organic load in faecal sludge (ESI – 14, ESI - 09).Therefore, the lack of faecal sludge treatment plants and long travel distances to the STPs which were assigned for faecal sludge dumping motivates the truck operators to dispose the waste wherever it is convenient for them and get away by bribing the local policemen (ESI – 01, ESI – 08, ESI -15).

At the on-site containment level, it is reported that, most of these systems are not constructed according to the CPEEHO manual which provides the guidelines for safe management of blackwater (Dasgupta et al., 2019). These systems are not lined at the bottom or the sides which allows the leaking of wastewater into ground and potentially contaminate the aquifer. Due to space constraint, septic tanks are not provided with soak-away pits and instead the overflow is connected to a stormwater drain. There is a mix of responses from the interviews in this matter as citizen group representatives believe that there is no threat from on-site systems in terms of aquifer contamination while many others strongly feel there is a definite link which is supported by anecdotal evidences from open wells and literature (ESI – 06, ESI - 07). Studies suggest that the groundwater is indeed polluted with sewage due to leaking sewer pipes (Sheeba et al., 2017). But due to the lack of an extensive study to isolate the contribution of on-site sanitation systems to this issue, it still remains a grey area.

Interview data also suggest that on-site sanitation systems are not monitored by the municipal engineers who approve the design. They are eventually constructed according to the working knowledge of the mason. There has been a huge focus on educating the masons of the threats of not constructing pits and septic tanks according to guidelines (ESI - 11). Although there is a national level policy framework for the management of faecal waste, it has not been actively undertaken in the city of Bengaluru. The vast extents of the city combined with unclear roles by different government bodies make it harder to monitor and regulate the by-laws that are in place. This leads to the development of informal arrangements and quick disposal of the faecal sludge to make it profitable for the residents and desludging truck operators (ESI -02).

4.5 System lever 5: Treated water reuse

Reuse of treated wastewater has an immense potential in the city of Bengaluru as there is a huge stress on the groundwater levels. Traditionally, lakes were the source of water supply for the people who lived in Bengaluru city. Interview data suggests that the dependence on groundwater resources and supply of water from external sources outside the city formed the basis for deteriorating waterbody health. Since the water needs have been met by external sources there wasn't enough incentive to endorse reuse of treated wastewater. But in the recent years, as Bengaluru is moving close to a day zero situation, citizens and authorities are more inclined towards improving waterbody health and recharging the groundwater levels.

There are several reasons why reuse of treated wastewater is not feasible in Bengaluru city. Firstly, since the performance of the centralized STPs and small-scale treatment plants are inadequate, there is no room for reuse as it may pose a threat to public health. Additionally, there is a stigma towards the use of treated wastewater among the user since there are instances where the water carries undesirable smell and colour. Even though Karnataka is the first state to adopt a wastewater reuse policy, it has not had an uptake be users and implementing agencies. Largely wastewater reuse dialogue was centered on irrigational activities while in an urban context this seemed irrelevant. But in the year 2017, regulations and discharge standards have been revamped to be centered more on the reuse point of view and promoted use of the treated wastewater for secondary purposes. But reuse for such purposes requires advanced tertiary treatment options which requires heavy investment and consumes a lot of spaces. This has been the main bottleneck for consultants who propose treatment solutions for their customers who generally prefer cheap solutions and that which doesn't require a lot of space in an urban context.

In the recent past BWSSB has also been exploring avenues to treat the wastewater adequately and using it for secondary uses. This can be seen in the case of the Koramangala STP which supplies the treated wastewater for watering the plants and trees in Cubbon park. Another example where this is showing promise is the Kempegowda International Airport where the treated wastewater is fully reused within the facility. Interview with an implementor of several small-scale treatment plant in the city suggest that apartment complexes are starting to see reuse of treated wastewater profitable as they save a lot of money on buying addition water for secondary purposes. Due to the water stress in Bengaluru, apartments are purchasing water from water mafia tankers at Rs. 80 – 100 per cubic meter. On the other hand, the operational cost for running a 500 - 600 KLD wastewater treatment plant and reusing

the treated water in their apartment facility is only Rs. 12 – 13 per cubic meter. Therefore, It is said that the saving in purchase of freshwater is worked out to be almost Rs. 28,500 per day for some apartments which is a significant amount (ESI - 13). This has formed a motivation for them to properly maintain the STPs within their apartment premises and to constantly check the performance.

Finally, interview data suggests that there is not an established platform for small scale sewage treatment plants to sell the excess treated wastewater. There is a lot of potential to sell it for construction purposes as they are not allowed to extract groundwater for construction (ESI – 06, ESI - 15).

4.6 System lever 6: Citizen participation

Bengaluru city has been known for its citizen activism for protection of the environment and working closely with the government in order to realize their needs. It is one of the unique cities where people from all walks of life come together for a common cause such as lake protection and often spearheaded by enthusiasts or NGOs in the city. The main driver for the citizen activism in Bengaluru city has been the water stress that has been gripping the city coupled with people who have once seen the lakes in pristine conditions. The emotional connect developed by residents who grow up with the lakes gave rise to the formation of informal groups who fought the government authorities by means of public interest litigations in the court of law (ESI – 02 , ESI - 05). Onset of social media connect between people and incoming educated class of migrants gave rise to the unification of their concerns regarding these matters.

With consecutive successes in getting what the public wants from the city administration, citizen involvement started getting prime importance for the betterment of the environment. All interviewees agree that citizens are getting more and more informed and willing to act together in order to push the authorities to fix sanitation issues in their neighbourhoods. One of the citizen group representatives said, “We often forget that we live in a democracy and we could bring about a change if we wanted to’’. This has revolutionized how the city administration works in terms of public service delivery as there is more and more involvement of the different stakeholders involved in the project rather than just following a top-down approach. As discussed earlier, the traditional approach by authorities in order to rejuvenate a lake is more civil oriented. But with the involvement of informed experts through NGOs, citizen groups have managed to break the trend and push the government agencies for a more wholistic approach which now includes conservation of biodiversity and ecological aspects (ESI – 03, ESI – 04, ESI -06).

Users of the lake for recreation and people who live at the immediate surrounds of the lake are most affected by the deterioration of the lake. Bird watchers in Bengaluru city are one of the first groups to bring out the condition of lakes and how the biodiversity has been lost in the last decades. It takes a visibly deteriorating lake for the citizens to get sensitivitised by the issue and start working together. But therein lies the vicious cycle as pointed out by one of the interviewees. When the lake is polluted, it is undesirable for the users to visit the lake and often it gets abandoned. Once the lake is abandoned it is used for nefarious activities, discharge of faecal sludge and wastewater to the point that the lake is polluted beyond recovery. Therefore, it requires the lake to be safe, accessible and a motivated individual/group to takes in order to take protection measures for the lake which is being polluted (ESI - 09). As discussed

earlier, there is also a political push by elected representatives to improve the lake situation as they are reliant on the residents' votes (ESI - 05).

The example of Jakkur lakes where participation of the citizens in lake related activities right from planning until of monitoring sewage inflow is currently being endorsed as the best model by NGOs. This is also accepted largely by the lake authorities as they don't have the capacity to monitor it themselves and they encourage citizen groups to participate (ESI - 06). Citizen groups also play an active role in creating awareness among the people as to how they can protect the lake and best practices with respect disposal of waste. They keep a constant check of the quality of treated wastewater that is discharged into the lake and immediately notify the authorities when the efficiency of the system drops. This way, there is an effective working partnership between BBMP and the citizen group who takes care of the lake. On the contrary, one of the citizen group members stated that, it motivates the authorities to completely transfer their responsibilities to the citizens (ESI - 07).

In some cases, it is said that citizen groups are more activists than environmentalists which means that without the right cause, citizen groups are prone to be misguided (ESI – 14). There is also a phenomenon of bourgeoisie environmentalism observed among the middle-class communities who are motivated lay claim of the lake as their own. Therefore, they to oppress and marginalize other users of the lake such as fishermen and cloth washers (ESI -15).

4.7 Relevance of CWIS

Having understood the sanitation system in the city of Bengaluru and the major drivers which influence the health of waterbodies, it is attempted to analyse the relevance of City-wide Inclusive Sanitation for the case study area. The relevance of CWIS principles are summarized in figure 28 below:

Equity	Environmental health and public health	Mix of sanitation systems	Comprehensive planning	Monitoring and regulation	Mix of business models
Access to safely managed sanitation for all citizens, specially urban poor	Closing the loop of wastewater and hence reducing the stress on groundwater	Address impacts of rapid urbanization which currently pollutes the lakes	To help involve all stakeholders right from planning to implementation	Address the current monitoring and regulation gaps with respect to sanitation and waterbodies	Address the issue with lack of finace and capacity of sanitation infrastructure
To equally share benefits of urban lake by all classes of people	Boosting the urban economy and limiting pollution of urban waterbodies	Helps in contexualization of sanitation solutions by decision makers	Aids in Knowledge sharing and collaboration between different government agencies	Restricts illegal discharge of sewage into the lake	PPP partnerships to enhance operation, maintainence and treatment of sewage and faecal sludge

Figure 28 Relevance of CWIS for the city's sanitation issues and waterbody health

One of the issues that was brought up at several instances during the interviews is that, there is not enough contextualization being done during planning exercise for the city. Authorities follow rigid methodologies which may have been proven to work in developed countries. City-wide inclusive sanitation seems directly appropriate for Bengaluru city in this sense. In principle, CWIS is rather a contextual approach toward sanitation planning in the city and not a hard-fast solution which can be replicated without context. It consists of several steps including understanding the urban fabric and the context which addresses the issue of the current sanitation planning being

more adhoc. It also advocates formulating a multidisciplinary team for planning exercise while it is currently very much dominated by civil engineers and urban planners.

As mentioned earlier, rapid urbanization often gives rise to a mix of sanitation systems that are inevitable and authorities are not prepared for it due to poor planning. CWIS has at its core, the acceptance of different sanitation technologies which are equipped for different social, demographic and income classes of people. Not only at the level of spatial setting, it identifies the different service delivery models that could be emerging as a result of these different sanitation solutions. Therefore it can help decision-makers to be proactive and prepared to address the different informal arrangement that could arise due to the constantly expanding cities.

From the analysis, it was revealed that there government entities are often siloed and does not cooperate together for matters related to sanitation services. Unclear roles and responsibilities has been adversely affecting the overall safe delivery of sanitation services. Additionally, putting heavy focus on infrastructure without the understanding of the regulatory framework, inclusion of stakeholder and private players has hampered the efficiency of the implemented interventions. CWIS understands this issue with developing countries and recommends imaging sanitation as a service to delivered in its entirety. Right from the infrastructure, to the political will and the enabling environments are studied beforehand for the recommended solutions to be a success.

Another issue with the urban sanitation system is that there is no inclusivity in the activities that are undertaken by the authorities when it comes to sewage management and lakes for that matter. CWIS encourages dialogue between the agencies involved, including the stakeholders who benefit from the solutions. It can also potentially create a sense of ownership among the stakeholders and eliminates the chances of facing unnecessary legal pursuits which are currently faced on a constant basis by the institutional stakeholders.

Additionally, it is often seen that the lower income class of people are the ones who are adversely affected in the city due to poor sanitation. They often live in the informal settlements which has poor sanitary conditions and are often marginalized in terms of infrastructure. CWIS supports providing equitable sanitation for all the citizens, therefore, the quality of sanitation received by different classes of people would remain the same which could bring people together and break inhibitions with respect to income-class. It addresses the issue of informal settlements with inadequate infrastructure which eventually dispose their wastewater into the stormwater drain or the lakes.

CWIS also recommends integration of the different public service deliveries such water supply, sanitation, solid waste management and urban planning (Scott et al., 2019). This is particularly relevant for the case study area since they are often seen to be addressed separately. There is a lot of potential to exchange data and information across the departments who are responsible for these services which can benefit in designing better solutions. For example, when city development authorities makes plan which do not align with the extension plans of BWSSB, there is a possibility for design capacities being exceed and eventually poor performance of the systems.

Therefore, CWIS has a role to play in potentially solving the problem of partially treated wastewater from the STPs that are currently entering into the lakes.

According to CWIS principles, Public Private Partnership (PPP) is of equal importance in a developing context where the government is unable to finance sanitation infrastructure. As understood from the system, finance plays a huge role for the lacking sewer infrastructure, treatment units and capacities of the government agencies. Therefore by boosting the urban economy through PPP there is a huge potential for improving the overall sanitation status of the city and thereby improving the lake. Resource recovery from the wastewater and faecal sludge is endorsed by CWIS framework and the PPP models can come in handy as a means to achieve the same. PPP doesn't limit itself to the financing for the sanitation projects only as it also has a potential for taking ownership of the interventions and solving the issue of both infrastructure and skill capacity which is lacking presently. Additionally, monitoring of systems and enforcement of regulations was seen to be one of the major issues with respect to Bengaluru city. By including all the stakeholders involved, incentivising PPPs and knowledge sharing between the different institutional agencies, this issue can be minimized further.

With respect to the faecal sludge management in the city, CWIS has a potential to improve the existing situation in the city since it aims to address all the elements of the sanitation value chain. While authorities are reactive (i.e) act only when there is a need, CWIS can help decision-makers to be proactive and visualize the implications of the solution. It encourages understanding and embracing the different business models that are possible with faecal sludge management. This way, it will address the pollution pathway that currently exists through the desludging trucks and on-site containment systems.

As people and authorities have started caring about the environmental health equally as much as public health, the implementation of CWIS principles can ensure that both are addressed during the planning exercise. This is because, it completes the loop of wastewater by addressing it from the source until the reuse of the wastewater. Therefore, nutrients are not lost into the environment or end up polluting urban waterbodies, which makes CWIS environmentally sustainable. Thus, it is seen that CWIS principles have a significant relevance for improving sanitation planning in Bengaluru by addressing the major system levers of urban sanitation and indirectly curbing the pollution pathways into the urban waterbodies.

Chapter 5: Conclusion and recommendations

Urban sanitation in developing countries requires systems thinking as there is a plethora of different variables which can impact the delivery of adequate sanitation for the people. In the traditional sense, sanitation planning in urban cities focused on keeping people away from human-waste related pathogens. As cities are growing at exponential rates, government agencies are struggling to provide adequate safe sanitation in their cities. In recent years, due to a range of factors such as increasing water stress, recreational needs and biodiversity protection in an urban fabric, urban waterbodies are deemed worthy of conservation. The objective of this research was to systematically understand urban sanitation and how it relates to urban waterbody health using a case study in Bengaluru, India. Having understood the system adequately, the aim of the thesis was to answer the research question, can "Citywide Inclusive Sanitation as a planning approach in the betterment of urban waterbodies?"

Firstly, using the results from the quantitative water quality testing, the faecal flows from the SFD for the city of Bengaluru was validated at the scale of Kommaghatta lake. Subsequently, using the qualitative data from semi-structured interviews three significant pollution pathways which contribute to pollution of Bengaluru lakes were identified. The predominant pathway for the pollution of waterbodies in Bengaluru city is through the stormwater drainage. A variety of sources contribute to the flow in stormwater drains, ranging from: direct discharge of wastewater in informal settlement around the lake periphery, partially treated wastewater from the small scale STPs, overflow from on-site containment systems and dumping of faecal sludge by the desludging trucks. From these findings, it is concluded that there is a definite link between failed urban sanitation and deteriorating waterbody health in Bengaluru city.

Six major system levers influence the dynamics of urban sanitation in Bengaluru and they form the basis of the pollution pathways that enter into the lake. CWIS is seen to have a significant relevance for solving urban sanitation issues which were identified through these system levers. In addition to solving urban sanitation issues which centres on public health matters, there is also an environmental case for CWIS which addresses waterbody pollution pathways that are linked to these system levers. Even though waterbody health is differently understood by key stakeholders, arresting pollution load from entering into the lake can be viewed as an improvement of condition of the waterbody. Therefore, it is concluded that CWIS has a potential to solve urban sanitation issues and thereby improve waterbodies health in developing cities.

The qualitative data collected for the study may be influenced by the telephonic mode of interviews in which subtle information could have been lost. Therefore, it is recommended to conduct face to face semi-structured interviews for future studies. The conclusions made in this study with respect to the system levers and relevance of CWIS principles are by qualitative analyses. In order to test the efficiency of CWIS principles for the betterment of waterbody health, it may require a quantitative study using system dynamic modelling and a comparative case study. Finally, further studies can be done in order to demystify the term "Waterbody health" and define physical, chemical and biological parameters coupled with user preferences to arrive at contextual waterbody health index.

The system levers and pollution pathways into the lake as established in this study are contextual to the city of Bengaluru and requires other case studies in order to be compared and scaled to other cities in India. Nevertheless, the system levers as identified in the study are more generic across several Indian cities as it is extensively discussed in literature. The striking difference is the participation of citizens for lake related activities which is very unique to the city of Bengaluru. Findings from this research can help to improve decision making in terms of urban sanitation by paying close attention to the cause-effect relationships between variables in the urban sanitation sphere. It also opened a new space of research where urban sanitation planning can be studied in a multi-disciplinary manner which includes, socio-spatial aspects, public health and environment health.

References:

Ali, A., & Hussain, A. (2019). Water Pollution in Pak. *Environmental International*, *2*(2), 150–160.

Axelrod, R. (2015). Structure of decision: The cognitive maps of political elites. In *Structure of Decision: The Cognitive Maps of Political Elites*. https://doi.org/10.2307/2616237

Bhateria, R., & Jain, D. (2016). Water quality assessment of lake water: a review. *Sustainable Water Resources Management*, *2*(2), 161–173.

Biome. (2016). *Bangalore and its Lakes*. 97. http://biometrust.org/wp-content/uploads/2017/01/Bangalore-Lakes-Biome-Dec-2016.pdf

Biswas, D., & Jamwal, P. (2017). Swachh Bharat Mission: Groundwater Contamination in Peri-urban India. *Economic and Political Weekly*, *LII*, 18–20.

BMGF. (2010). *Water, Sanitation & Health*. https://docs.gatesfoundation.org/documents/water-sanitation-hygiene-fact-sheet-2010.pdf

Bryman, A. (2016). *Social research methods*. Oxford university press.

Chaplin, S. E. (2011). Indian cities, sanitation and the state: the politics of the failure to provide. *Environment and Urbanization*, *23*(1), 57–70.

Chitradurga Srinivasa Murthy, S. P., & Ray, I. (2019). When the pits fill up: (In)visible flows of waste in urban India. *Journal of Water, Sanitation and Hygiene for Development*. https://doi.org/10.2166/washdev.2019.153

CPCB. (n.d.-a). *Use based Classification of Surface Waters in India*. Retrieved November 15, 2020, from https://cpcb.nic.in/water-quality-criteria-2/?&page_id=water-quality-criteria-2

CPCB. (n.d.-b). *Wastewater discharge standards*. Retrieved November 15, 2020, from https://cpcb.nic.in/wqstandards/

CPHEEO. (n.d.). *CHAPTER 7: RECYCLING AND REUSE OF SEWAGE*. Retrieved November 15, 2020, from http://cpheeo.gov.in/upload/uploadfiles/files/engineering_chapter7.pdf

Dasgupta, S., Agarwal, N., & Mukherjee, A. (2019). *Unearthed - Facts of On-Site Sanitation in Urban India*.

Dul, J., & Hak, T. (2007). *Case study methodology in business research*. Routledge.

Eawag-Sandec. (2018). *Citywide inclusive sanitation*. https://www.eawag.ch/en/department/sandec/projects/sesp/citywide-inclusive-sanitation-cwis/

Ebneyamini, S., & Sadeghi M., M. R. (2018). Toward developing a framework for conducting case study research. *International Journal of Qualitative Methods*, *17*(1), 1609406918817954.

Ghosh, S. K. (2016). Swachhaa Bharat Mission (SBM) – A Paradigm Shift in Waste Management and Cleanliness in India. *Procedia Environmental Sciences*, *35*, 15–27. https://doi.org/10.1016/j.proenv.2016.07.002

Hawkins, P., Blackett, I., & Heymans, C. (2013). *Poor-inclusive urban sanitation: An overview*.

IWA. (2014). *Sanitation 21: A Planning Framework for Improving City-wide Sanitation Services*.

Jamwal, P., Lele, S., & Menon, M. (2016). *Rethinking water quality standards in the context of urban rivers*.

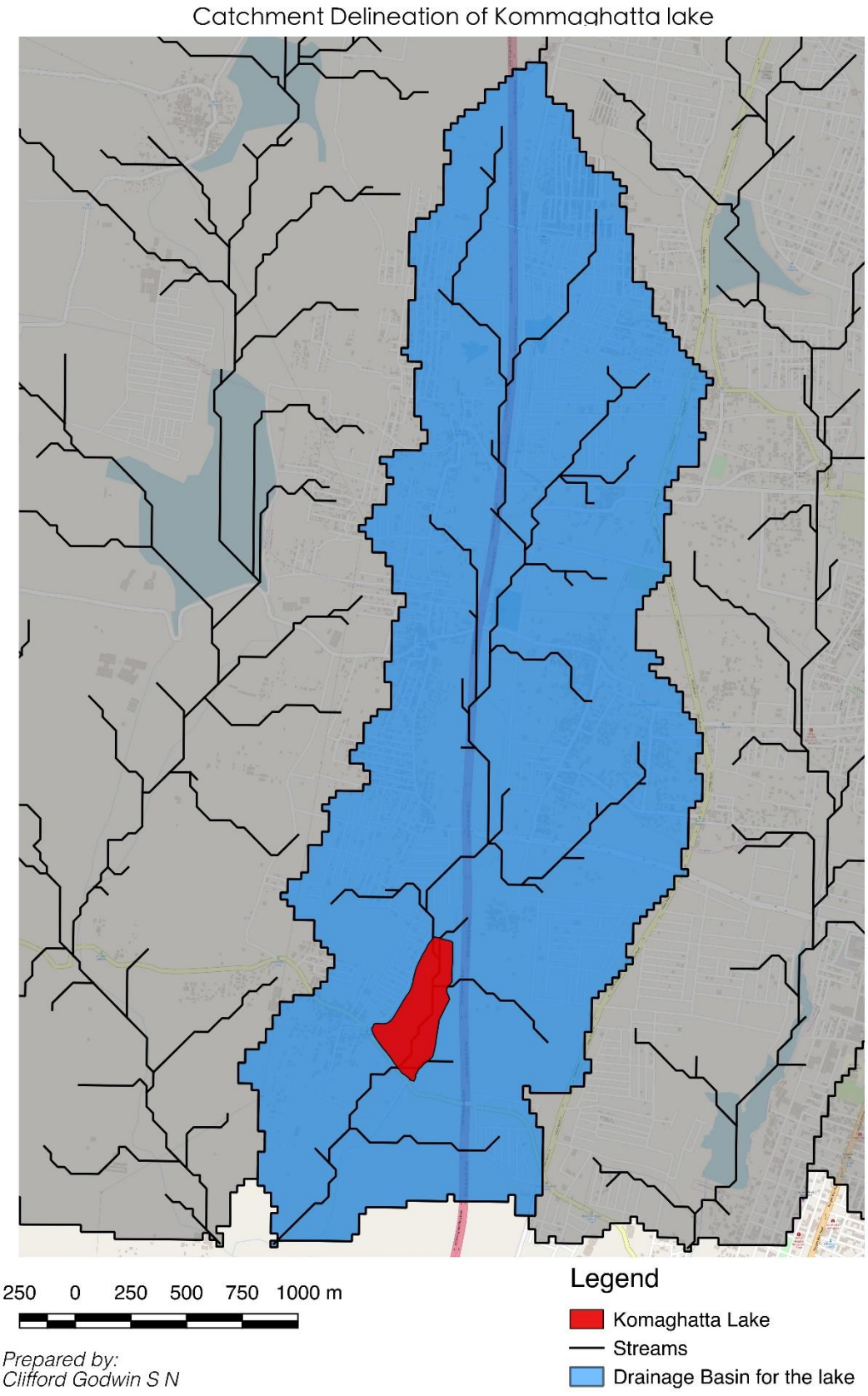
JMP. (2017). *Household*. https://washdata.org/data/household#!/table?geo0=country&geo1=IND

Kankal, N. C., Indurkar, M. M., Gudadhe, S. K., & Wate, S. R. (2012). *Water Quality Index of*

Surface Water Bodies of Gujarat , India. *440020*(1), 39–48.
Klinger, M., Ulrich, L., Wolf, A. T., Reynaud, N., Philip, L., & Luethi, C. (2019). *Technology, implementation and operation of small-scale sanitation in India. Performance analysis and policy recommendations. Small-scale sanitation scaling-up (4S) - project report vol. I*.
Konteh, F. H. (2009). Urban sanitation and health in the developing world: reminiscing the nineteenth century industrial nations. *Health & Place*, *15*(1), 69–78.
McQuaig, S. M., Scott, T. M., Harwood, V. J., Farrah, S. R., & Lukasik, J. O. (2006). Detection of human-derived fecal pollution in environmental waters by use of a PCR-based human polyomavirus assay. *Applied and Environmental Microbiology*, *72*(12), 7567–7574.
Narayan, A S, Fischer, M., & Lüthi, C. (2020). Social Network Analysis for Water, Sanitation, and Hygiene (WASH): Application in Governance of Decentralized Wastewater Treatment in India Using a Novel Validation Methodology. *Frontiers in Environmental Science*, *7*, 198.
Narayan, A S, & Lüthi, C. (2019a). *Citywide Inclusive Sanitation and SDG 6*.
Narayan, A S, & Lüthi, C. (2019b). *Citywide Inclusive Sanitation : Old Wine in New Bottle ?*
Narayan, Abishek S. (2020). *Solving urban sanitation – sustainably and equitably Citywide Inclusive Sanitation (CWIS) is gaining traction as an integrated approach that can*. *August*, 18–21.
Narayanan, N., Ray, I., Gopakumar, G., & Argade, P. (2017). Towards sustainable urban sanitation: A capacity-building approach to wastewater mapping for small towns in India. *Journal of Water Sanitation and Hygiene for Development*, *8*, washdev2017071. https://doi.org/10.2166/washdev.2017.071
Naughton, C., & Mihelicic, J. (2018). *Introduction to the Importance of Sanitation*. https://doi.org/10.14321/waterpathogens.1
NITI Aayog, I. (2019). *Composite Water Resources Management: Performance of States*. https://niti.gov.in/sites/default/files/2019-06/Final Report of the Research Study on Composite Water Resources Management Index for Indian States conducted by Dalberg Global Development Advisors Pvt. Ltd_New Delhi.pdf
Osuhor, P. C., & Essien, E. S. (1978). Urbanisation and its effects on environmental sanitation. *Public Health*, *92*(2), 69–75. https://doi.org/10.1016/S0033-3506(78)80031-6
Peal, A., Evans, B., Ahilan, S., Ban, R., Blackett, I., Hawkins, P., Schoebitz, L., Scott, R., Sleigh, A., Strande, L., & others. (2020). *Estimating safely managed sanitation in urban areas; lessons learned from a global implementation of excreta-flow diagrams*.
Peal, A., Evans, B., Blackett, I., Hawkins, P., & Heymans, C. (2014). Fecal sludge management (FSM): Analytical tools for assessing FSM in cities. *Journal of Water, Sanitation and Hygiene for Development*, *4*, 371. https://doi.org/10.2166/washdev.2014.139
Ramachandra, T. V, Aithal, B. H., B, A., & G, S. (2015). Environmental auditing of bangalore wetlands. *ENVIS Technical Report 72*, *January*.
Ramachandra, T. V, Aithal, B. H., S, V., & Lone, A. A. (2013). *Conservation of Bellandur Wetlands: Obligation of Decision Makers to Ensure Intergenerational Equity*.
Reymond, P., Chandragiri, R., & Ulrich, L. (2020). Governance Arrangements for the Scaling Up of Small-Scale Wastewater Treatment and Reuse Systems – Lessons From India. *Frontiers in Environmental Science*, *8*, 72. https://doi.org/10.3389/fenvs.2020.00072
Sahasranaman, M., & Ganguly, A. (2018). *Wastewater Treatment for Water Security in India*.

SBM. (2019). *Household toilets*. https://sbm.gov.in/sbmReport/home.aspx
Schellenberg, T., Subramanian, V., Ganeshan, G., Tompkins, D., & Pradeep, R. (2020). Wastewater discharge standards in the evolving context of urban sustainability--The case of India. *Frontiers in Environmental Science*, *8*, 30.
Schrecongost, A., Pedi, D., Rosenboom, J. W., Shrestha, R., & Ban, R. (2020). Citywide Inclusive Sanitation: A Public Service Approach for Reaching the Urban Sanitation SDGs. *Frontiers in Environmental Science*, *8*(February), 1–8. https://doi.org/10.3389/fenvs.2020.00019
Sheeba, G., Jalagam, A., & Venkatasubramanian, P. (2017). Drinking water contamination from peri-urban Bengaluru, India. *CURRENT SCIENCE*, *113*(9), 1702.
Strande, L., Ronteltap, M., & Brdjanovic, D. (2014). *Faecal Sludge Management: System Approach for Implementation and Operation*.
Sushmita, S., Aparna, P., & Subhojit, G. (2017). *Bellandur Lake: a story of toxic froth and fire*. DownToEarth. https://www.downtoearth.org.in/coverage/environment/bellandur-lake-a-story-of-toxic-froth-and-fire-57139
UNESCO. (2017). World Water Development Report (WWDR). *Wastewater: The Untapped Resource*.
UNHABITAT. (2016). *World Cities Report 2016*. https://doi.org/https://doi.org/https://doi.org/10.18356/d201a997-en
UNP-Fund. (2007). UNFPA state of world population: unleashing the potential of urban growth. *United Nations Population Fund*, *2007*, 12–19.
Ventana Systems. (n.d.). *Vensim*. Retrieved November 14, 2020, from https://vensim.com/free-download/
Wankhade, K. (2015). Urban sanitation in India: key shifts in the national policy frame. *Environment and Urbanization*, *27*(2), 555–572.
WHO. (2019). *Sanitation factsheet*. https://www.who.int/news-room/fact-sheets/detail/sanitation

Appendix I: Catchment of Kommaghatta lake



Appendix II: Parameters tested and their method

Sn.no	Parameter	Analysis method	On-site (Yes/No)
1	Ammonia	Merck test kit	No
2	BOD	Oxitop	No
3	Cadmium	Merck test kit	No
4	Calcium	Merck test kit	No
5	Chloride	Merck test kit	No
7	Chromate	Merck test kit	No
8	COD	Closed reflex method	No
9	Copper	Merck test kit	No
10	Alkalinity	Merck test kit	No
11	Dissolved Oxygen	DO probe	Yes
12	Electrical Conductivity	EC Probe	Yes
13	Fixed Solids	APHA method	No
14	Fluoride	Merck test kit	No
15	Iron	Merck test kit	No
16	Lead	Merck test kit	No
17	Magnesium	Merck test kit	No
18	Manganese	Merck test kit	No
19	Nickel	Merck test kit	No
20	Nitrate	Merck test kit	No
22	pH	Ph probe	Yes
23	Phosphate	Merck test kit	No
24	Potassium	Merck test kit	No
25	Settleable Solids	APHA	No
26	Sodium	Merck test kit	No
27	Sulfate	Merck test kit	No
28	Temp.	Ph probe	Yes
30	Total Dissolved Solids	APHA	No
31	Total Hardness	Merck test kit	No
32	Total kjeldahl nitrogen	Kjeldahl method, APHA	No
33	Total Nitrogen	Merck test kit	No
34	Total Phosphorus	Merck test kit	No
35	Total Solids	APHA	No
36	Total Suspended Solids	APHA	No
37	Turbidity	Turbidity meter	Yes
38	Volatile Solids	APHA	No
39	Zinc	Merck test kit	No
40	E. Coli	APHA	No
41	Faecal coliform	APHA	No
42	Total coliform	APHA	No

Appendix III: Sample collection form

Surface Water

Environmental Sample Collection Form

Sample ID

Collection Date

__ __ / __ __ / __ __

DAY MONTH YEAR

Collection Time

__ __ : __ __ ___

HOUR MINUTE AM/PM

Location

☐ Main inlet

☐ Secondary inlet: North-East Stormwater drain

Weather Condition (select one) yesterday?

☐ Sunny ☐ Cloudy

☐ Raining

Did it rain in this neighborhood

☐ Yes

☐ No

Enumerator Name

Notes

On-site parameters:

Dissolved Oxygen -

Electrical Conductivity -

Ph -

Temperature -

Turbidity -

Did you take a photo?

☐ Yes

☐ No

Appendix IV: Results of the Composite sample

Sn.no	Parameter	Stormwater inlet	Main inlet	Unit
1	Ammonia as NH_3-N	9.4	13.5	mg/l
2	Biochemical Oxygen Demand – 27 ° C, 3 days	63	90	mg/l
3	Cadmium	0.04	0.06	mg/l
4	Calcium	120.2	140.3	mg/l
5	Chloride	181.2	228.9	mg/l
7	Chromate	<0.01	<0.01	mg/l
8	Chemical Oxygen Demand	122.4	204	mg/l
9	Copper	<0.05	<0.05	mg/l
10	Total Alkalinity as $CaCO_3$	565.5	646.4	mg/l
11	Dissolved Oxygen @ 25 Degree Celsius	4.1	4.1	mg/l
12	Electrical Conductivity @ 25 Degree Celsius	1438	1678	µmhos/cm
13	Fixed Solids	688	764	mg/l
14	Fluoride	0.5	0.1	mg/l
15	Iron	0.3	1	mg/l
16	Lead	0.07	0.13	mg/l
17	Magnesium	53.5	68.1	mg/l
18	Manganese	<0.1	<0.1	mg/l
19	Nickel	<0.01	<0.01	mg/l
20	Nitrates as NO_3	<0.1	<0.1	mg/l
22	pH @ 26 Deg C	7.5	7.1	-
23	Phosphates as PO_4	6.7	8.4	mg/l
24	Potassium	26.3	28.6	mg/l
25	Settleable Solids	<1.0	2	ml/L
26	Sodium	130.4	141.9	mg/l
27	Sulfates as SO_4	34.4	40.8	mg/l
28	Total Dissolved Solids	1456	1040	mg/l
29	Total Hardness as $CaCO_3$	520	630	mg/l
30	Total Kjeldahl Nitrogen as N	16.2	25.1	mg/l
31	Total Nitrogen	16.2	25.1	mg/l
32	Total Phosphorus	2.2	2.7	mg/l
33	Total Solids	1492	1232	mg/l
34	Total Suspended Solids	36	192	mg/l
35	Turbidity	13.8	45	NTU
36	Volatile Solids	242	532	mg/l
37	Zinc	0.19	0.23	mg/l
38	E. Coli	present	present	-
39	Faecal coliform	3500	5400	/100ml
40	Total coliform	16100	9200	/100ml

Appendix V: Results of the grab sample analysis

Sn.no	Parameter	Stormwater inlet @ 8AM	Main inlet @ 8AM	SMV layout stormwater	Overflowing manhole	Unit
1	Colour	Grey	Light grey	Dark grey	Dark grey	-
2	pH	7.5	7.7	7.7	7.4	-
3	Dissolved Oxygen	8.6	0.5	6.0	1.2	mg/L
4	Electrical conductivity	1.4	1.8	1.7	1.8	mS/cm
5	Temperature	26	25.6	25.7	25.9	Deg C
7	Turbidity	37.7	137	145	141	NTU
8	Total suspended solids	71	195	214	296	mg/L
9	Total dissolved solids	1130	1480	1360	1570	mg/L
10	Phosphates as PO_4^{3-}	54.6	12.9	9.4	36.0	mg/L
11	Phosphates as PO_4-P	17.8	4.2	3.1	11.7	mg/L
12	Ammonium as NH_4^+	51.6	48.8	37.3	42.4	mg/L
13	Ammonium as NH_4-N	40.2	37.9	29.0	33.0	mg/L
14	Nitrates as NO_3^-	2.2	3.4	2.5	3.0	mg/L
15	Nitrates as NO_3-N	0.5	0.8	0.6	0.7	mg/L
16	Chemical Oxygen Demand	209	335	357	489	mg/L
17	Biochemical Oxygen demand	115	170	170	260	mg/L
18	Faecal Coliform	24,000	8,500	16,000	10,000	MPN/100ml
19	Escherichia Coli	28,000	11,000	43,000	28,000	MPN/100ml

Appendix VI: Sample Interview guide

Name of interviewee	Date	Time	Reference code	Recorded?
				Y/N

Section: Introduction and consent		**Timing:** less than 5 minutes
		Done
Welcome and thank you	Personal introduction to the interviewee, and thank him/her for participating in the interview.	
Consent	Hand the project information sheet and obtain verbal consent from the interviewee. Wait until they read it or read it out to them if required. Confirm that the interviewee is happy that the conversation is being recorded[1].	
Introduction to the project	I am working on my graduation project for the completion of Master in Water Management at Delft University of Technology, Netherlands. One of the objectives of the project is to understand the decision making with respect to urban waterbodies in Bengaluru.	
Context	For the purpose of this project, key persons involved in the decision making related to urban water body health are being interviewed.	
Their details	Ask the interviewee's details – name, institution, experience, etc.	

Section: Urban waterbodies health and good indicators			**Timing:** 15 minutes	
Topic	Sought outcomes	Example prompt questions	Prompt examples	Done
Urban waterbodies	To understand the participant's view on the importance of waterbodies	What roles do lakes play in the city of Bengaluru? Are these roles valued by the respective stakeholders? Do they take it into account during decision-making?	Minimize Urban heat island effect, Biodiversity, recreation, fishes, ect.	
Perception of a healthy waterbody	To see how the participant perceives a healthy lake and elicit good indicators what responsibility they hold towards it.	how do you judge the health of lakes in Bengaluru? How can you (agency/actor/institution) play a role in contributing to improving this situation? So, in your opinion, what are some aspects/indicators of a healthy lake?	Polluted, encroached, loss of flora and fauna Aesthetic, clear, No smell No water hyacinth	

[1] If the interviewee does not wish to be recorded, it will be necessary to take notes of the conversation. This inevitably will slow the discussion and probably reduce the amount of information that can be collected. Explain to the interviewee that there may be gaps in the conversation while you make notes.

Section: Urban waterbodies health and good indicators			**Timing:** 15 minutes	
Topic	Sought outcomes	Example prompt questions	Prompt examples	Done
Linking to parameters	To see if the participant links preferred explanation of healthy lake to water quality parameters	Do you think that these aspects can be linked to water quality parameters? How so? Some examples?	Nutrients, Dissolved oxygen	

Section: Wastewater and system levers		**Timing:** 10 minutes		
Topic	Sought outcomes	Example prompt questions	Prompt examples	Done
Wastewater management in Bengaluru	To get into the subject of sewage and hear the participant's view on the current wastewater management situation in Bengaluru. To see if the participant automatically links the current situation to declining urban waterbody health	How would you describe the wastewater management in the city of Bengaluru? Does managing wastewater have an influence on waterbodies in Bengaluru? If so, what are the impacts?	Public health issues, water stress	
System levers	To understand the participant's view on why the red outfalls, exist. (Present the SFD and explain to the participant) Perform why analysis. (If possible, draw a cognitive map based on the answers, to bring everything into perspective)	What do you think happens to the red stream of wastewater in the shit flow diagram? What in your opinion, is the reason for these red outfalls? What needs to be fixed? Is it easy to do that? What are some of the challenges?	Groundwater, surface water lakes Policy, informal arrangements, financing, regulation, lack of maintenance, lack of infrastructure	
Revisiting urban waterbody heath indicators	To elicit further indicators after the discussion on sewage and where it ends up	would you like to add any further indicators for urban waterbody health?		

Appendix VII: Interview transcripts

Reference code	Recorded?
ESI-01	Y

Q: What is your expertise?

A: It is much more on groundwater, lakes. My background is on socio-hydrology and hydrologic modelling

Q: What is the role of ATREE in lake related activities in Bengaluru?

A: ATREE is a knowledge provider/broker and we generate and synthesize knowledge for decision makers

Q: And who are these decision makers?

A: I have been primarily working with citizen groups and using them as lobbyists rather than working directly with the government. We generally work with the “issue-public”, people who are seriously engaged in the space of lakes.

Q: What are the roles that lakes play in the city of Bengaluru?

A: They are aesthetic and recreational; they recharge the groundwater; Act as buffers for flooding. Not so much now as they are receiving sewage presently, but in the traditional sense when the lakes were emptied by the end of the monsoon and they filled up rainwater. Apart from that, they act as haven in concrete jungle and aid in biodiversity. Finally, they also benefit livelihoods for different classes of people in the city.

Q: You had mentioned several roles that lakes play in the city of Bengaluru. How are these roles valued by different stakeholders?

A: I feel there is a segmentation across the different stakeholders. Even within Bengaluru, what you will see is that the upper class immigrants tend to value the aesthetic and recreational aspects so that they can practice yoga or birdwatching in the lake. Whereas the poorer classes rely on the lake for direct uses such as cloth washing, not so much on the drinking anymore since the quality of the water is poor. Finally, there are the old ‘traditional’ villagers in the peri-urban regions who still rely on lakes for farming and fishing contracts. The old poor and new poor who have different types resource dependencies on the lake. The urban upper middleclass prefers it for aesthetics and recreational reasons. A lot of them talk about lakes being important for groundwater recharge and that's part of the rhetoric, but I don't know to what extent people internalize that.

Q: Have you studies the groundwater aquifers in Bengaluru to understand their interaction with lake systems?

Several studies have been done, notably by aquadam and Biome for kaikundanahalli lake and its observed to be quite complex. The reason being, the groundwater level is quite shallow due to leaking of the cauvery pipelines. It is barely, 15 feet below the ground in my area (sadhashiv nagar). So you see quite the opposite in this case, where the groundwater is recharging the lake but on the other hand, there isn't much groundwater dependence here because the urban areas are pipe-water rich. While in peri-urban areas, there is anecdotal evidences and formal that lakes do recharge groundwater. In eastern Bengaluru, a mix of the two is observed where there is a shallow aquifer and a saprolite layer underneath such that the groundwater contributes to the lake while the deeper aquifers are still depleted.

Q: What is the present state of lakes in the city of Bengaluru?
A: It is a mix of lakes receiving completely untreated sewage and very few lakes which receives purely rainwater. This is because, lakes receive water from storm water drains and they carry sewage with them as the city is not fully sewered.

1. Lakes with raw sewage
2. Lakes with diversion drains: Built with a step, such that only when there is a huge surge of storm water that it inters into the lake. Other times it will be bypass the lake (Dry flow). Sometimes the step is very high that it will only receive inflow if there is an extreme event such as 100 mm rainfall. So the lake is predominantly dry during the year
3. Lakes with STP at the mouth of the lake: Jakkur
   They receive treated wastewater but they are seen to be with high nutrient since they are not tertiary treated. So algal bloom and other processes are still seen to be observed.

Q: What are the criteria to evaluate that the lake is clean or of good quality?

A: Priyanka Jamwal is currently working on estimating Lake health index for the lakes in Bengaluru using what different people want from the lake. Defining the LHI relative to what peoples vision for the lake is. Largely, it should be avoiding fish kill – Dissolved oxygen above an acceptable level.
As an expert, we shouldn't talk about lake health separately: we need to ask the citizens as to what they want from the lake.
If you ask me what the citizens want, there is a variable between people saying, "we don't want the lake to be a stinking mess" to "we want the lake to be swimmable or of drinking water quality"

I think swimmable is a reasonable goal, but I don't think we are anywhere near that.

Q: Do you think these can be linked to water quality parameters ? If so, what are some examples?

A: Swimming has its own WQ parameters.
For keeping the fishes alive, DO and ammonia levels are important.

But we don't have a good sense of is: what nutrient level in the lake should such that they sustain the WQ parameters mentioned above. I don't think we really understand enough about these lakes to answer this question.

Q: In your experience, were these WQ parameters important for decision makers for lake rejuvenation projects?

A: I don't know If the decisionmakers are thinking in terms of WQ parameters for these projects. Because the problem is there are multiple stakeholders involved (BBMP, BWSSB, KSPCB and fisheries) and all of them have different expectations and there is no consistency.

1. There is need for clarity on standards
2. Adequate financing
3. We need better inter-agency co-ordination between the stakeholders

Q: How would you describe the Wastewater management in Bengaluru?

A: Other than its terrible?

1. We don't have enough sewage treatment capacity
2. There is not enough sewerage network built; last-mile connection to STPs are lacking
3. The city is growing faster than the infrastructure.
4. Bengaluru has a zero discharge limit. But if the sewage treatment system breaks down, it lets out untreated sewage.
5. In slums where there is no space for on-site systems, hence they are discharged directly
6. The existing STPs don't perform well due to lack of power, expertise

Q: What then is happening in the 110 villages that are added to BBMP ?

A: They are unsewered. And this is where Feacal sludge management happens. The honeysuckers either carry it to a FSTP or dump it in “Rajkalve” (stormwater drains) – Shraddha prasad’s work.

Q: why are they dumping it in Rajkalve?

A: If you read his work, it’s a case of petty corruption. Where you get paid take the FS out but you don't get paid to deliver it anywhere. So there is no incentive for the truck operators to drive across city and spend a ton of delivering it if you can just bribe the police and dump it in the storm water drain.

Q: Is there a regulation or a guideline to manage this?

A: There might be one. But the problem in India is not the lack of regulation. It’s always the enforcement. There are regulations to dump it in the FSTP but there are not enough treatment plants in Bengaluru. So it's costly for the truck operators to travel long distances

Q: What is the predominant choice of sanitation technology (sewered or unsewered) in Bengaluru?

A: It depends on the area. It doesn't make sense to have on-site systems in urban areas.

Q: What about to the supernant/leechate from the on-site sanitation systems? Do they have to be treated?
A: Priyanka Jamwal has done some empirical work which shows that the aquifers are contaminated.

Q: And do you think that's due to the on-site sanitation systems?

A: That's what her research shows. As a scientist I believe what the data says. If somebody says differently tomorrow, I will change my mind.

Q: The wastewater standards have been changing quite a lot in the recent years, do you have any comment on this?

Well, I think changing the standards doesn't make a difference. I think, the problem is not being able to enforce it.

Q: Why is it not being enforced ?

A: It is tough for many reasons,

1. Lack of financing
2. Corruption
3. There is no cadre of sanitation engineers who are certified to fix the small scale sanitation systems in the apartments. Lack of capacity

Q: Finally what are some criteria for a healthy lake ?

As a scientist I would want to build consensus with the public before establishing the criteria.

As a citizen, my position is that it should be clean, free of solid waste, increased biodiversity and swimmable.

Reference code	Recorded?
ESI-02	Y

Q: What is your PhD on ?

A: My PhD is on what are the qualitative requirements, in terms of water chemistry in order to ensure that different stakeholder, that participate and engage would have their end uses met. And how these water quality targets can help achieve that target over a period of time.

Q: What are the roles that lakes in Bengaluru play in the urban environment?

A: The immediate roles that lakes play depends on what stakeholder group you come from. Aesthetics, a place where you go for nature and go for health purposes, for socializing, the other is the ecological perspective where conservation takes the key role. For example, the conservation of birds and wildlife in general. Third is recharging groundwater, because Bangalore does have a lot of borewells and these lakes do help in that. Fourth would be, in terms of an urban context would be a place where you can store treated wastewater. Partially or completely treated wastewater. Also as a reserve for flooding in order to retain the excess water flow. These are the relevant roles in an urban context. But traditionally, these lakes are tanks, they were used for fisheries and drinking water. Even now it is used for fisheries and harvesting.

Q: How are these roles being valued by the respective stakeholders?

A: That is where things become quite interesting. Firstly, immediate citizen groups value the lake a lot for its recreational value, the health benefits, the conservation opportunities these lakes provide. Also, people who are depended on these lakes for livelihood such as fishermen, people who harvest fodder in peri urban areas. Institutes views the lake more from an aesthetic point of view. They manages the lakes in a manner that they are visually appealing, there is no foul smell or things that are off-putting. Other benefits are not being looked into as much one would hope.

Q: Why do they want it to look good and not off-putting ?

A: Again, it's partly by what people want because visual ques, olfactory ques , these are very strong. It can immediately trigger and emotional response. Also, it is easier to fix these problems, for example if there is solid waste dumped in the lake, the easiest way to fix it is to remove it. Similarly if a lot of sewage is entering the lake through the storm water drain, you just construct a diversion channel or you block the drain. And the lake gets better. But these are short fixes, they don't address the complex problem that these lakes have.

Q: How do you judge the health of lakes in Bengaluru?

A: So, I think it is a combination of lot of things. Generally speaking, when one says health, it is not a single matrix or parameter. It's a combination of many things. For example, from a lake perspective, for me, if there are a lot of bird, DIVERSE birds,

there is a lot of diverse plants in the lake, like not along the side where it is beautified or gardens have been made. That the lake water is clean that you can see upto a certain depth. That there are a number of diverse fishes, multiples uses are derived from the lake. It could be economic uses like fishing, recreational uses like visting the lake for its clean ambience. Using it for religious purposes such as idol immersion. Using it as groundwater recharge structure, using it to hold secondary treated water for uses.

Q: How much of these uses are being realized in Bengaluru?

A: Apart from the secondary uses of the water, almost all of them are getting fulfilled. Although I would like to point out that the plant diversity in the lakes or whether the water is clear or not are not being fulfilled. Plants that are found at the junction of land and water and inside the lake is important than landscaping.

Q: Why is that important?

A: What I mentioned earlier are for the health of the lake in the human uses perspective but having a lot of plants is important for the ecological health of the lake. If you look at the food pyramid of the lake, plants are at the bottom. They sort of the buildup the system. So if there is diversity in the plants, it shows that it can support a diverse group of organisms. That ensure that the lakes are sustainable for a much longer time. Sustainable in the sense, their ability to absorb shocks during sudden pollution. Ability to conserve birds and desired species.

Q: How important is this aspect for the decisionmakers in the city?

A: It is, I see that citizen groups are realizing the importance of ecological diversity. I think that is also translating in for the institutional stakeholders, but I'm not sure how it is translating in terms of policy and ground implementation. There are small individual steps but that doesn't mean it is transcending across the city. It seems a little haphazard because different lake groups are not communicating with each other. You can't be in your own silos, but you have to reach across the table and have a conversations.

Q: what role do citizen groups play in the city?

A: They play a significant role, they ensure that the decision making is sort of driven from bottom up, they help and voice the problems of the lakes that they choose to represent. They engage the different administrative units that we need all need to sit down together if we want to protect, improve or rejuvenate the lakes. They are the point where sort of they get every other agency which has the power to do things and represent people's voices saying what they want from the lakes they represent as opposed to the top-down approach where unified sense is applied across all the lakes.

Q: What drives the citizen groups?

A: It is a combination of few factors, there is an emotional nostalgia to these lakes. So older generations who have stayed in Bengaluru before it became the cosmopolitan that it is. They saw have a nostalgia as to this is how the lake was before, beautiful

and now, they see that it is going away. So they get emotional. This is one group of people who have grown up with these lakes.

The second thing is that, the incoming migrants are establishing links with these lakes. They feel that they should do something, that we can improve the situation. There seems to be general consensus that this is not what we want from the lakes or that the lake is bad. So let’s try to change things for the better. But the problem starts arising when we have to agree then what is the vision for the lakes.

Q: What are the sources of the lakes in Bengaluru?

A: They were designed to be rainwater harvesting structures and they are connected to storm water drains\ Rajkalvus. Earlier they were recieveing rainwater and the lakes were in a cascading system. Right now, a significant source of water is the partially treated or the untreated wastewater that they receive throughout the year, along with the rainfall that they receive during the monsoons.

Q: What is the impact of such a situation?

A: One is that these lakes were never designed to be treatment units themselves. They have a certain capacity to assimilate and treat certain amount of pollution, but not to the extent that they are receiving now, both the quantity and the quality of it. They are now getting polluted with excessive nutrient load, they are getting eutrophication due to excessive algae growth and also they are receiving the new age chemical like pesticides, pharmaceuticals and personal care products which doesn't breakdown naturally. It is showing that these are inhibitors of different enzymes which then have subsequent cascading negative impacts.

Q: Why are the pollutants coming into the lake?

A: It should be managed at the production source, consumer level and at the STP level.
There are industrial discharge standards available by the CPCB and ideally supposed to be adhered at all industrial units. But these standards are old and they look at classical pollutants and they do not account the emergent pollutants that are coming out like the synthetic pollutants.

Q: What is the reason for inflow of sewage into the lakes?

A: One thing is that there is an infrastructural problem. The core city area has sewer lines, however these sewer lines are old and built during the British era. So, they are not designed for the volume that is generated right now. Also, they are not repaired for the longest time, so there is a lot of seepage loss that is happening. So seeping is reaching in groundwater or in lakes. A lot of places have noticed that there is increase in groundwater levels which is also the area which has the oldest sewer lines. It is an informed assumption that these pipes are recharging the groundwater which leads to other complications that need to be considered.

There are parts of the city which doesn't have sewer. They have either soak pits or septic tanks or they have connected their sewer outlets to stormwater drains which

takes it into the lakes. In some cases, the water is collected from the SWD and diverted to STPs but the STPs are not designed to handle the load and to constantly run throughout the time. A lot of times, the STPs are not run 24/7 which is how it is designed to be. So when it stops, then the water is not treated and they divert the untreated water directly into the lake or the SWD.

Q: What is the problem with the on-site sanitation systems ? why are they contributing to the sewage inflow into the lake?

A: It is fine to use soakpits and septic tanks as long as they are built properly and managed properly. Following the engineering design. Accounting for the people in the household. But it comes with space constraints, so how does one navigate through that. Another reason is, once they are emptied, you need to dispose the sludge properly, but that is not being done properly and it is being dumped into the lake or into a drain that goes into a lake.

Q: Why are not running as per their design?

A: One is that there is no constant source of power. There are also an issue that the STP might be designed for a certain capacity without accounting for the growth in the next 10 years or 20 years. So it is an engineering problem, the other is the kind of waste the STPs receive from the storm water drains with solid waste, domestic and industrial effluent. STPs are ideally designed for domestic black and greywater. The solid waste hampers the segregation of waste from the wastewater. There are other local factors such as they don't want to over use the equipment because it will breakdown faster.

Q: Why is the sludge being dumped in to the lake? Isn’t there a law to regulate this?

A: So there are laws for treating the sludge but I think there is an implementation problem that is not allowing this. A lot of times, these tankers that clean out these soak pits and septic tanks are an informal organization. So they are not particular to anyone.
For them it is just like getting it done as quickly as possible. Some are licensed by the government who are supposed to clear out the tank and treat it. But I’m sure how many exists and how the government monitors them.
Also the apartments have treatment units and they partially treat it and dispose it directly into the nearest drain that they have access to.

Q: What about the supernatant from the on-site sanitation systems?

A: I think it should be a combination of both. Depending on how much waste is generated and the projected waste that will be generated in an area, we have certain decentralized units and have larger units.

Q: What would be the implications of adding the 110 villages to BBMP then?

A: It is hard to say right now, but one can say from experiences that there is a potential opportunity for decentralized wastewater treatment. But there needs to be a clear defined structure for it, who is accountable for what because that is the problem

with decentralized approaches. Everybody likes saying it, but at the end of the day every stakeholders have to own up to what they are responsible and accountable for. I would like to see such decentralized systems to be effective, efficient and see it turn around the situation but going by past, I would cautious.

It can be a positive way of approaching for the lakes, ultimately it will be a consortium between different entities, different local stakeholder, government agencies. It has to be a new normal. Lot of the lake rejuvenations and use is derived from this idea that lakes are these pristine natural places. While they are being naturalized, I would take caution in saying lakes have to natural waterbodies and they should only be used for conservation purposes or aesthetic purposes. Because they are in an urban context, we have to look at it in an adaptive way. As we adapt in an urban environment, these lakes also need to adapt. We need to accept that and say, this is the new normal, this is what that's gonna work and make it a democratic process such that we don't exclude or disadvantage people.

Q: What are some of the influences for the new normal?

A: More public awareness, public demanding for that. That will definitely give a political push. The other would be that the people involved in decision making to understand that the old notion of working in silos won't work anymore, we need to integrate. And we need not have to adopt all forms of technologies tested in other countries but we need to be engineerative in how we tackle the problem. It is not just accepting another solution, but it is about finding ways to address the problem. We can be tradition but still be creative Vs just accepting a solution and going for it without actually seeing if it is relevant for the context.

Q: Some criteria for a healthy lake?

A: This is very challenging to achieve, I do not see it happening in the immediate future, but in the intermittent or long term future it should be kept that. If not throughout the year, but at least during certain parts of the year that the lake water has a high clarity or high transparency. I would say, having a diverse seasonal group of plants (dynamic). But it has an underlying assumption that the lakes have a certain amount of water in it. One important thing to note is that, the lake can be still be useful even if it doesn't have water. That is a very challenging notion because when we say a lake, we immediately imagine water. This is something that needs be discussed in a public platform that the lake should always have water or can it dry up at certain seasons and still be useful for us.

Q :Links to the criteria you mentioned and the wastewater?

The pollution load that enters the lake, the more the lake’s water quality and its plant and bird diversity is going to be impacted. So there is a very strong link to that. But I do think that we can treat the water to a certain degree and then let the rest be done by the lake. Because waste is a relative term. What is waste for me could be value for someone else. Waste in the right amount and the type and quantity can definitely be beneficial.

Q: If you were to rejuvenate a lake, what would these indicators mean to you?

A: If I was a decision-maker, these indicators would let me see how the progress is going. But in terms of aspects, I would first and foremost engage with the stakeholders and ask them what is it you want from the lakes? Also, talking about a single lake is a good way to start but not a good way to rejuvenate because what happens upstream has consequences on the lake. Try to find a common ground where everyone benefits from it, if not entirely because, ultimately we are trying to maximize the benefits for everyone in a democracy. Then work out the indicators for their needs. I think plant diversity and water clarity are definitely reliable indicators. They might not be immediate indicators, but they are intermittent indicators.

Q : Is this being practiced in Bengaluru?

It is starting, but definitely, not as open a public discussion as one would want. Because I feel still it is a combination that people feel, I elected you, I'm talking about the perception of people on government institutes. You are supposed to manage this and fix this, which in a way is not wrong. They have been elected to ensure things run smoothly, but, because they relinquish their decision making and suddenly they are taken aback when decisions are made which are contradictory to what they would have wanted. Now, it's like a top down thing where they say this is what we have decided, we know what's best for you, even though it might not be in the best interest. So I think it's a combination of government feeling we decide what's the best for you and people also not engaging as they should or need to.

Q: How is the current decision making process with respect to lakes?

A: For government institutes, it is driven from a more civil engineering background. And again, if there is solid and if you remove it, the place looks better already. So it's a lot of quick fixes and engineer which are done which do doubt makes the place look better in certain way but it need not fulfill a multitude of purposes.

Reference code	Recorded?
ESI-03	**Y**

Q: Role of lakes in Bengaluru?

A: Some are natural lake and most of them are manmade lakes created for water supply and flood mitigation. Only through them the recharge of ground water is achieved. After exploiting the groundwater and surface water was polluted, the water was brought from far away and once the need was fulfilled the did not care about the waterbodies. The roles have changed because of that. Now it is a place to dispose sewage or wastewater. Slowly people started realizing the old situation and to see if can be brought back to the previous condition. Recently means last 10 or 15 years before.
People wanted clean water into the lake, they didn't want to have sewage. So what they did is, we should not allow sewage by laying interceptor lines and diverting it downstream. Almost 60 % covered with underground drainage but still we can see storm-water carrying sewage. So this scenario, they said that, once we have 95% coverage there won't be any sewage and that is how we will solve sewage mixing. That is what their previous thought.

Due to insufficient rainfall, the lakes got dry. So BBMP and people realized that if you want to fill the lakes, the only source is sewage. Due to global warming and climate change, the rain is also not coming in the right time expected and gets shifted. So only option is to treat the wastewater to the maximum extent and fill the lakes. That is how the rejuvenation of the lakes have started.

Q: Role of people?
Bengaluru is a special city. Where you see a lot of lake activities who conserve the lake. They are considered the biggest stakeholder for BBMP in Bengaluru now. They want the groundwater to be recharged and there are unique for many migratory birds to visit because of the good weather around the lakes. They also want good greenery around the lake. Lot of greenery is lost recently due to city development. Where there is water, you can develop greenery and where there is greenery, birds will come. People show lot of interest in naturalism and biodiversity. People also have seen if the lake is full, there is a good yield of their borewell.

Q: Why does wastewater enter lakes?
There is a limit to the coverage of the UGD (60-70%) the remaining lies in the city and mostly at the periphery of the city. On-site sanitations like septic tanks are adopted where the overflow of the systems comes and joins the stormwater drain. Or people create septic tanks only for black water and grey water is let into the SWD. So this can come from the upstream areas even though the downstream areas are covered with UGD.

If it is a first grade city, they need to connect their wastewater to UGD. The onsite sanitations needs to be constructed with CPEEHO guidelines of 48 hours of

retention time. Where the solids are trapped and the overflow is sent to the soak pit and not the storm water drain.

What about the sludge?
Usually the practice is, if it is a properly constructed septic tank, with the bottom of septic tank being layered then it might take 6 months to 2 years for the solids to filled up. The retention time is reduced if it is not desludged by this time. So the solids will escape the tank and reach the soak pit with foul smell. The desludging trucks/honeysuckers are used to clean and dispose it.

The government has the corporation vehicles but it is not adequate, so there are a lot of private players in this business. They are usually present in the outer periphery of the city. There is a logarithmic exponential growth in the city which nobody predicted 10-15 years before. So earlier plan only covered the core area of the city. The growth and the underground sewer services were not at all matching. It required finance for which funds were not available and also destroying existing infrastructure. So the business is happening in the outskirts of the city.

According to BWSSB, once the septic tank is cleaned, it has to be discharged into the nearest STP but this is not followed for many reasons:

1. Truck people are not willing to travel due to distance
2. STPs are not accepting it because their capacities are limited.
3. Some of the STPs are not working well

There is no regularized monitoring for the disposal of the sludge in the city. Only people know here and there. In Anekal, people say that it is disposed in the STPs, some in the farmlands where it is used as a fertilizer and some is disposed in the waterbodies or nallas. Some illegal disposals like opening a manhole and throwing it into UGD. Those kind of varied answers we got. So there is no regularized way of monitoring so far.

Q: How do you get waterbodies projects?
A: CDD has expertise in wastewater treatment, FSM and solid waste management and these are primary issues with waterbodies now. For pollution abetment, CDD has much expertise and contributed a lot.

Waterbody rejuvenation itself has a bigger approach. Every lake has its own characteristics and it behaves differently. It requires, groundwater recharge, biodiversity improvement, irrigation or water sources to recreation. So there is a wide range of activities involved and CDD has learnt all these things as an approach and not a solution. Starting from understanding the problem and defining a problem statement, to a whole set of rejuvenation approaches like groundwater recharge, solid waste management, wastewater management, biodiversity development and livelihood enhancement.

What people who come to us want is nature based solutions with minimal operation and maintenance which CDD is anchoring. Government programs like smart city programs, the CSR clients who are located near the lakes and citizen activist groups through crowd funding and also BBMP.

Q: What is their main expectations?
If you look at waterbody rejuvenation, it is becoming a fancy term that everyone wants to do. The word is very easily used. CDD values the word. Whenever we are approached for waterbody rejuvenation, we try to understand their need. Their idea might be to create a natural park and they call it waterbody rejuvenation. Some people want sewage/ pollution control. CDD stands in its own approach in understanding what the lake needs and what the client wants. We are in a very good position to make the client understand what the lake needs and what can be executed.

One client came and asked for a treatment facility for one of the lake inlets. It is mainly wastewater treatment but they call it waterbody rejuvenation. When the lake had 3 or 4 inlets and the client was concentrating on just this one inlet. So his purpose might not be fulfilled. He wants to do wastewater treatment for the entire water coming from upstream but he doesn't know the volume and quality of the water coming.

Waterbody rejuvenation approach – CDD Society : check online

Q: Indicators for waterbody health
Vision of CDD is thriving waterbodies.
Clean water, it should have 3-4 mg/l of DO
We want some birds
Should support some livelihoods of the people for harvesting fodder for animals.
They can do some natural fishing in certain areas
It should be a place where they go for recreation.
It should be a waterbody that connects people.

There are hidden uses of groundwater recharge, greenery in urban area and I can keep adding more and more. But we focus on thriving waterbody because, the waterbody should itself have life and be lively.

Reference code	Recorded?
ESI-04	Y

Q: Who was the client. Was it was government project ?

A: It was funded by smart city India ltd. Smart cities in India were focusing more on road development, improving the school and transportation. Only Coimbatore city corporation along with the Coimbatore smart city ltd. has allocated 60-70 million USD for rejuvenation of lakes. It being an industrial city, they lack more green spaces. So it is to link up waterbody with greenspaces and also to have a water security. So restoring the waterbody was one of their ideas for water security.

Q: How about the situation in Bengaluru? What roles do lakes play?

A: Bengaluru lakes are under BBMP today. They have their own department called the lake department which is mostly civil engineers. I still feel there is no hydrologist, no environmental engineer in the team where the focus is more on the civil engineering aspects. Nevertheless, the citizens of Bengaluru, formed local citizen groups, trusts, NGOs, for example Jalposhan, Mphasis for mahadevpura. They are pushing the government to rejuvenate these lakes. In the whole of India, Bangalore is shown as an example how the government and the people can work here. Because there are so many success stories also in Bengaluru.

Q: What is the need for Rejuvenation? What is the current situation of lakes in Bengaluru?

A: If you look at the current situation, Initially there were about 800 lakes in Bengaluru. But today, there are hardly 200 lakes. So 600 have been either encroached legally or illegally by the government and also the private people. So if you look at the current situation of the lakes, they are sewage dump yards where lot of illegal activities are going on. And the major issue is encroachments. Many of the lakes which were around 400 acres are now 200 acres or 100 acres. So it is very sad to see it actually.

Q: How do you judge a health of lake in Bengaluru?

A: When I visit a lake, I see the color of the water, the water quality is quite important. I have to see biodiversity in the lake. Only if they have clean water only then biodiversity will be there. It is a very clear indicator that the lake is a very healthy state. If I see weeds, water hyacinth around the lake. Then I know there is sewage entering in to the lake and action has to be taken. This is a clear indicator.

Q: Does everyone else also feel the same things when they want the lake to be rejuvenated? What do they look for ?

A: Bengaluru lakes are seasonal lakes. They have water in monsoon and winter, in summer they go dry. When they ask for rejuvenation, first of all they want water in the lake. But what Bengaluru has been doing is diverting all the dry weather flows. They have been creating a channel which goes along the boundary. It is called a diversion

channel where all the sewage is diverted to the downstream. So all sewage which has been flowing into the lake has been diverted to the downstream. But with this arranged, they also started diverting the monsoon flows and there is no water in the lake. This is one problem and it has to be rectified. Government started doing this for all the lakes. There is a lot of groundwater issues, it has gone deeper. There are man-made lakes which are potentially used for recharging the groundwater and also a source of water until we got water from Cauvery river 80 km down Bengaluru.

Q: How about the citizens? What do they look for in a lake?

A: Each citizen wants different things, someone wants, paved pathways, park around the lake, wants to do fishing, some amusement park around the lake. But the citizen groups are pushing for ecological rejuvenation of the lake. It is not just for recreation, but for the biodiversity, we create an ecosystem in the lake. They are also educating these people. One example I can give you is, Jakkur lake. It is divided into 2 zones. 1/3rd of the lake is a community zone and 2/3rd of the lake is a conservation zone. Where, the in the community zone you have more ornamental but native plants. So this how, the same model is being replicated all around Bengaluru.

Q: You water quality parameters do you look for in the lake water?

A: Phosphorous, Nitrogen, BOD, COD, dissolved oxygen for the biodiversity to survive. I've seen lakes in Bengaluru that are green in color. Because of the algae content. Until you stop the sewage inflow it is very difficult. What I'm proposing is, to have a wetland in all the inlets so that the nutrients can be trapped in these wetlands and some amount of clean water can go in to the lake.

Q: And in that case, allowing sewage into the lake is okay?

A: But with lower quality. In most of the cities in India, not in Bengaluru, I have seen grey water going into the lake. Black water gets trapped in septic tank. Grey water has a BOD of 120 to 150 or 200. So ideally, a sedimentation pond or a wetland can manage it.

Q: How about the regulations ? is it legal to discharge this water into the lakes in Bengaluru?

A: I have a different thought to it. As per the discharge standards, if you are treating the water, you have to treat it to 20 or 10 BOD. For Nitrogen there is some standard, for phosphorous there is some standards. But nothing is under your control, it all plays with the finances. If you see Jakkur lake, you have a 15 MLD treatment plant for one of the inlets. But the amount of wastewater coming in is around, 20-25 MLD. The corporation/city doesn't have even money to treat the remaining 10 MLD. Either it has to go untreated into the lake, or treat it somehow to a certain extent partially with sediment pond/wetlands. That is still enough I think for the lake to be in a better condition. I feel doing something is better than nothing. This is just my opinion, but looking at the standards, people do have to follow it.

Q: Can the parameters you mentioned be linked to the indicators you mentioned, like biodiversity, ect.

A: Ideally, they are linked. One example I can give you is east Calcutta wetlands. The city didn't have a sewerage system until 1990. All the wastewater that is generated in the city, goes into the channel. It's about 128 sq.km of wetland area with ponds and lakes. Initially, the water is let into ponds where sedimentation takes place and they have a parabolic arch where all the sediments are trapped in the this pond before reaching the next pond. In the second pond, the plankton starts growing there in the presence of sunlight (less than 0.75m). What happens here is , they start introducing fishlets, which feed on the planktons, so the water that comes out of the pond is 99% E.Coli free.

Q: So what is the current situation of wastewater management in Bengaluru?

A: In Bengaluru, about 1400 – 1600 MLD of wastewater is being generated out of which, they have 1200 -1300 MLD is sent to the treatment plant. But I don't know how the treatment plants are working. Because most of the treatment plants are only upto the secondary level. This treated water, for example in KP (Koramangal-challarghatta) valley treatment, the entire water from there to the Kollar district for the lakes. The remaining 200 MLD, from unauthorized settlements, if the household is not connected to the sewage network, they all dispose their water to the drain. So as I said before, there has been diversion channels created at the inlet of the lakes and connected to the outlet. So this outlet join a bigger lake called Bellandur lake. Where, we had done flow measurement with Friends of Lakes. Identified about 200 MLD of wastewater is going into the lake of a 900 lake. So this is an entire sewage pool. The government is trying hard, but it is difficult to give the connection on time even if the government imposes a rule saying we will cut your water supply or electricity. Still there are lot of unauthorized disposal of wastewater into the drains.

Q: So the enforcement is difficult?

A: Yes

Q: I did water quality testing in the inlets of Kommaghatta lake and I found BOD, COD and pathogens in the inflow. What is your comment on that?

A: If there is a 10 minute rain, it is enough for wastewater flushing into the lake. Maybe in a diluted form, flushing into the lake. Especially if you see kommaghatta lake, that part of the town is still under development stage. Maybe in the next 5 years, the entire cathment of Kommaghatta lake is going to be urbanized. Now it is partially urbanized with farmlands, I think the next 5 years, it is going to be completely urbanized and more wastewater is going to flow in because those areas are not connected to the underground drainage systems.

Q: When the government develops an area, do they provide, OSS and sewer lines?

A: When BDA develops a land, it is mandatory that a treatment plant should exist before. But I think, most of the places it is not followed. One example I can give is the BDA layout that is built close to Kommaghatta lake around the Kengeri area, a areas where there was a possibility to connect to the UGD, they have laid the sewer line. But

I’m not sure if the sewer lines are really going to the treatment plant or letting it into the drain. In most of the cases, they are letting it into the drain. In the new layout, there is no sewer network, they have footpaths, stormwater drains and each house their septic tanks. In future, once the build the sewer lines, they may connect to it.

Q: Why is not enough money pumped into constructing sewage infrastructure?

A: Most of the treatment plants are being constructed. Close to Kommaghatta lake itself in Kengeri, there is a 60 MLD treatment plant being constructed. It will be inaugurated in 2 or 3 months after the COVID situation. The possibility is all the water from BDA layouts can go there. But you know these infrastructure projects, the city, I said no, there is 1400 MLD of wastewater that is generated. They have the money, they try to cater that money to service the existing boundary. They BDA layouts are in the periphery most. To service these areas it might take more time. So laying of sewer lines and connecting sewage networks it will take 4-5 years down the lane.

Q: Then why is this problem happening even in the city ?

A: In my opinion, it is more of the unauthorized dumping of wastewater. There are many industries around the area. I wouldn't say illegal but there are small scale industries. So in the night time around 11 or 12 they would open their vales and they would let that into the open drains. We will not know, even the pollution control board can't identify it. And many of the treatment plants, the individual treatment plants, I think, it might not be cost effective to operate because of the technologies they have gone into. One example I can give you is, Bangalore has a rule that every apartment has to have their own treatment system and meet the discharge standard and they are forcing zero liquid discharge. Sometime, what happens is, the apartment builders implement a treatment system, like SBR or ASP or MBR technology which requires high operation and maintenance. When the building is handed over to the residents, housing communities, they find it difficult to operate the plant. Because the operation cost is really really high there, So what they do is, they don't treat the water, again in the night times, sometimes, they have a collection tanks and they let it into the trains. That is why most of the wastewater goes into the stormwater drains.

Q: How about the standards that are set in Bengaluru? Is it achievable?

A: I was having this conversation with a PCB official when I was in a conference. They were giving a different opinion. Because almost all the rivers are going dry. So usually when you dispose the wastewater at 30 BOD, ideally it will not be 30 BOD, when you say 30 BOD, they will at least leave 60, 70 BOD and discharge into the water. This is creating more pollution in the non-perinial river. When you set the standards at 10 BOD, atleast you will have 25 or 30 BOD so that when you let it into the rivers or waterbodies or lakes. This is the pollution control board’s view. My view is 30 BOD is more than sufficient for letting into these waterbodies especially. But strictly 30 BOD or if you treat using nature based systems like wetlands, leaving it 40, 45 or 50 BOD is fine because the waterbody can handle that loads. That is how we try to link the 50 BOD to the east culcutta wetlands, where wastewater is used to grow fish. So these fishes can also gain nutritions. Till date, 50 percent of the fishes to Kolkata is being supplied from east kolkatta wetlands which is grown from sewage and they don't have

any issues with respect to health. So 50 BOD will not be a problem because it aids the growth actually.

Q: How about the on-site sanitation systems?
A: If you look at the management, either they will have pit or septic tanks. If they have a pit, it leeches into the ground. The septic outlet will be connected to a storm water drain. Which means the suspended particles will move into the drain. Entire India, putting wastewater into storm water drain is not allowed. But what to do? Government itself has to provide the infrastructure which is not there.

Q: Is the septic tank supposed to work like that?

A: Septic tanks should always have a soak away/ soak pit. But most of the Indian cities, even in Bengaluru, they don't provide the soak away. Septic tank has to always accompany a soak pit. Until and unless, if you are hitting hard rock down, there are no point of percolation.

Q: How are they managed?

A: There are usually truck operators, Vaccum truck operators, private cess pool vehicles. You call them and for a charge of around 1500 to 2000 Rs. Per load, they can desludge the pit/septic tank. Initially, there was a place, the Mylsandra STP, initially they were accepting septage. To go to Hebbal treatment plant or Mylsandra treatment plant to dispose the sludge. But I think they have restricted that, because the Total solid load is really really high and the systems were not performing very well. So the question now is, they are still disposing into drains, farmlands or into waterbodies.

Q: How are the existing performing in Bengaluru?

A: With respect the articles and literature I have read, I have contact with few workers who are working on lakes. They say that few treatment plants are upto the mark and few treatment plants are not performing very well.

Q: Why are they not performing well?

A: Because of operational issues and especially, sometimes they are underloaded and sometimes they are overloaded. Once you have this extra water, it is going into the drain or waterbody. So even with treated water, again it is coming back to the same state. So ideally there is treated and untreated water you are mixing it.

Q: What are some of the reasons for the red outfalls in the shit flow diagram?

A: From offsite systems, it says 38% is not being delivered this is what ends up in the waterbodies. The treatment systems have operational issues. I myself have attended an enquiry if the system can be converted into a low operation system like DEWATS of Phytoroids. So most of the systems are under performing or people doesn't have enough money for operating and maintaining these independent wastewater systems. So most of the wastewater is being collected, contained and still goes down into the drain.

And illegal discharge, for example, let's take Peenya industry. They say that they have their own treatment system. But still, the lake next to it, Hirohalli is completely polluted. So it was polluted and they implemented a natured based system called, Soil biotechnology. In a matter of 1 or 2 months, the plant got defunct because all the microorganisms died because of the industrial pollutants from the Peenya industrial estate. So there is a lot of illegal dumping.

Q: Why do they not construct soak pits?

A: I think, unavailability of space. If you see most of the sights and areas, people try to utilize the land to the maximum. Having a septic tank itself is a space constraint another soak pit they have to provide? So will think in that aspect.

Also the building bylaw and rules and regulations, people have it on paper but not on the ground. So that is also an issue.

Q: What are the reasons the sludge is being are dumped in drains, waterbodies and fields?

A: There is no treatment system there. In Devenahalli town, CDD Society built a treatment plant where any FS generated within the town can be discharged. So you have a space for discharging the waste. They were having the Mylsandra and Hebbal treatment plant, but now they don't have. So they go for open field dumping or discharging into the lakes.

Q: Is it not being monitored? Why?

A: No it's being monitored. There is no license for the people. A faecal sludge management policy is already come but it has not tricked to the ground yet in bigger cities like Bengaluru. CDD Society was the pioneer in FSM in India, where we developed the FSM policy for Devanahalli which is currently being followed. For a bigger city like Bengaluru where there are 11 million people, monitoring is sort of difficult. Most of the cases, the septic tanks and pits are provided in the peripheral region which is still being developed. In whitefield field area, part of it is covered by UGD and most of it covered by onsite sanitation systems, if I would have provided disposal in Mylsandra treatment plant, which is 40 KMs away, do you think, the vehicle operator who gets 2,500 rs. from the consumer will come all the way 40 kms and travel back all the way 40 kms. So it doesn't make sense for them to lose money. They will either dispose it in the drain or in the night time.

Q: Why should a septic tank have a soak pit?

A: It is mandatory, according to the CPHEEO manual, septic tanks should accompany with soak pits or trenches.

Q: Is there a guiding document for decision makers to design sewage infrastructure?

A: If you see the CPHEEO manual for water treatment and wastewater treatment facilities. Any consultant, should follow that manual unless if it is a new technology and the pollution control board should clear it. And one more thing I want to tell is, you just can't design these systems. The procedure is, a consultant is appointed by the government to build a treatment plant, he has to get his design ready. And it is approved, by the pollution control board. They have to whet the design and you get a consent for establishment. Only then you can implement it on ground. Then you have to apply for consent for operation.

Q: This applies for also the apartments?

A: Everything! Everything goes through the pollution control board, yes!

Q: Finally some indicators you would like to say in a healthy lakes?

A: The major thing for any person, maybe not looking at it in a research point of view. As a common man, when I go to a lake, the lake has to be clean, the water should not be green, colour of algae, it has to be clear. I think it has to see biodiversity as an indicator, Visually, I should also see that no wastewater is entering into the lake. As a common man when I see wastewater entering, it's in my mind that the lake is not clean. Lot of trees around the lake would add a very good indicator. These are visual indicators, but we can take some samples, do some analysis, to check all your BOD, COD. And now a lot of pharmaceutical waste is also coming into the lake. There were many examples in Coimbatore where hospitals were discharging medical waste. Even though the quantities are less, a focus should be provided on that.

Reference code	Recorded?
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Q: What are some of the roles that lake play in the city of Bengaluru?

A: The main role of lakes in Bengaluru right now is the ecological aspects to sustain biodiversity. Secondly they recharge the groundwater to an extent and also play a recreational role. Finally they play social roles such that it caters to livelihoods through fishing, cloth washing, animal rearing.

Q: How do you judge the health of a lake as to if it requires any intervention?

A: Lakes were traditionally man-made tanks/reservoirs have lost their irrigation purpose. Therefore, they have to assume new roles based on their watershed and the urbanization around it.

Broadly, they shouldn't have untreated sewage water inflow
Should have a protected boundary and free from debris dumping
It should hold water for some part of the year.

Q: How is the present situation with respect to lakes in Bengaluru?

A: Many lakes have been revived. Some are doing pretty ok while some are largely neglected.

Q: What is the reason for such a diversity in the status of the lakes?

A: It is based on the local community and the local elected representatives (corporators, MLAs and MPs) who lobby for the protection of the lakes. If they do it successfully, then the lake is protected; if they don't put pressure on the system, then the lake is occupied and ravaged.

Q: What motivates the people to involve in the citizen movement for the conservation of lakes in Bengaluru?

A: The first review of the lake in Bengaluru happened due to the birdwatchers in the city of Bengaluru who saw the deterioration of biodiversity of the birds (the sheer quantity and quality). They went about doing a survey of their own. This resulted as the lakshanman rao committee report which pressurized the state government to act on the issue.

The second wave of lake action happened when people started filing public interest litigations for the protection of lakes. This also came from the civil society, NGOs and environmental protection groups. This resulted in the justice N. K. Patil report which formed the guidelines for the protection of lakes.

The third wave of lake action is from the individual communities around the lake who are championed the lake for their immediate vicinity and they pressurized the system through media, court cases or even through pushing their elected representatives.

Q: Where does Biome fit in the picture?

A: We have been doing several things:

1. We are involved with the birdwatchers group
2. We were part of civic which filed PILs
3. We are involved with lake groups such as friends of Lake
4. We also work with BWSSB and BBMP to make sure that the WWTP run well and SWD are done correctly such that the lakes receive the water
5. We also audit the lake management to put pressure on the system

Q: What is happening with respect to sewage management in the city?

A: The city is exploded with population. The institutions are unable to keep up and provide underground sewerage for the entire city. So they are gradually ramping up the network as well the treatment plant. The city has enough capacity to treat the wastewater but it doesn't have the network to convey it to the treatment plants. So until this is fixed, you will see sewage being dumped in stormwater drains and entering into the lakes.

There is not enough political appetite to make investment in the network and there is no pressure by the citizens to create these networks. Therefore the BWSSB struggles to manage this situation due to lack of funds. But due to the pressure from courts, this is being mitigated and in two years, the city will have a large coverage. But due to the rapid expansion of the city and the investment in sewage infrastructure being lumpy(project based), there will always be some level of sewage that will be entering into the lake.

Only in the last 45- 50 years, the European cities have cracked the sewerage problem and in the last 20 years Asian cities in south Korea etc. have cracked this issue.
China is presently solving it and this is the challenge of the whole concept of urbanization.

Q: How are lakes performing in urban Bengaluru?

A: What should the lakes perform? It’s not clear as to what the lakes should perform. Like I told you, it is constructed for irrigation purpose. Now what’s the role of the lake? Is it for flood control? Is it for environmental purpose? Is it for ecological purpose? Is it for land-use purpose? Is it for recharge the groundwater? Is it to receive and store waste-water for some time? Till we define a reason why lakes should exist in a city, it is difficult to say how they are doing.

Q: BBMP as the sole custodians of the lakes, have they defined any such roles for urban lakes?

It is not clear as to if the lake is owned by the community or the custodian (BBMP). It depends on the scale of the lake, small lakes can be taken as a community lake. If it's the last lake like Yelahanka, Jakkur or Belandur, then it is a city level challenge. Who should determine it? , how it should be determined, is up in the air! It is not clear how it is to be done.

But what the Justice N.K. Patil report suggests is that the BBMP should be the overall charge of the lake, there should be adequate citizen participation and consultation before the plan of a lake. Once the public interests are captured, it has to be incorporated to the best extent possible in the DPR, then the Lake should be developed. That's the process it goes through.

Q: I noticed from literature review and site visits, that it is primarily civil-driven and the lakes have diversions. Are the government officials changing their view in the past years?

A: You can't, because citizens don't want stormwater to enter into the lake, citizens want a diversion because it affects their immediate neighbourhood. But diverting the stormwater drain means that the rainwater is also diverted, therefore these lakes would not fill up at all and so the question has to be answered as to how do we manage that? Sewage flowing into stormwater drain. It is a difficult one to address, a more responsible lake will take responsibility of both stormwater and sewage coming in, make sure that both are treated before it enters the lake. Diversion is a temporary solution, not a permanent solution.

Q: Also, if we were to ponder why there is sewage in the stormwater drains. Aren't there separate sewer lines in the cities?

A: Sewer lines are old, there is not enough investment in the sewer network, the density of the city has gone up.
Sewage lines are not able to cater to the current load put in, there is also people's practice of chucking all sorts of things in the sewage lines.
And flood water is entering into the sewage lines, sewage line sections are put in the storm drain,
there is no preventive maintenance.
There is no replacement of lines after the life span is over.

All this goes to the fact that the BWSSB is not financially robust and stable to make this better. Where should the money come from for the sewerage network? Citizens are not willing to pay for the water, the true cost of water, forget sewage. Therefore, institutions struggle, unless institutions have money, it will not invest in sewerage network. Unless that can't happen, you will find sewage flowing in the storm water drain.

Q: I'm trying to understand how Swatch Bharath mission … to this..

A: Swatch Bharath mission has not virtually contributed to anything related to sewerage network. It was just for building toilets

Q: Does that solve anything for the sanitation situation?

A: Well it prevents a bit of open defecation, but it transfers the problems from toilets to pit toilets or septic tanks or the sewer network.

Q: How are the these pit latrines and septic tanks managed in the city of Bengaluru?

A: They are all being managed by private honeysuckers, because the government doesn't provide any honeysuckers and they put it farm fields or dump it in sewage lines and there is no structured way of managing this.

Q: I would like to focus on the shit-flow diagram for Bengaluru, if you are aware of it

A: It's a waste of time to do it. I think it's a lousy idea, that's my person opinion. I don't think it makes any sense at all. It's sort of fancy for the world because it's funded by bigtime funders but I think it has virtually no role to play.

Q: You had mentioned that there are no funds for BBMP to invest in sewerage infrastructure. What I'm wondering is, when there is much fund mobilization for Swatch Bharath mission, why not for the sewerage systems as both for towards providing better sanitation?

A: Swatch Bharath gramin had a main focus on rural areas while the swatch Bharath urban was a very small package. For the rural areas, it was mainly focused on twinpit toilets and they were self-contained. But for urban areas it was difficult to create a template because some cities do not have sewerage networks at all or some have limited sewerage networks so it couldn't focus on extending or expanding the sewerage network. So it got sort of lost in the way.

Q: Do you think if there is link between the on-site sanitation systems which evolved out of the swatch Bharath mission to a waterbody like lake in Bengaluru.

A: Yes! There is no direct link at all. It depends on if there is a underground, groundwater base link between the two. But that's not been studied enough.

Q: But is that possible?
A: Well, It may be but I don't think that's the major problem. The major problem is still untreated sewage, wastewater flowing.

Q: Are there any other challenges with respect to sewage treatment plants?

A: We have got 28 STP set up in Bengaluru which is by BWSSB and we got more than 3000 private WWTP. The STPs and WWTPs are performing perfectly well, its just the network that is not able to collect all the sewage and bring it to the treatment plant. If they were brought to the STPs they would function well.

Q: What was the case with Bellandur lake? What was the problem?

A: The problem is still the network. Bellandur is 46th in a chain of lakes and we are trying to address the 46th lake in one go. We came with a rigid valley approach and tackled all the lakes beforehand and made sure all the sewage upstream is collected properly and left treated into the lake then there would be no issue with Bellandur. The thing is that we are starting from bottom up, therefore Bellandur is receiving untreated wastewater from stormwater drain and industrial effluent and all. So that's the problem.

Q: If were to be a decision-maker what are some aspects of the lake that would be important for you. Eg: clean water, flora fauna, etc.

A: We have worked extensively with Jakkur and there is some space essentially for livelihood. A lake should provide livelihood opportunities for the best extent possible. Second is for ecological biodiversity as much as possible. Third it should be filled with treated wastewater. We should managed to figure out a way to manage as a wetland not as a lake itself. A wetland is much more biodiverse and has the ability to treat some amount of untreated wastewater. And then it should be seen in the context of what's called integrated urban water management. As a solution to the city's flooding problem, livelihood problem, ecological biodiversity problem and especially, wastewater problem. So base treated wastewater filled into the lake is the way to go.

Q: When you say treated water, what quality of standards do you mean?

A: See, when you treat the lake as a wetland, then you can send in secondary treated wastewater and there's no problem with it. We need to focus upon BOD less than 10, if that is achieved then the wetland will take care of the rest.

Q: Is it possible to achieve that limit?

A: YES!! Bengaluru is running one of the largest treated wastewater transfer for agriculture and the treated wastewater is filling lakes. It's already filled 46 lakes in Kolar, it's going to fill another 100 odd there. Overall 500 lakes will be filled with this treated wastewater. All the STPs are performing to the parameters required and it has been used for groundwater recharge and agriculture purposes. So there is no problems with the STPs at all.

Q: What is the impact of the present situation with respect to lakes (Unrejuvenated) on people, environment?

A: People are not dependent on these lakes. There is this notion that the lakes are important for the city's water security, but that's rubbish. Because we are getting most of our water from Cauvery. So absence of a lake means that there is community space or a common pool resource for that neighborhood and it can have negative effects because there is sewage pooling there or debris and it becomes a breeding ground for vectors and it also becomes a social breeding ground for criminal activities. If it is taken care of then it becomes a common pool resource for senior citizens, women, children. It is more to be seen as a good park with water in it.

Water hyacinth is not a problem,, it is a symptom of the fact that untreated wastewater is getting into the lake. Water hyacinth is actually treating the wastewater. It is one of the best plants to remove the pollutants. The question is do we harvest it regularly and

compost it. If we do that then water hyacinth is not problem. But definitely mosquito breeding, vector breeding and reptile breeding is the bigger challenge.

Q: Any other remarks that you would like to make in terms of Bengaluru lakes.

A: Definitely, governance is the major challenge. Unless we set the governance architecture right, unless we make sure that responsibility, power and acoountability all three go hand in hand and unless we make community participation more rigourous, we will continue to keep debating these lakes for another 35 years. I have seen these lakes been debated over for the last 36 years and it will still continue.

Q: If you were to look back and comment at the progress, what would that be?

A: Well, for a huge metropolitan city, one of the fastest growing city in the world, we have done a fairly good job.

Q: What is the metric you use to say that?

A: There has been a lot of community participation. There is no other city in India with so much community participation and activism to ensure that the lakes are protected. No other city in India can come anywhere closer. With that they have achieved and demonstrated that it can be done. I can tell you the names, Puttenahalli, Jakkur and many other lakes, they have all shown that it can work that itself is a huge success.

Q: What are the type of organization that approach Biome.

A: No one approaches Biome, we go and work with the communities, we work with fishermen, we work with policy makers, we work with STP operators of BWSSB, we try to create civil society groups and community groups. We work with BWSSB itself to try to fine tune things to be functioning well and the sewer networks.

Q: What did you do with policy makers, What was lacking? What's the problem?

A: For example the wastewater policy for Karnataka is the first one which recognizes the agriculture and ecological use as the primary use for the wastewater. We wrote rainwater harvesting policy to recharge the groundwater table so that lakes are fed through groundwater.

Q: Final question, what is the role of multilateral funding agencies in this?

A: Not really needed, it just that the state has to mobilize internal resources and citizens have to be aware of how much they consume, Worldbank and multilateral institutes are unnecessary.

Reference code	Recorded?
ESI-06	Y

Q: Is Jalposh the first citizen group to come together for a lake?

A: The first citizen group that came forward for lake conservation was Puttenahalli Neighbourhood Lake improvement trust (PNLIT). It was the first one to work with the BBMP for this kind of setup. The second one was Kaikondrahalli.

Q: What was the reason for you to start Jalposhan? What was the issue with Jakkur lake?

A: As I told you, we were work with wholistic community development for the Jakkur area and environment is one of the verticals. We were looking to plant more trees, saving natural resources. I live close to the lake, so I have observed the lake undergoing rejuvenation process. I have seen it before rejuvenation, I have seen it during rejuvenation and post rejuvenation. After rejuvenation, maintenance was an issue because we didn't have maintenance funds; we only had rejuvenation funds. We had spent about 13 crores for this project, so we thought something should be done. And if we didn't take care, it will go back to square one. Some community involvement was necessary to sustain it and that's how the conversation started with BDA and BBMP and we called for a citizen meeting in October 2014. We had about 50 plus citizens second it. So Jalposhan was kickstarted informally and few months later we felt the need to formally register it to adopt the lake from BBMP and seriously work with it.

Q: So Jalposhan was also involved in the rejuvenation/planning process?

A: No that was not the case, we are part of the 110 villages that were added to the BBMP, so in 2007 already the process started and in 2008 the lake rejuvenation works started. BDA had taken over. There wasn’t much citizen engagement at that time as the conversion from BMC to BBMP was happening. It was all rural here and few apartments were coming up. The IT and BT crowd had migrated here, otherwise, it was purely the localites/village people. I’m quite positive that the citizens were not involved in the planning process, even though they had a good advisory board for BDA. But they were quite interactive as a foundation when we met with the engineers they were forthcoming and even the contractors were good and gave the information. But not that they came and consulted the people. Between 2008 and 2013, BDA was in the scene, we tried to converse with them and tried to explore options for future involvement.

Q: What do you think are some of the roles that lakes play in the city of Bengaluru?

A: In Bengaluru, it has two streams of importance. One would be from an ecological aspect because water is a very important aspect for Bengaluru. We don't have any direct source of water except for our lakes. If all our lakes are good with drinking quality water, we don't have to stress cauvery. Today we are totally dependant on

Cauvery and we are spending a lot more money that what BWSSP is actually collecting from people for water. There is a lot of investment done to bring cauvery water all the way from Coorg to Bengaluru and supply that. Inspite of that, we do not know the quality of the water from cauvery because we hear that there is a lot of pollution and tests have revealed that it is not completely clean. So from that aspects, the lakes can, I mean it's difficult at this point of time because the lakes are polluted. But if we can revive and get them back to their old status, atleast a couple of them can drinking water source, Bengaluru can look for being a little self-sustained to provide water for the people. If not for drinking water, at least for other purposes so that the demand on cauvery will be less. Uses like, gardening, cleaning, if it can be of that quality atleast. Drinking water has to be really clean according to WHO standards. Whereas for other purposes like irrigation, agriculture, cleaning, if lake water can be used, even horticulture department if they can use all these sources other than ground water, then there is less demand on groundwater, So water itself is the main aspect that is connect to the lake for a community to look at a lake a resource.

The second is urban biodiversity, because today in Bengaluru, we are so filled with concrete, we rarely have an oxygen pocket. Lake addresses this issue by giving some space for plants and trees to grow and enhance the biodiversity and enrich the green cover. And it also gives a little scope for the urban wildlife to sustain. Like in our lake we have seen lot of wildlife, we have seen jungle hares, Indian mongoose, foxes (a while ago), peahens and peacocks. It creates a scope for wildlife to come back in an urban setup which we completely removed. Biodiversity is equally important for human existence. The pandemic and diseases that you see around, a lot of people are predicting it to the lack of biodiversity. If there was a lot of biodiversity, it could have balanced there itself. Because it is coming from the wildlife, the virus and not from the human beings.

Then the more human perspective is that it is more for recreation, fitness and a place to walk, job, run, cycle and they want to take their families and children out. It is important for an urban lake. Rural lake probably would not require that perspective but urban lakes do.

Q: You engage with a lot of citizens, what is their predominant requirement from the community?

A: When you speak about today's urban communities, we are more inclined towards urban amenities. We are environmental conscious is a little less normally. I don't think the priority is to conserve the lake or environment. They look at it as an asset you know? Where they can spend quality time. So I would say, 80-85 % look at the lake as an asset for them to use. That is why we do a lot of programs to attract people to the lake. When we speak about lake programs, we do voluntary drive, we do art programs, marathons, cyclothon and education programs. So the we try to reach out to different people with different interests. To make them realize there is something in our community and we need to take care. Lot of people will have selfish motives for themselves. But once they come and start using the lake, that's when the second level of evolution that, "hey im using this space now what can I do for it?"

Q: What are the people able to do in terms of protecting the lake in the city of Bengaluru.

A: When we speak of Jakkur lake, we have different interest groups. What we have realized is that you can't force environment on the people or make them feel guilty. It has to come from inside. Different levels of participation by the citizens. We educate them to do two basic things: from your house how can you manage the garbage and separate, and not to dump in the storm water drain which in turn comes into the lake. We educate them to not use shampoos with phosphates and replace it with alternatives such as shikakai or rita which doesn't pollute even it reaches the lake. We have conducted a lot of bioenzyme, composting workshops to create awareness to the residents as it how it all affects the lakes and they are more onboard to make lifestyle changes. Then STPs, every apartment has an STP, they should not release water into the lake. These kind of awareness we try to create such that atleast if they are not adding to the conservation efforts, they will not add to the pollution efforts. Most of the apartments that are in and around jakkur today, don't release any STP water or even excess water into lake. They may use it for irrigation at the lake but they can't simply be let into the lake.

Q: And this was a local governance among the citizens or did BBMP enforce it ?

A: See there are two things, the law also says STP water is not supposed to be released into the lake. But the citizens ensure that these are not happening. So whenever we see that someone is violating it, we first go and educate the people (manager/apartment). If construction wastewater is being released, we go and educate the builder. Step one, we try to handle it at our level through awareness and education. But if they are not congenial, we raise a complaint to BBMP of pollution control board. They will send their engineers to tackle the problem. So it is done on both sides, as a community we try to build a comradeship among the residents to save the lake, if that doesn't happen, we have to take the legal way (BBMP/BWSSB depending on the issue)

Q: How citizen groups influence the decisions by the government?

A: If you ask me at the high policy level, it is quite difficult, because the KLCDA cracked a bill through the parliament we didn't have any control over that and they passed the bill over night without much people in the attendance. It was a bill to handover everything to KTCDA. So these kind of amendments do not have public consultations. We tried a lot to change things but we were not able to, we tried reaching out to the governor, chief minister as a federation of lakes. We tried to influence them but it did not work. They have now allowed to construct roads, bridges to be constructed inside the lake if required. But locally people try to protest and they don't let them do it, that happens for sure. Government is not ready to take people's view at the policy level. But the BBMP is pro-citizen, and they are open for citizens to participate in DPR, maintenance and have started being eco-friendly since the Puttenahalli lake rejuvenation started in 2012. They are supportive within the legal framework ofcourse. They encourage us to consult the communities and get back, so I consider BBMP lakes as very pro-citizen and open to participation. Because of this, many lakes are being conserved, if this was a difficult process, nobody would have stepped in. You can always sign a MOU and participate now. They have a clear cut way of working with citizens.

Q: How do you judge a lake if it is being lake?

A: When I moved to Jakkur in 2006, the lake was a village resource and people were still using it, farmers were using it, cattle were around. So it was a beautiful rustic lake. It was a proper rural village lake. In 2007 when BBMP came, the villages became part of the city and all the new developments started. That is when sewage started and there were problems in the lake. At the same time, the arkavathi project also started where BDA started acquiring all the farm lands, the farmers lost their lands here and they disconnected from the lake. They were upset with the whole project and they didn't use the water anymore from the lake. Same time, the sewage was coming and there was no one to monitor it. Fortunately, LDA took proactive initiative to hand it over to BDA and get it rejuvenated. We didn't have a Bellandur case, it didn't get to a worst case scenario. We didn't have a major pollution issue at jakkur and we already had an STP there. BWSSB out an STP there already in 2004. It was ready to receive treated wastewater rather than sewage. So in many ways it was in favour of the lake and it happened at the right time. Unlike the south Bengaluru lakes, we didn't suffer. Because after rejuvenation, after citizen groups were in place is when the development happened. Today everything is in citizen control you know. When new developments come, we can talk to them and moniter. We don't allow encroachment, we don't have direct sewage issue. We just have the stormwater drain issues because UGD lines are being laid now because it's the new 110 villages. This causes a little problem but BWSSB is taking measures such as pumping into the STP or being diverted to the next UGD. This was prompted from our citizen groups because we monitored all the inlets, we monitor the UGD lines and the outlet of the STP. If we notice the outlet water to be not as per quality, we immediately call the STP manager and get an update. For the inlets we co-ordinate with BWSSB and they will give an update as to what's happening and come and resolve the problem. If it's a major problem, we address it with the chairman of BWSSB and he comes for inspection.

The first level of quality check is the clarity of the water and the second is smell. Third is if things doesn't look good, if it looks like there is really an issue, then we ask ATREE to intervene or IISC, KSPCB to come and do a WQ test. We only request it when an intervention is required. First level is the visual signs because that is a major indicator.

Q: So if we talk about indicator for the lake, what would you say?

A: Generally for the citizens, we say, if you see visually if there is a problem, either in the lake, or in the inlet, just take a picture & your observation and send in the group. In terms of colour, turbidity, floating sewage, or things like that. And the second is smell, any common citizen can smell. Everyday someone monitors, I take care of operations so I do one visit every day. Multiple people are monitoring, fisherman also monitor, that is why we don't have major issues. We take up the problem immediately, sometimes the resolution takes a couple of days but minor problems are handled within 24 hours. We just have to give one call and immediately they attend it. It is a one on one communication, No whatsapp group. We know who is in charge of what, so direct messages are sent to them and they resolve it. We are looking forward to an action committee with all the concerned engineers in one group. The current joint commissioners are not as proactive so it is being in a slumber mode. It takes a dynamic bureaucrat to interact with people. In the CE of lakes, both of them were like that, they

were “people for people”. It was easy to communicate with them and get your ideas across.

Thirdly, it goes for a test. Currently we have ATREE working with us, Priyanka and her team are continuously doing testing. Beyond the water quality, the algal growth, hyacinth all the fowls are indicators. If there is a hyacinth we know that there is a sewage point entry from there. Hyacinth means nutrients, if nutrients are not there, they wouldn't come. Similarly with algae, algal growth wouldn't happen if there isn’t any nutrient. It is just an indicator, so that if they are seen to be present we need to do further testing.

Q: What about the wastewater management in the city of Bengaluru? Why is sewage entering into the lake? What is your opinion?

A: Fortunately for Jakkur we have an STP, Jakkur is the first role-model for integrated urban water management system. This model is not being replicated across the lakes, nobody has replicated it across. Each lake should have a treatment plant and let in only the treated wastewater and also have a constructed wetland like jakkur to take care of the secondary level treatement. So everylake should have a constructed wetland at the inlet of the lake to restrict the amount of sewage entering and they act as a shock absorber. Jalshakthi Abiyan has recommened Jakkur as a model for the lakes, these interventions you know, integrated urban water management, constructed wetlands.

Q: Why is this not happening in other lakes?

A: One advantage is that in Jakkur we don't industrial waste coming in. We only receive domestic waste. The COVID hasn't affected our water quality and the water source. Other lakes receive industrial waste coming in, you know. Coping with industrial waste is a big challenge for the communities. They have to release somewhere and infrastructure is not in place for that. That needs to be done strictly by the pollution control board. They have to make the law and make sure that there is infrastructure for the law to executed. This is not happening. The second challenge is the availability of land. STPs require a little bit of land and the running costs, who is going to bear the running costs, for example , the STP at Jakkur requires 10,00,000 RS per month. It’s not a small amount. If you go around Bengaluru, there are lot of STPs, but they are not functional. Because of the same reason there is no funds and they give away. Because they need constant maintenance and upgradation. If BWSSB and BBMP gets proper funds for sewer and STP then it will be easier. Some major issues are at the policy level and the government level. They government has to treat sewage as a priority then sewage can also become a resource. Treated water can solve Bengaluru’s water crisis. If they can be used for horticulture and construction purposes, lot of water can be saved. If there is a mandate to use treated water for these purposes and not groundwater, I think, we can save a lot of demand on groundwater.

Q: Why is treated water not being used then?

A: The policy, the ease of getting it, ease of use! It the system! The system has to be in place right? Today the construction waste and debris, why they should land in a

lake? There is no rule about it reaching from the source to the destination. There should be a system of tracking it right? Now that we don't allow them to dump inside, they are dumping outside. If you go today, you will see atleast 50 piles of debris. Though we have a lot of technology, we don't have a system. Lot of CSR funds are available to build technology for these issues, I'm not sure if it because of corruption that technologies are not being used or it is really a problem with the system. It is the same with the treated wastewater.
The use of groundwater can be tracked by having an online portal and making it transparent. We have a lot of treated water, we don't know how to utilize it and make a network of it. The law is there, construction should not use groundwater. But nobody is following it.

Q: Is the treatment meeting the standards set by the pollution control board?

A: I think so, because, the pollution control board has a mandate and the STPs adhere to it. There are private treated wastewater which can sell the excess using an online portal.

Q: In Jakkur are you using the treated wastewater. Is there any stigma?

A: In Jakkur the treated water is coming to the lake, the lake becomes reservoir. Once it comes there, it charges the groundwater, the borewells and openwells in and around jakkur are functional. So there is an indirect use. For the lake purpose, entirely the irrigation is done with the lake water. We don't use groundwater. There is no stigma in that sense, people are using the water and they don't know until we tell them it is treated wastewater.

Q: How are the sewage pits managed in Bengaluru?

A: We went for a real huge sewage pit and we didn't have an overflow for the past 12 years, We planned it very well that we wouldn't have to empty It every now and then. Whenever these pits fill up, the honeysuckers come and remove it, unfortunately, these honesuckers, sometimes dump it in the stormwater drains. That is another issue. Until they have a system to unload it in a designated area, that itself can become a threat to dump sewage into the lakes. It is not a complete loop right now.

Q: Does the onsite systems leach and contaminate the groundwater?

A: That is a little tricky, we do not know much about this. We will know if there is anything happening in the environment like if there is a borewell nearby starts yielding polluted water, we will know that some aquifer is being polluted. But what we went for is a raised sewage pit on raised ground. So it is not going very deep into the ground. I'm assuming it is not going deep into the aquifer. I don't know if the sewage pits have been polluting ground water.

Q: In terms of the regulations in sewage or wastewater management in Bengaluru do you have any comments.

A: See in terms of sewage management, we see a lot of change recently in the citizens perspective and the bureaucratic handing. The citizens are becoming more aware of

it these days because lot of them didn't even know what these rajkalvues were all about. They were not even aware that storm water always links to a lake. In our community, because of constant awareness, they know that if I dump into the storm water drain at one end, it pollutes the lake on the other end.

At the policy level, SWDs are being concretized a lot, this is not helping in recharging the aquifer. So only at the mouth and end of the aquifer, there is recharge, inbetween the aquifer is dry and It dies. These engineering problems maybe not a good scenario for Bengaluru. Likewise, there has been a lot of involvement.

Q: Final list of waterbody health indicators?

A: Water quality, all the parameters I just told you. Visual and testing. We also look at biodiversity, we look at how many birds are there at the lake. How many plants are surviving at the lake. So if lot of flora, fauna, bees, butterflies, if everything is there and it is really a diverse biospace, then we know that the lake is in good health. There is something called bio-indicators, I've just been introduced to the topic. I'm also trying to find out. How many trees, how many plants and what has brought in what, Which tree bring in which bird. How we change it over time by planting new trees. We are working on it to make sure that those are also in place for the lake.

Reference code	Recorded?
ESI-07	Y

Q: What was the problem with the lake for you to start it?

A: Sewage water was entering inside, as urbanization grows, the lowest point is where they want to send everything. So lowest point starts receiving sewage and there was too much of sewage into the lake. We had to see what we can do to save the lake. This is the story of every urban lake, where urbanization has happened, is happening or will happen. You will see that lakes are one of the main ecological and environmental zones that are getting into trouble. Because of influx of sewage from the nearby area or effluents of industrial areas. This is the case of urban lakes now. Comparing an urban lake to a rural lake would be an utter foolishness. They are different issues.

Q: What makes it different?

A: Rural lakes have too much influx of phosphates, fertilizers and there is a clear catchment area for a rural lake. There is a runoff that comes and enters into the lake and there are chances that this will bring in the fertilizers. Whereas, in an urban lake, it is the **nallas** which serves as their catchment. It has to flow through the nallas, and it takes in sewage, industrial effluent and everything that is on its way. Whatever we as throw as waste, at the end of the has to end up somewhere. Many of the time, it ends up in the lake and that is how the anything that can be pushed around will be taken into the lake.

With its value being really high for real estate, encroachment is very high on an urban lake. Encroachment is much lesser in rural lakes compared to urban lakes. For urban lakes the whole idea of what a lake is supposed to do is lost.

The imagination of a lake is only based on its recreational and social purposes. Many are not understanding that the lake can do much more than that. A lake can be an environmental ecological biodiversity space. It is totally lost. Most of them study, learn but they stop there itself. That is why in the rural lakes, there is still some live, it's importance is felt much more higher because agriculture is dependent on it, animals are dependent on it. So there is a connect between the people/community and the lake. Here the connection between the community and the urban lake is only to that 30 minutes or 1 hour of work. Going around the lake and coming back, play in the lake. The basic necessity of human being is food and water, so the rural communities feel that is fulfilled by the lake. Urban communities doesn't see that at all because they get their water from somewhere.

Q: What are the roles that lakes play in an urban setup?

A: Apart from the social and recreational purposes, the point of water security and water balance in the area can be taken care of by the lake. But the design of the rejuvenation also has to be in that manner. Before preparing the DPR of the

rejuvenation of the lake, you first need to understand what is the role that the lake can actually play. Can it recharge the groundwater? If sewage is still going to come and I don't have methodology to put good treated water. So only then we can recharge the ground water and other things. But that imagination has to come into people's minds.

Next is flood mitigation, just yesterday, one of the poshest areas in Bangalore (Koramangala) was flooded with 2-3 feet of water in houses. Why did that happen? Down to that one is Chalghatta lake which is 124 acres. It was converted into a golf course. Now you can see how much importance was given to recreation and now it is flooding. It is totally unscientific. It could be a flood mitigation zone, but it is not given any importance. This example, show what our development priorities are. The importance is not on solving problems but increasing the luxuries. So the basic needs are lost.

Q: Who would to be blamed for such a situation?

A: First, it is the people themselves who think that they don't have any powers in a democracy. Citizen participation in governance is the foundation. You can change policies. In India when a draft policy is released, you will not even find 0.1 % of the people responding to it. When you are not responding and not participating in the governance, and you think only be voting your participation is over, you are ending up not being in democracy at all. It is the duty of the citizens to get involved also. Not just take your rights and run away. They are the eyes and ears of the enforcement department. With its implementation also, the corruption becomes lesser and lesser. That is the reason we formed friends of lakes. That's why we didn't even registered friends lakes, to go behind the bureaucrats and politicians and get work done. It was successful and that's why we expanded from 1 or 2 lakes to 22 lakes. It became an umbrella organization to being other organizations together to exchange notes and exchange knowledge and other things.
Fight court cases, fight everything together. Demand everything together. Show that when citizen really are awake they can actually bring in a change. We have seen that it can happen. Informal structures can also work is what we wanted to experiment and show.

Q: What about letting sewage into lake?

A: One thing to note is that, with an underground sewage system, it has to come to the lowest point, so they end up coming near the lake at any cost. The whole thing is, the Rajakalvue or the main drains, them carrying sewage is what I've heard. Instead of taking it in the underground drainage, when they find it easy to let it into the open drain and walk off. It's part of the corruption. That's where we have messed it up. If you go and ask BWSSB, they would clearly tell, we have got around 1900 connections like that (to main storm water drains). Obviously it will go and land in the lake itself. Hundred percent it should be monitored, but who is doing this pollution ? BWSSB. That is why we call it "Bangalore Water and Sewage Supply Board". They supply us sewage also, so we called it so. They are the main polluters, not planning properly, not putting properly, they get crores of money still they are not able to perform their duties. Now who is supposed to monitor then? It has to be done by the regulatory. The regulatory is KSPCB. Let us see who is consisting of :

1. Chairman (Politicians)

2. Member secretary – IFS officer from environment department
3. 3 more members – nominated board members (Politicians)
4. Chairman of BWSSB

So the major polluter himself is sitting in the regulatory, which is supposed to tell them "you are doing wrong". Then nobody can question. Over. What are you expecting to come out of it then?

If you want an institution in a democracy to fail, do it like this.

Q: How about the existing infrastructure we have? What is your comment on that?

A: With certain policies, like Zero discharge policy and other, we have seen that the carrying capacity of the sewers are so bad that there are double the carrying capacity go in the same area. They would have calculated the STP depending up on this carrying capacity of this pipe. So they are inadequate. They don't have place to now suddenly put it up. So if an urban expansion is not planned, this is the result. Bangalore is one of the typical example as to how corruption and very bad urban planning can land up a city in worst living conditions. Three urban planners will sit together, put it off as a comprehensive development plan or revised master plan of the city and we have all others sitting and watching it without. It has to be much much more participartory. After civil engineering or architecture, everybody is an urban planner. It is not even meeting the carrying capacity of the sewer. They don't want to even talk about it. Right from planning we need to be involved. Not after everything goes wrong. Right from policy to planning, participatory governance has to happen. If government is not doing it, we have to forcefully get it done.

Q: Has it been changing in the past few years?

A: Very very little. That too those changes are happening due to judiciary involvement. Or else it is not happening in anyway. There are court cases which are pushing them to do that. So participatory governance is happening. 100s of contempt of court. Just because they can't do anything without having to do that, they do it. It is not out of free will. They will float a draft and say comment on this. When you respond, they will say, these objections are not valid. There is not even an answer for that. So participatory governance also has to be defined. Overwhelmingly if there is an opposition to something, I mean across the people, especially for environmental issues, there needs to be relook. So your projects will be stopped. Unless and until we look at inclusive development with environment, ecology and humanity we are going to land in bigger problems.

Q: The fact that BBMP is going to be the custodian of all lakes, will it change anything?

A: That is supposed to be the right way of doing it. The 74th amendment act of Nagar Palika, whatever is within the municipality limits, all will come under the municipality. I will keep my comment reserved to see if BBMP will perform or not perform. But surely they don't have the money to perform. The money should come from Government of Karnataka for sure. They are not even getting the taxes collect properly. There are poor people without any access to water. For them, I will vote because of the promise

of water supply. Chikbellapur, Anekal, Shirighetta and Hoskote. There are high chances that we will land up in that situation in Bengaluru. There are examples where the water supply was reduced to 2 days a week in areas which didn't vote for the politician.

Q: How about the sewage? Due to this kind of a difference in the income class.

More of the slum areas are near sewage inlet or sewage outlet, somewhere the sewage is flowing. They are also the people who suffer flooding, because you didn't go by the gradient and contour. You cause a lot of trouble for the other side, for the poor community people. When it happens there, they are least bothered about it, When it turns to you, then you start crying about it.

Q: What about the rural areas? Where there are no sewer line?

A: There they are going for twin pit or something like that. And, the honeysucker, they go, they take it out and they put in a faecal sludge treatment plant, in Devanahalli it happens like that. Or they go and dump it in farm lands, and that is mixed with normal cow dung and if you leave it for 3 months, it is rich is nitrogen and potassium. That they put in it in the farm fields. So there is a sustainable methodology actually going on over there. Is it UGD which is pushing lot of things into one place, so it becomes very uh.. However, I would not compare it with big technology and this one. We can't have honey suckers all over the place. The method is sustainable but we have to look at other factors also.

Q: Do you think it has an impact on the lake? That kind of a practice.

A: It has a good impact on the lake, for example Dal lake where the twin pit system was put and Dal lake was good. There were some issues in the Dal lake also when around 600 house boats were discharging the waste directly into the lake. If it is present far away from the city then it is good. In the city, have an STP and treat the water until tertiary level and then it can be let into the lake. Right now it is really bad. Because BWSSB doesn't look like they have the will to do something exemplary to treat the water to tertiary standards and they are fighting the supreme court telling it cannot be reach such water quality standards. You can imagine then what they are asking for.

They are fighting back that they are not able to meet the standards as set by the CPCB which we find it very absurd. Phosphate content, Nitrate content, Sulphate content and the nutrients mainly which has been defined in the new water quality standards. They are not even equipped to meet that in terms of the infrastructure. They need to invest more to meet this kind of water quality. Again the things is transparency in checking and processes has to be established. Which is totally lacking.

Q: When you see a lake, what are some indicators, or what is important to you for it to be healthy?

A: That is what we are doing with the National institute of design. We have two interns from there. My paper is on the "Lake Health Index". If I look at the lake as a layman, one of the first question is what am I seeing around the lake. Four choices:

Agriculture/farmlands, industry, apartments, small houses. Now I know what marks, or how much weightage I can give for that. That is my thesis now. Like that we have 27 questions. Weightage meaning what is the lake supporting, that would then tell the water quality.

Then the next question is what is the colour of the lake, whether it is brownish, whether it is greenish, black or transparent.

Physical, visual indicator, then comes the chemical indicator. We have small pH and EC probes. Onsite we will do. The next will be biological. Then we have limnology and orbithology. What fishes are there and are there fishermen around. If there are underwater plants and what kind of plants which are growing at the edge of the lake. All these are indicators. We are not currently looking at entomology but we are planning to look at that also. Then which bird, if there is kingfisher, then the water is very clear. That is the reason kingfisher is around. If has to see the fish right. So it will be given higher weightage. Presence of moorhen indicates it is a sewage area. Taking all this into account we want to tell how healthy is the lake. Whether it is in green zone or orange zone or yellow zone or red zone.

Q: Have you defined the values of green, yellow, orange and red zones?

A: That is the thing it is all about. What is the weightage we give is the question. If we give an 8 to Kingfisher and a 2 to moorhen, we need to justify why.
The funniest thing I observed is that the Kingfisher didn't enter the water at all. He was just standing there and saw a dragon fly and took him and went off. So should I now consider the water to be good or bad? So the presence of Kingfisher what will it give us, I don't know. Our research is going on, work is going on.

Why we started with Lake health index is this only. Whenever people go to a lake, they start with what a beautiful lake. And the you would go there, you will find blue green algae blooming full with cyano bacteria in it. Smelling water. But play area and park is very nice. So now the lake is good. You are not looking at the water at all. This has become the urban context of the lake. See end of the day, what will the MLA come and tell, what is the use of this water being here, I have had one of the very powerful person in Karnataka asking me, what is the use of this lake. Close the lake, make it into a forest, nice park, everything people will enjoy. Corrupt!! He doesn't even know what all the lake can do. What kind of an ecological spot it is. So we have an environmental economics person working on it to recreate the environmental conditions, how many crores we have to spend on it. To recreate the same thing.

Q: What will you do with the finding of your research? To share it as knowledge documents?

A: No no no. We are planning to use it in the courts, investigations. Now of our work is to finish just a book, I have got my doctor and I have walked out. We are working so that at a certain point we can float out the set of indicators. My own LHI is more for a common man or layman. From there, if 40 citizens and have gone to 40 different locations and check the phosphate, BOD or whatever is possible, so that the citizen doesn't get exhausted. Somebody will do the chemistry, somebody will do the biological tests, someone will look at the plants or birds or fishes. We gave got 14

volunteers and 15 college students to come there and do the survey for us. The quality may be low, but the quantity will be high. From there onwards, some researchers can further research on it. Don't expect us to be accurate. It can go to the court but there it will be challenged in a different format. “Who are these people, what have they done? Are they scientist to come and take proper sampling? Which methodology have the followed?”

We are making 10 indicative parameters to tell you this lake is poorly managed. That means we don't have to tell you the BOD or so. People have told there are something black black floating here. Garbage is floating, then they can go and do the research there.

We have not included the socio-polical, governance parts in the questionnaire. That also can be a factor, but we should bring the focus back on to water first in an urban area. Then we can focus on funding, other flora or fauna, biodiversity and ecology. Tousif is working on it and within 6-7 we will be coming out with it either in a paper format or an act format. ATEE is helping us with it. We will be uploading all this to the Bengaluru urban lakes dashboard. And people will be able to upload the data for the different lakes. We think more than 1000 surveys we will get for just one lake. From there you can analyze the data and conduct research.

Reference code	Recorded?
ESI-08	Y

Q: How you describe the wastewater management in Bengaluru?

A: My thesis was on looking at some of the waterbodies in Bengaluru and what is impacting their water quality. I specifically studied sankee tank.

1. Bengaluru used to have more than 400 lakes. It does not have any rivers, it was designed to collect rainwater and they were interconnected for supply of water. It is shocking to see what is happening today, because Bengaluru is one of the most water stressed cities in India. We think day zero will be very close around 2025. Mainly because how the city has grown. Urbanization has impacted the city, how the land use pattern has changed. So out of the 400 less than 100 remain active today and they are also in a poor condition. That is mainly because most of these waterbodies have been filled with debris to provide for real estate because people need places to live as the city grows.
2. Because of the population increase, there has been a significant load on the groundwater also. Because there is less surface water available. Because of extra unregulated extraction, the water quality is poor and the water level has gone done. What used to be 100 feet before now has been 1500 feet to get access to clean water. The water quality is affected, the surface water, groundwater. So you see from various studies that there is sewage contamination, there is excess nitrogen in the groundwater and surface water is contaminated. The situation of Bengaluru is really poor and the main reason is issues related to urbanization and unregulated growth. If you look at the canals and assess the quality, you would find industrial waste and also solid waste. All these issues are because there is fragmented management and the regulations even if they are there they are not implemented and monitored regularly. Poor management is one of the main reasons for the quality of the water.
3.

Q: How do you assess the quality/health of the waterbodies?

A: First thing is the observation. You see first, the quantity of water which has decreases. It has a lot of weeds growing in it. It smells. It is not clear. So it is first visual observation and see something is not right.

Of course, when you do the analysis, you realize that there heavy metals or sewage contamination, organic load is extremely high, because of that the weeds are growing there. So it all links to each other and it's like a cycle.

The best thing to do then, what real estate has done is, make sure sewage goes into a waterbody and it is dead and they just fill it up with concrete debris and make is appear that something can come up on that waterbody. That how it is mostly.

Q: Why is there a fragmentation and lack of monitoring?

A: It is a complex urban problem, it's not that there is one entity that is responsible for these waterbodies. 30 years ago they were under the municipality. Then they set up the lake development authority and then the irrigation department who were for it. So there is some department or the other who are responsible for some aspects of managing these waterbodies. Ownership is not clear as to who owns the lakes. Monitoring is the responsibility of the PCB but then again mostly seen from the perspective from the industrial pollution, this was 15 years ago. Once the LDA came in, then they also started looking at sewage, but it was not a enforce. So when you look at a waterbody, you understand the basin concept, so it is not a single point of contamination, so you don't know where it is coming from. So to trace it back and understand who are polluters and address them would be a huge job and people don't have the time or resources to carry out this activity. So they transfer responsibility to other which is a halfhearted effort. The approach to management is not appropriate. You are trying to treat it at the waterbody instead of not being efficient in treating it at the source. Multiple department, roles not being clear. Sometimes people also talk about, this is not my job. Then there is the real estate lobby. They have a lot of money. They say I want this land here, let's see how we can work it out. They say Bellandur is in the state it is today only because of the real estate lobby. They wanted land around it to develop and the companies are somehow responsible for filling up parts of the lake and take the land away for making it their own.

It's just a concept of 'would you treat it upstream or downstream?' Treating at the source is easier for industries which will be much effective instead of treating a mixed wastewater coming in at the lake. Because it could be rainwater, it could be industrial wastewater, it could be sewage. So there are multiple parameter you have to address and the treatment approach would be very complex. But if you treat it at source and let it into the storm water drain which would eventually reach the lake, it is easier.

Q: What is your comment on the status of STPs in Bengaluru?

A: I wouldn't know the current status in the last 2 years. I believe that some of them are improved. When I did a study 8-10 years ago, we studied 14 STPs which existing at that time, most of these STPs, were not working up to their capacities. One was that it was not getting enough wastewater. So where was the wastewater going? So it was mostly going into GW or a waterbody.

Because it was operating such that the operator sees water and he will run it, maybe on a Sunday, not enough wastewater is coming in, so he wouldn't operate one component of the treatment plant. So just the primary treatment was working and secondary treatment wouldn't work. And most of the STPs in Bengaluru only has only treatment upto secondary level. Most of these STPs release their wastewater into open canals, into storm water drains which reaches one of these waterbodies. Some of the recent studies I came across show that some of the STPs have improved their capacity, more water has been connected to the treatment plant. They are treating but they are not meeting the standards, but this does not mean they stop releasing the water. Partially treated water is being let out which again has enough nutrients so that it causes the usual problems like eutrophication takes place and the sequence of issues continues.

The other problem we see in Bengaluru connected to the real estate filling up surface water is urban flooding. The rainwater has no place to go, there is a lot of concrete and these waterbodies which used to act as sinks for the rainwater are no longer there. Every monsoon we see this problem of low lying areas and areas that were developed where lakes used to be is flooded every areas.

Loss of property, monetary loss (people houses, for the city to fix the situation) and public health issues. If solid waste was managed and the waterbodies were receiving water, these issues wouldn't be there. So waterbodies are linked to everything that is happening around it. So when you talk about citywide wastewater or waterbody health, it is definitely linked. You might say, you are taking care of the extra number of people that are coming in to the city but then what impact it has on the waterbody. We are not thinking about that. That is because we don't see water as an ecological component of the entire environment of the city we are living in. We are looking at it in isolation, therefore, we link up the issues and this leads to conflicts and poor resource management.

Q: What the roles that waterbodies play in Bengaluru?

A: We get less rains because the greenery has gone because the lakes are not there and the birds are not there. It has a great ecological impact. It’s not that of the waterbody is there, we will have water to drink. We will also have groundwater, it means migratory bird and the regular flora, fauna in the city is disappearing. That's because the water is not available.

There is also an impact from where do people want to settle. If you talk to the older generation, they say there is nothing nice left in Bengaluru now. So I would rather go back
Because the beauty of the place is gone. The aesthetics and tourism are missing that they contemplate moving out.

People come now for pubs and shopping but not for originally what it was, “garden city”. The greenery is reducing. There is ecological , aesthetic loss, economic loss (flooding), resource loss (extraction from ground due to bad water quality). Earlier it used to come from mysore. Now it going to come from hesserghatta and we are going further and further for bring water. What’s there in Bengaluru is not adequate or it is contaminated.

Q: Why does sewage enter SWD and into the lake?

A: As I mentioned, the STPs runs under its capacity because the final connection from the house to the final trunk link has not be done. That could be because of technical issues, the household does pay or bad planning. Why this last mile connection is not done is another research altogether. But because it is not done, people tend to have onsite sanitations, if the design of these on-site sanitations are not done properly, then most probably they are contaminating the groundwater and the overflow of the septic tank, is going straight into the drains which are in the locality. These drains finally lead somehow because they need someplace to flow into. So they either end up in the surface water body if there is one close by or into the rajkalvus which are connecting these waterbodies. One it enters these rajkalvus they are entering into the

waterbodies. People throw solidwaste into the drains and rajkalvus and stagnation takes place. Because sewage is going in, you also see a lot of weeds growing in. So instead of free flowing water, you have stagnant water with high nutrient content and it becomes septic. It might not have a lot of direct sewage flowing into it but because of the condition in which it is, it becomes sewage. Also these canals haven't been desilted for years, so that is another issue. And inflow of direct sewage from houses or overflow of onsite sanitation systems. Sometimes you will find the desludging trucks from the city, when they see that no one is watching, they empty the contents into these canals or even into the lakes. So you have, clandestine (it's not supposed to be, it has to be checked by the pollution control board or police because it is illegal to dump it into a waterbody)disposal of faecal matter into the drain and water bodies. If nobody is watching I can quietly dispose it rather than going to a sewage treatment plant. Because in Bengaluru, another issue is that there are only 2 STPs that allow faecal sludge (2015/16) to come into the treatment plant for co-treatment. I don't know if it changed in the recent years. Where do these trucks dispose these sludge from on-site sanitation systems? They need a place to empty it, then if there too far away, the would dispose it the rajkulve or lake or even a storm water drain which would go into drain which is covered by slabs. People think it goes into a drain but it actually goes into a storm water drain which would take it to the waterbody.

Earlier there used to be many more STPs that used to accept FS, but there were lot of issues with getting industrial waste and from septic tanks from industrial pockets. They were not just sewage, they were contaminated with industrial wastewater. The STPs would check the quality of the sludge over a period of time initially, they sign an agreement with the sludge operated that they will bring sewage from a certain enterprise. They check it randomly or at the beginning for a week. After that they only check the quality of treatment. That became a loophole and they started bring industrial waste after they cracked the pattern of checking.

Before this, the trucks were supposed to bring a report of the quality of the sludge load they bring in, that was very cumbersome. So these truck drivers said I can't sit with the sludge until the report comes and lose business.
So they said they would rather dump it somewhere else. That's why they started checking randomly and they found more industrial waste is coming in. That's why they reduced the number of STPs that allowed the sludge to come in. One was in north and one was in south part. It was not covering the entire city and the truck drivers find it difficult to travel 20 kms during traffic and it was not economical for them.

Q: follow up about the design of on-site sanitation systems?

A: When we make a house, then there is a building plan that has to be approved by municipality. In that the septic tank or a pit design has to be approved. When people submit the plan, they give the right design according to CPEEHO manual. When they actually implement, then according to what the mason knows, the septic tank or the pit is made. So what is actually built is not the right design, it is because of the convenience of the owner and the mason. The owner would say, I don't have 40000 for the tank, I have just 20000, so you make it according to what you think is appropriate. The mason would then say I know what works, but it could not be watertight, it's a single chamber, they don't do plastering properly, the effluent of the septic tank should go to a soak pit but the groundwater table in the water would be

high and they know the soakpit would fill up. So they do not it to the soakpit and directly connect it to the stormwater drain. Also a pit, if it is in a high groundwater area, the water going in to the pit also flows out from the pit because it is not water tight, so it contaminates the soil and groundwater around it. So we have not done an entire study to understand what is the quality of onsite sanitation structures that have been built and it's quite difficult to assess once it is built and filled. The contamination of Gw, the nitrate content in it is an indication that there is sewage contamination. And the nitrate contamination in Bengaluru is high. So I think there are some reports from ARTEE and IISC that show the nitrate content and pathogen content in the groundwater is higher than what is should be. And mostly it could be linked to OSS.

Q: What is the process of a waterbody rejuvenation?

Look at the waterbody from a basin perspective. Where is the water coming from, the inflows. To understand the source, the contamination levels and what they would actually bring into the waterbody. Understanding the ecological set up of the waterbody where it is located and what is the land use, population around it. And the sources the of pollution that might enter in. So looking not only at the waterbody but in a larger canvas.

That has been the approach in the studies and projects that I have come across.

1. What are the sources
2. What is the ecological set up of the lake
3. What are the uses derived from the lake. For recreational, is it just for ecological purpose, is it for drinking water. What service is the waterbody is providing.

When we look at it this way, it is a more holistic approach to reduce the pollution and also to improve the efficiency of its use. And ensure how it can be maintained to provide the service it is supposed to provide. Instead of being a linear flow, something coming in and going out, it has to serve a purpose. If a project is approached in this manner then I think it is sustainable and most effective.

Q: What are some indicators for a rejuvenated waterbody?

A : It has to look clean, it has to not smell, it should not have too much of weeds, because weeds are also important or the flora in the waterbody is important because it helps in the water cycle and cleaning the water. It helps in providing oxygen, the water ecology of the water has to be maintained. It should have adequate oxygen, and nutrients but it should not be overloaded with it. It should be able to flow. It maybe be a lotic or lentic waterbody whatever maybe its feature, it should be able to maintain it. It should be appeal, because waterbody provides aesthetic value. So it should look nice, it should provide its ecological services to the people living around the waterbody. If it is for drinking purposes, it should not have any pollutants, if it is for recreation, it needs to be adequately clean but it need not be drinking water quality. If it is for ecological purposes, there should be enough flora and fauna, in and around the waterbody so it maintains the ecological balance. The quality of the water is important. It should be of enough quantity, only then it can serve its purpose. Be a sink for rainwater. It should replenish the groundwater. As it is all interlinked, and we have seen jakkur lake and how it supports fishermen in the area, there is economic benefits which should be maintained.

Q: What is your comment in terms of governance of wastewater management?

A: This is something that has been tried in Bengaluru and has got the maximum benefit. Is the community approach. If you involve people in looking after their waterbody, then they will somehow ensure that it is not polluted. If you look at some of the success stories in and around Bengaluru, in the recent past. Then you will notice that wherever these waterbodies are really looking good and serving the purpose they were originally for. It is where the community has been involved. Along with the government, yes there are many issues, we should address who is the owner of these waterbodies, who is providing funds for it. Who is checking the quality. So the government plays an important role yes. But the community, getting funds from CSR initiatives, community also adds sometimes has been beneficial. And I think it is the right approach, because the people who lives around that the waterbody has a stake in it. For example if the lake next to my building is stinking, I'm affected by it. So I would want that the water to get cleaned. So I have a stake in that. So if you involve me the chances of getting that water to remain clean would be higher than if you didn't involve me. This approach is very important to consider as to how to involve the community and all the stakeholders who are affected by the quality of the waterbody or the use of the waterbody. They should be involved in the planning and the management of the waterbody because yes, the government has a role but the community has an even larger role to play, because they have a higher stake in the waterbody than the government.

Q: What is your comments on the discharge standards ?

A: In India, right now, the standard are for discharge of treated water. Earlier it used to be from the reuse perspective, saying if you use it for letting it out, irrigation, etc.
But if you look at the standards now, from 2018, then it is one standard. Most of the industries and STPs are not being able to achieve this standard. I think it is very stringent, but the monitoring and control is not being carried out. It is also not possible to meet those standards, going from 0 to 100 immediately. I think the standards in India needs to take an incremental approach, where they say, define the standards according to the usage. That would be more effective, easier to implement, easier to monitor also, because we could think of a way of voluntary reporting, if it is like waterbody in my area and I report it and the pollution control board checks it once or twice a month. That can be a different approach such that the community or a third party who is responsible to the waterbody takes the responsibility to report the quality. An incremental approach would be more effective also with monitoring and control. If the users of the waterbody is involved it would be more resource efficient. It would make it more transparent, of course there will be people who wouldn't follow the rules. But that we should hope someday it will change.

Q: How would you link the indicators with physical parameters? Examples

The main parameters that we should look in a waterbody are the nutrient levels, the N P K values and then the organic load, the oxygen levels. Depending on usage, the pathogen content, the faecal coliform and E.Coli. There are many new emerging pollutants. The sludge from these waterbodies maybe heavy metal also, because of industrial contamination. Sulphate content, chloride content.

If you have organic content, the turbidity would indicate it, maybe floating material, solids are coming in. Higher levels of dissolved solids.

The oxygen levels would indicate again if it is septic or there can be live in the water. The nutrient content would indicate whether there is contamination from organic or sewage sources. For example, sewage or industries. The amount of weed growth or plant growth would indicate the nutrient levels. The more the green in the water means, there is enough food and the food is coming from these nutrients. That's also an important indicator to understand the quality. If there is not enough oxygen, and if the water is not flowing, because of the stagnation of solid waste or the high amount of silt then you start getting smell from the water. It indicate that the organic content is high or the nutrient content is high, or there is no flow in the water. So the oxygen is no oxygen in the water and it starts smelling. It gets depleted if the organic load is high or nutrient load is high because it gets used up for photosynthesis or by microorganisms that are using it to degrade and eat the food that is available in the water.

Reference code	Recorded?
ESI-09	Y

Q: What are the roles that lake play in the city of Bengaluru?

A: It's available in the **lake primer.** To a large extent, the groundwater recharge of the shallow aquifer is still there. In a modern context, it's more for biodiversity, for relaxation, these are the only green spaces to an extent looked at for recreation. There is also livelihoods built around the lake for example fishermen are given access to fish in the lake, grass cutters are allowed to cut the grass and feed livestock. Flood mitigation and also a place for religious activities, Still in some of the lakes, the do last rite and they do immersion of idols.

Q: How to access the health of a water body which tells you the lakes needs ?

A: The health of the lake is not the only the quality of water, but also the quality of the biodiversity or the accessibility, there is a whole bunch. For example, if there is a lot of water, but it is largely used for gambling, drinking and it is not accessible for regular people who are not indulging in any of these activities, then it is still not a healthy lake. Even if it is only very rich folks who are doing yoga around the lake that is also not an indicator that there is a whole bunch of other who are not being able to use the lake. For us it is important that it supports and encourages a diversity of uses. There is no one lake standard although there has been an attempt for it. The government set standard is in terms of the water that is present in the lake and depending upon the quality of the parameter such as DO, pH, BOD, Nitrates, they decide if the lake water can be used for fishing or irrigation. When a lake is called for rejuvenation, if it is silted up or it can't hold more water, it may need desilting. Typically, what the BBMP does for rejuvenation is the desilting, strengthening of the bunds, creation of a walkway. Every time, they come in, these things are always done. But the next round of rejuvenation would be to clean up the inlets and outlets. This is phase one. Phase two is all about creating gazebos toilets and amphitheaters. The core and critical part is for the lake itself and the other is for making it accessible for different people entertainment and relaxation.

Normally we work based on people's request to rejuvenate a lake. There has to be a key stakeholder who is interested in whatever they perceive as the improvement of the lake. Normally that is the starting point with which we get involved in a lake. The reason for approaching is, water is not coming into the lake, the lake is full of dirty water, the lake is dry, the lake is losing its water. We do measure water quality, we have been doing it as a part of a project, systematically, through the citizen lakes dashboard project. It is a citizen science project which is to make people more and more aware of the parameters you test for water quality in a lake and why you test for water quality in a lake. If the fish died, you could know something is wrong, water quality is bad. So instead of those indicators, why do you want to test record and maintain share the water quality and biodiversity parameters. We have been doing that as part of the citizen science project.

We didn't involve BBMP or institutional stakeholders because, ideally the PCB should be doing water quality sampling and recording it. In their site there used to be data available but they never tell you what the parameters are. So all the lakes will be at D or E. It wasn't telling people much about the lake. They don't really want to tell you the individual parameters and when you text the quality of the lake, it is a function of where are you picking the samples from, is it the same sample every time. What time, was it taken, because DO varies with time. In the morning it will be low in the day time. What we have done is, as much as getting the water quality, it is an effort to make the people interested in monitoring the water quality. Funded by oracle. ATREE, Biome, FFEM (test kit providers). Phone based app for collect water quality. Data is available on the website.

Q: What do you do with this information?

A: That would be dependent. It is not really easy, what to test for, how to do it in an ongoing basis and record it and to have others do it. What are the actions we can take now? We still haven't gotten that far, to be very conclusive. For instance, if there is an apartment that is discharging sewage into the lake, they would say they are not doing it, but looking at the quality you can establish what is really happening. When we were measuring DO in the lake, certain places the DO was particularly low. So you can say these places for fish kill. So how can you increase the oxygen in those particular areas. It gives you the triggers to take actions. But yea, not all action has been taken, this is what helps you understand and guides you towards the actions.

Q: What the sources of water into lakes?

A: Its rainwater from the catchment. Or it could be wastewater which could be treated or untreated, domestic or industrial. But it is wastewater from the catchment. With or without permission. Treated wastewater is allowed in some cases like jakkur for example. Bengaluru's treated wastewater is also being pumped into the lakes in kolar. Puttenhalli, JP nagar these are the examples. Untreated wastewater still enters into lakes because they have nowhere else to leave their wastewater. There is no use of treated wastewater they let it into the lake.

Q: What is your comment on wastewater management in Bengaluru?

A: There is a lack of ownership, nobody really is responsible for it. Some of the STPs , there are 2-3 types of groups that are taking care of the wastewater. One is BWSSB, wherever you have the sewer lines, I'm not sure if everybody has a connection, even if they do, I'm not sure if all of the wastewater makes its way to the STP and how it is being treated or how well it is being treated. So there is some opacity also, you don't really know, all of this. How is the STP working on a given day, where is it discharging, so that's one stakeholder. BWSSB and its way of handling the wastewater. The next is private handing of wastewater, whoever is setting up their own treatment plants, and it is quite difficult to run the STP at a small scale, so in many cases that private STPs are not designs or maintained well. There are several reports to substantiate this. Again water quality standards are not known. Even in cases it has been run well, there is no avenue to use the wastewater which leads to excess treated wastewater. That is also a challenge.

The time, manpower, the skills which they require. They don't have it. After gardening and flushing they are left with excess treated wastewater.
The third category, is the STP that are run at lakes. They are run by BBMP and not BWSSB. There also, who is taking responsibility to run it on an ongoing basis, where are the funds for that, and to maintain it. That's also the tricky part. The challenge is no proper ownership.

Q: What is the situation of the lakes in Bengaluru?

A: There is no one answer for that. What I can say is that it is very hopeful. Because in all cases, there is somebody who is interested or some group who tries to make it better. Different lakes are in different status.

Q: What was the driver for the citizen groups?

A: It's the thing with Bengalureans I guess, at large. Because there is a general concern for the things that happen around you. It is hard to say the driver. One instance I can think of, so there are so many problem with the city right, traffic, waste management or air quality. I can imagine people being interested in this, because it directly affects them. Lakes are not something that directly affects their livelihoods or their commutes. It is really like this additional thing unless you stay next to a lake. So most people who are interested in the lake is because it is in their neighborhood and they were able to see it and access it. When you see a lake and you can figure out there is a problem with it and something you could do to make it happen. Because Jalposhan, PNLIT was all started by people who live next to the lake and so they felt something can be done.

Q: What is the status of groundwater in Bengaluru?

A: It is pretty bad, because every day we are extracting a lot. The city needs about 1500 – 2000 MLD out of which 50 % is coming from groundwater. It Is estimated that 800 – 1000 MLD is the amount being extracted from the ground. Probably, 100 – 200 MLD is the recharge into the ground. That means we are depleted the aquifer aquifer from anywhere between 500 – 700 MLD. Having said that there are zones which are putting effort into groundwater recharge, we have noticed improvements. There are some demonstrative actions which if demonstrated at scale can help do away with the problem. The deeper you go, the water is harder, salty/saline and the TDS is higher. But many parts of Bengalure, you get groundwater at 200 – 300 feet below the ground, the water is of reasonable quality, where there is no bacterial contamination. Where the water is close is to portable standards. When it is deep, it is hardness, salinity and high TDS. When it is shallow aquifer, there is softness, e.coli and bacterial contamination.

Q: Onsite sanitation systems in Bengaluru? What can these systems do for overall sewage management in Bengaluru?

A: I think they help alleviate the sitation where there is no sewerage network provided by BWSSS. So far, what I have seen, this probably has to be studied, but those villages are heavily urbanized, and they have apartments with STPs. Effect of GW contamination due to Onsite sanitation systems is not something I have worked out.

Q: Water quality and uses?

A: For activities it may not. There are many lakes where the water quality is good but it is just that they are remote (eg: Kanakpura lake) and no access to most part. But if you step in and see the city lake, it is different. It is important to categorize these urban lake from a rural waterbody. In an urban waterbody, if the lake is larger, there are not all parts of the lake which is accessible, so in certain cases, where people don't feel secure, there has been bad behavior. Where there is no security. It is a vicious cycle, because then it becomes unsafe and then people don't go, then again the activities continue. For the overall status, this seems to be on the decline, as the lake becomes more of a place where many people are going to, even if it for walking, jogging or some club to talk or laughing club with senior citizen, security and timing at the lake. Those activities disappear over a period of time. Water quality or water availability in abandoned places effectively is important. So that people will improve it and try to being more people in, what we call as positive activities in the lakes. If people started being active, then they try to bring back the quality rather than the people being drawn to a clean lake in Bengaluru.

Q: What are some crucial points for lake rejuvenation activities for you?

Design considerations are important:

1. Wetland around the inlets, designated and designed to an extent. With thoughts as to make the water pass through the wetland before entering the waterbody. The wetlands becomes a place where the water (clean runoff/wastewater) to be treated a bit before it enters the lake. It certainly improves the water quality and it is a place where the birds nest and there is a lot more bio-diversity than the lake spread itself. Usually what we see in a lake is the water but if we look closely, the fishes, the birds, the nesting, the spawning, all this happens in the marshy wetlandish areas. It can also work as a shock preventing mechanism. When you have a load of rainwater, the temperature difference causes the fishes to die. So the wetlands, is more resilient than the lake itself. So it is a very important design feature.
2. The other thing is slopes being at 45 degrees. Most of the lakes right now make sure that maximum area of the lake is utilized for the water to be there. So the slopes are steep and prevents people from walking into the lake. We should a good profile which is shallow and accessible, which provides habitat for different biodiversity, plants and birds. The other thing is, the side slopes are stone pitched to avoid erosion of steep slopes. So if you have a gradual slope, the stone pitching can be minimized to structural requirements only. It is being done right now without it being a requirement because right now it is the default. You make a whole, you desilt, slope are stone pitched. Right now it is also assumed that the walking path will go all around the lake. But it might be nice to keep some part of the lake as a conservation zone with limited access unless with authorization. I saw this in a wetland restoration in Chennai, and I thought it was good.
3. Access to measure water quality, display boards to tell you about the lake series, whom to contact. Whatever is done is done without a lot of conversation or thought.

so these are design features.

The other thing is, there has to be a diversity of uses and users, and they all have to come together more than once along with people who think they want to design for the lake, in what we call the lake vision exercise. So the people who are rejuvenating the lakes can go and look at the good and bad lakes in Bengaluru and make sure they identify the stakeholders. Most of the times, the fishermen, cattle rearers are excluded. So it has to be a consultative lake visioning exercise to get buy in from all stakeholders. Because some of the lakes we ran into were dumping ground for some guys who ran chicken shops by the side. So the meat waste would be dumped or some Pharmaceutical industries that are dumping some. So you have to bring in all those stakeholders as well. Because you can rejuvenate it but they will continue with that behavior. There has to be a core group but the extended group that decides what has to be done with the lake, you have to make sure that as many stakeholders as possible are involved.

Reference code	Recorded?
ESI-10	Y

Q: Who were the target audience for the decision support tools?

A: We were little ahead of our time when we made the model. Of course the advisory was there but there was no policy as such. We consulted government agencies, multilateral funding agencies and consultants who make plans or DPRs. It was a planning tool and not a design tool. We packaged it together with the FSM toolbox which was done by AIT. It was during FSM4 which was held in Chennai that all the people who were working in this field like peter Hawkins, Isabelle, Linda Strade and AIT, CEPT, CSE came together to share and have a common platform because everybody was working in their own silos, making their own tools. This was the first time everybody in one room and the next phase of the FSM toolbox is when Athena was a part of it. From a planner's perspective it is a great tool because it has all the elements however from the condition of developing country, their capacity and bandwidth to carry out data collection, the data parameters. It is robust by it's a lot for them to chew. In some way we need to push toward a sustained data collection. Otherwise planning is really ADHOC.

Q: How would you describe the situation with FSM or CSP before your intervention?

A: Really, data collection, we did not do a lot in Bengaluru. This was mostly done in the cities of Warangal. In Bengaluru, the whole mindset was towards of course the UGD and as you know there are these the STPs in the apartments. Then you have the honeysucker who would take it and dump it anywhere I have seen myself, near my house. So that's a reality, because there is no FSTP. And all of these small apartments who don't have the STPs have the septic tanks and the sludge out of them is carried out by these honeysuckers. And it is dumped at the nearest culvert or whatever.

Q: What is the motivation for decision makers to pick sewer systems?

A: If you really think about it. And this is my understanding. In engineering school that's what you have learnt right? That's what one of the stalwarts in sanitation has said, Sujaya, I have to unlearn what I have learnt in college. Because what we learnt was networked systems. Because that is considered the gold standard by many officials even the ministry right now. They still think that decentralized or systems or FSM is a intermediate solution. Or a transition to a, a stop-gap measure. It comes from what your training is and what you considered. We have not seen any example of really good FSM treatment or management happening. There are of course, the co-treatment options. There has not been a best practice model that your environmental outcomes are achieved. Even if it is achieved it is not visible, I mean, there are cities that are doing a good job with trenches, very low tech, but at least taking care of it in a safe manner. It is still not considered as great as membrane technology. It is the mindset. Another thing is, this is my understanding with my experience in the mobility sector, there is a bit of bias towards big infrastructure projects, sewerage being a big

investment. So there is a tendency to go towards that too by the government officials. There could be incentive but I don't have evidence for that. There is sort of a political economy, there as I understand. But more than that, it is more of a mindset of “flush it and forget it” if there is a sewer system and taken care of. If that was happening very well and replicated across many cities, we wouldn’t have to do FSM. There are issues with STPs and UGD. One of the challenges for the STP to cover and be accessible to all is our cities are growing very fast. The coverage/ network that you need to have, the infrastructure is the not as fast as your cities. I feel, when we say a city/ area, it has no correlation to infrastructure. There are livable streets. There are three main factors right,

a. occupation type
b. density

It has nothing to do with infrastructure. The area becomes urban, but the urban infrastructure has not reached yet. There is a huge lag. The rate of urbanization has been so high in the last 30-40 years. Once the areas are densely constructed, there are land issues, it is time consuming, legal issues and it lags it furthers. I have had one bureaucrats say to me, if today I plan for an area, in 15 years it **may be** developed. In the 15 years, the environmental impact of no sanitation is huge. That is where we need to look at other options. That is where sewerage has failed in our cities.

What I see for a big city like Bengaluru, there has to be a portfolio of solutions, that is what the decision support tool was trying to achieve. You can't have a one size fit all sort of a solution. When you are looking at inclusive, integrated sanitation solution you need to look at different aspects. For a slum or just a migrant community, what sort of solution works, you need to be inclusive!! They might be here for a season. It could be a portable solutions, innovative ones. So there are different aspects that needs to be looked at a micro level, rather than just at a macro level. So many population, so that much length of UGD, that's it.

Another aspect is that, some of them might not be able to connect. Because the last mile connectivity is main right? Poor households are not able to make that, so if they have toilets, they just flow into the drain.

Q: Where do the wastewater end up from these drains ?

A: To the nearest lake or waterbodies. Or it goes into the groundwater.

Q: Is that allowed?

A: The wastewater that comes out, nobody tests. So we don't know what the quality is. Is it really according to the standards by the PCBs to go into the waterbodies. There is a threshold that we release it to waterbody. Being part of the Ease of Index exercise as part of the ministry, I was the team leader, we did 70 indicators from different sectors, and wastewater quality was one of the index for the water sector. And we tried to collect about that, that data is not at all available. For some cities it might be there since they are part of the Ganga action plan, or river action plan. There they might be having some data. But on a regular basis, it is not monitored in the cities. So we don't know.

When we see the lakes in Bengaluru, we know! What's flowing into it is not the best quality. Or the quality it should be right.

Q: And in your observation, how are the lakes in Bengaluru?

A: So I have seen a change, I stay in Bellundar and the lake there is one of the most notorious one. But at the same time, I have seen agara, iblur, kaikundranahalli lake, where all of these three lakes have been revived. It has been cleaned up, revived, there has been filters in agara lake where the solid waste has been taken up. The nets are taking it up. And there are these wetlands, which are doing the next level of cleaning before it goes into the lake. This has been only possible by the push of the citizens, of course BBMP has been part of it and all. But it is the citizens who really put their hearts and souls and time to get this done. We all contributed for the lake rejuvenation from our apartment. There was no choice, you had to do it. Which is good. Which shows things can be done. There has been a lot of renewed attention to lakes. Financial allocation (BBMP) done for the lake, STPs are now being set up for the Bellandur lake in HSR layout to counter the wastewater issues. In warthur the private players are putting a lot of CSR funds into the rejuvenation, in fact you know Devenahalli right? There are big apartments coming in property tax. Now they want to use this money, it's the city, who wants to invest in lakes. It is a lot of the involvement. Even the FSTP in Devenahalli was more of a confidence building thing. Which helped. We are a small municipal corporation, we can do it. They are even cleaning their storm water drains, solid waste and now they are looking into lakes. So it is about learning. Some municipalities do it better than others based on the political leadership who can push things. Which is a big learning for me, also in Bangladesh for example in Sakipur, a small step which they had done a project by wateraid, a DEWATS in a slum. It gathered a lot of attention, from researcher and other in and around. They got recognition and the major thought, "we can do it".

Q: And what do you mean by waterbody rejuvenation?

A: Looking at different aspects, why is first getting polluted? Checking the sources of contamination. What the stakeholders around the waterbody want from it? There are different uses, the land use around the waterbody is very different. What do the stakeholders want from it and be a part of it? How really can it be rejuvenated and how quickly can it be rejuvenated? What are the technical options? Just a wetland is enough or do you need more aggressive methods?

To look at land use, social impacts, economic impacts - fishing, aquaculture. To achieve that, what is the BOD, COD that needs to be maintained in the lake. You can't take away everything from the lake for aquaculture (eg). For the sustainability of the lake, it needs to be active, it can't be a dead zone. Where no one comes or detached and delinked from nature. You need to re-link it. It could be an economic, social, recreational, aesthetic. And that depends on the stakeholders and it is very important because they are the ones who will actually take care of the lake. Some people do yoga, go jogging, there are amphitheaters, some do bird watching. So it becomes daily part of our lives. If that link is not there, you are on your own and the urban lake is on its own. Bellandur lake is to a certain extent that! Bellandur lake is very detached, there is no access to it. It is a big lake. I think the connection is very important.

Q: Rudimentary factors for a lake in decision making?

That would be the environmental outcomes, as a decision maker, my mandate would be to have a good environment and sustaining that is very important and for that, the others would be necessary. The water quality should be as per standards for the use recommended. If it is just for a lake, not for bathing, etc. then the water quality can be a little lowered if it is not intended for it. The

For example, in Calcutta, there is a lake called the Dhakuria lake. you have a rowing and swimming clubs. These are the stakeholders. Your water can't smell else no one will come to the club. The water quality has to be maintained. So putting all this together, so if the lake quality is maintained, it is a win-win situation. It's been there for 50 years, it is a beautiful aesthetic area, people go for walks. People connect to the lake.

Q: As an urban specialist, what is the role of lakes in your plans for urban areas?

A: It is very important thing and it makes a lot of difference. It's a huge impact on your mental state. It is an open body, a place where you can take a leisurely walk around it. The trees around it. It has a lot of cascading effects, first of all, a lake is there in your neighbourhood. First of all, the important thing that is missing is the accessibility to the lakes, they are gated, which maybe because of nuisance. The lake accessibility is also an aspect of the land use planning. Every layout should have a good access to the lake. It's good for mental and physical health. Apart from this are the obvious aspects like, it helps your groundwater and if shows that the sanitation systems are working well right?

If you don't have one is what we see in Bengaluru; an indication of bad sanitation systems as well. It is a huge connect that you see. Lakes are a huge indicator of the health of the sanitation systems.

Q: What is the motivation for multilateral agencies for them to work in a developing context like India, specially the sanitation space and what impact do they have ?

I think the motivation is, in a country ours, infrastructure is lacking, so we are a huge market. That is a clear motivation for any bank.

Apart from the obvious reasons, I think the SDG targets are key right now. That becomes how we move the ladder of Human development index becomes an indicator of where India is standing in the world.

Q: What about the SBM? Did it have an impact or was it internal?

A: I think SBM is a great effort, I might not agree with the huge numbers of ODF and to show that we want to, I mean it came from the prime minister. It was a clear indication of the motivation and the inclination to have better sanitation in the cities. Whatever it is 70% or 90% achievement, we can argue about it. But we can't take the

credit away from what's been done. I think the most important part of SBM we have achieved is the foundation for community engagement. The swatch sevaks and the ground level workers, who have taken sanitation as their responsibility. That I think is very important for the next stage to
Really, and the SHGs is a great achievement, taking those and if we work in the next stage, that would be great.

Q: Is there a new FSM policy in place?

A: The FSSM alliance was formed in 2016, and the policy was in effect since 2017. It is very much in effect. It is the FSSM policy.

Q: Can this be enforced? Is it a draft?

A : The policy is at a national level and it gives you an overall guidelines of what needs to be done. Many states have come up with their own policy as to what needs to be done. And then it goes to the city. Because the city has the implementation responsibility. That is where they have their own rules and regulations. It could be by-laws like, "If you don't have septic tank as per CPEEHO then you would get NOC". That is one penalty. These are things that has to be enforced and monitored by the city.

In Bengaluru, yes, a lot of these apartments are given a fine of Rs. 5,00,000 or something, the bigger apartments complex. A lot of people from our apartment is also fighting saying the STP quality is fine. I think, they have done a blanket penalty, because the lake issue. This is around the Bellandur lake.

Q: What about the peri-urban areas ?

A: It is not being monitored. What happens is that, the drawing of the plan is according to the plan, then you get an NOC. But after it is built, nobody is inspecting how it is built. That is where the problem is,

Q: What happens because of such a situation?

A: So if a septic tank with a soak pit is what is ok. If that works well, that is the primary level treatment. If the septic tank is desludged regularly, then the whole process is complete. Whatever the water is collected from the soakpit into the drain, is treated, then it is not an issue. However, if you do not have a proper functioning septic tank without a soak pit, then there is no treatment. It is basically, garbage in and garbage out. It is just a storing tank most of the time. There is no degeneration of the faecal matter. The septic tank is meant to be primary treatment. So the effluent does contain a lot bio-organic matter. So that when the water goes out into groundwater or the drain is much more safer.

Q: Groundwater situation in Bengaluru?

The G.W in our area is bad, we rely on water mafias for water. And we have Cauvery connection very less. However I would think that there is a concerted effort in this part of Bengaluru at least , in rainwater harvesting. If you see the structure plan of

Bengaluru which I was part of as well, it wanted to grow towards the south-west, towards mysore, Kengeri. Because then the water issue would not be there. But whatever happened politically and all, the airport up north-east which is totally water scare. So what was recommended in the next structure plan is that, you can't take the city where it is not growing. So let it grow there, you need really aggressive rainwater harvesting policy which the airport has done a good job about that. So it might be sustainable.

Q: Co-treatment in Bengaluru?

Trichy, there is a segregation module before it is pumped to the STP. They say that having this is much better because if they put it in the peri-urban culverts there are issues about people complaining and police action which is a lot of chaos for them. And it is within the city, in Trichy. So they just come and put it. That's what they said.

Q: Indicators for a healthy urban waterbody?

Quality of the waterbody as per use. I wouldn’t say BOD 10 or COD 30. NO!
I’m saying, contextual quality is what I would say. Use-wise quality standards. Recreational is important in the urban fabric. Other uses If I can think of, In Calcutta, there are waterbodies for aquaculture that could be the peri-urban ones. There is a economic life to it as well.

Reference code	Recorded?
ESI-11	Y

Q: Who are the target participants the capacity building trainings?

A: Administrative officials such as IAS, commissioners and chief officials from every state on sanitation aspects. In SCBP, the target groups are stakeholders are from national mission and state and town officials where public health, engineering, administration, elected representatives, NGOs and focused academia (IIT, BITS, IIM). Grass root level masons training is also being developed. Started in 2015. The partners are from the state level, advocating faecal sludge management as the prime focus. There was a lot of demand for capacity building and implementation of decentralized sanitation solutions in the state and city level. Which led SCBP to generate a 4 module capacity building:

1. Orientation module for general audience
2. Technical modules for designing systems and technologies (DEWATS, ECOSAN,CEPT)

We have supported 10 states in India so far.

Q: What is the need for the capacity building in Sanitation?

A: When you sanitation, mostly everybody think about sewer system, and centralized sanitation solutions. Everybody felt at one point of time that we have to copy paste these solutions in every part. There was a time in India where this was the norm, every city was applying for it, not thinking about the water supply which they have. Or the problem which was in the ground level. Never decentralized solutions were thought about and it was never considered. Around 2011 it came out that it was not possible. There ecological sanitation revolution at this time. ECOSAN as a concept came, I'm just saying what I think ok?
Then everybody questioned it, because they thought it was just the UDDT and dry sanitation. When people understood the principle for Ecosan which is closing the loops of nutrient and water cycle, lot of technologies evolved. Then people thought about treating it at source, where on-site sanitation got attention. There is very good acceptance in certain levels. But still, with the top-down approach, there are a lot of capacity gaps. There are people who don't know about it. When we go do a city planning exercise, when we start thinking about a solution for sanitation, the chief commissioner always want a centralized sewer system, they will always choose for a sophisticated, bigger system which gives the city to ask for a bigger amount of money/grant. They are not looking about what is need.

When we did a training needs analysis before starting the program, "why is it needed for state, city and national level for the ULB staff. Because who is taking decisions?" Sanitation has become a state subject now. Every state has to develop it, are the officials equipped enough, knowing Is not important, detailing is important to make the by-laws for the municipalities. We understand that sensitization is very important for the elected representatives and commissioners. But focused trainings are required for

financing, technical designing and maybe they will appoint a consult to do the design for the city. But to understand the design, they should be equally equipped to see what they have asked for. That was the reason behind developing these modules.

We understood that DPRs had a structure which are copy-pasted in a report, there is a lot of things which is being missed. Specially, the messages which is supposed to come from city top-level officials, because they don't know these things. It's not only for sanitation, also for solid waste management, water management as such. It is not taken in a holistic way. The orientation module also touches up on integrated water management, technology options that are available for it and focus on ODF. What after ODF? It is not a last step. We need to think about treatment after that right? Now that you have contained all the faecal matter, what about the treatment and safe transport of it ?
It was not known to people right. When you ask to define sewage, sludge, faecal sludge people struggle. These are all reasons, start with sensitization, technical trainings and deep technical trainings for workers.

Q: How would describe the sanitation situation in Bengaluru?

A: I Haven't worked in Bengaluru much, but as a citizen I can answer you. We moved to an apartment next to a lake. There is always an environmental advocate in you when you work in this subject right? I was quite upset with how people treat wastewater. Flush and forget is what everybody does right? Getting involved in the society, we came to know that there is no treatment plant, just from the septic tank, it was given to the storm water drain. When I raised voice, they said there is a treatment plant outside the society. I was keen to know, because I know the lake is being polluted, it was with lot of hyacinth and all everything. You know that sewage is coming into the lake. Near sarjapur, dhotakanahalli lake, attribute lake to bellandur. I'm very close to the team of friends of lake, so I told them about this lake. This is 2014, there was no step taken by BBMP or BWSSB to see the treatment capacity of these treatment units in each societies. I met the commission in a workshop, he said the bylaws are being made, there are bylaws being made, officials don't want to go and check these places. Suddenly there was bigger flood and all the sewage from the lake came to road. The society I was living in was a poor society. Then there was a big voice and BBMP official came. We visited a lot treatment units, in the societies, it was just made for the sake of it, it was not working, it was half baked. Then I got a chance to do a scoping study in the area, this is how I understood that there are a lot policy issues and technical issues. Bengaluru grows every day, the outskirts are constantly being added to BBMP. As the organizational structure is not increasing with people to come and check. We found of that these units are not working, there was a drive to change it and we got money from CSR activities and kind of made the units which are near to our society are working. Now the Dhotekanahalli is one of the cleanest lakes. Biome and paradigm worked on it.

They have done rejuvenation of 7-8 lakes. He worked on rejuvenation of Kundenahalli lake which is one of the first lake and was even awarded.

Q: When you say clean lake, what do you mean?

A: Clean as in, now the birds have come back okay, the have used decentralized treatment. They have taken care of nalla that is coming in and treated and put it back in the lake. So it took some time, the lake looks much cleaner, there is no eutrophication happening. Varthur lake also they are doing some lake. They made a circular model with an STP on one side with SHG. They have done a unique way of managing it all. It is a no energy, natural system and ecofriendly. It is still working well in Kundenahalli lake. The natural ecosystem is back, so the biodiversity is very important for the lakes right?
Clear indication of the water, yes you can do the characteristics of the water quality but seeing the coming back of the natural system, you can see that lake is becoming better day by day. These lakes have migratory bird population coming every year. There was a time that there was no birds coming and the water was becoming black and black. The lake was dying and fish was dying. But this has been improving now. All the tanks in Bengaluru had a natural ecosystem, the washerman community, they came back. And that's also an indication of how it was 60 years ago. A biodiversity check was done with washi or WRI through stakeholder interaction and I went there to see. Sometimes, the scientific explanation we are giving, as opposed to the explanation by these communities whose lives are connected to the lake, what they say makes much more sense.

Q: Can wastewater enter into the lake ?

A: See there are rules that it is not supposed to happen. It is always intercept and clean. Bengaluru city has already told it is not acceptable. But it is still happening, bellandur will not be in this situation if this was not happening. You can see that lot nallas which were natural drains have now become sewage carriers. It is only because the rules are not followed and wastewater is dumped into the natural streams. There is no monitoring. It is a citizen duty, and when the construction happens, it has to be checked for STP, rainwater harvesting and buffer to lake boundary (50 meters). If they had looked on to it, this won't happen. There is something happening but I can't comment on it, sorry.

Q: Why training for masons?

A: The masons training is for making a good septic tank, make sure that they have all technical norms which are needed. The masons who know how to do it are not there and cities also depend on them. So it is for giving the correct information and also on a social side to given them a certificate and make their job a little dignified. The social identity is also important. It's still going on.

Q: ODF & ODF++?

A: Earlier the idea was just for open defecation free cities and states when SBM was happening. And once that was achieved, it is now important how the toilet facilities are maintained, collected transported and disposed. So it's more of creating barriers for pathogens. It is very important to do that. So it capacity building for that concept was created. The ministry when they announced ODF+ it built on ODF aspects and it was a step by step process. It was a gradual movement.

Q: What is the FSM arrangement in Bengaluru?

A: Mostly these trucks come and take the sludge right ? and it is supposed to go to a treatment plant. In Bengaluru it is done, sometimes these honeysuckers dispose it off in the lakes. And in open fields. I just heard a report that Devenahalli is not receiving faecal sludge because, it is designed for certain capacity and it is undercapacity. It is not properly treated anywhere in Bengaluru to my knowledge. Odissa is a good example, they have around 114 cities with FSTP final stages. They have even polices and regulation, an institutional, organizational structure made. So that it is seamlessly done. Rajasthan also. But Bengaluru not so much.

Q: Are there any links to the lack FSM to other impacts in the city?

A: It is all linked right? The CWIS, if not done properly, everything will be affected. When I do a training, I always tell them, we are connected right? One ecosystem is not happening properly, it will definitely, it is like a trickle down kind of thing, it goes to everything. If FSM is not done properly, if everything is done well except the septic tank is not desludged in the correct time, it is polluting our aquifer, the environment. If it not conveyed, treated, it is again going back to the place. All the episodes of pandemic, the pollution of water, the lakes being polluted, all comes to the fact that the environment needs more conscious effort. So it is all connected. And it is affecting us. And the bigger issue is on the way.

Q: In terms of institutional challenges with respect to wastewater?

A: Very tricky question. The Karnataka Urban water supply and drainage board is taking care of the whole state right. And Bengaluru, we have BWSSB. But what happens it that, water supply is done by someone, sewage is done by someone. There is no inclusiveness in any institutional mechanism in India. If I go and ask data for planning exercise, there is no data. They don't know and there is no connection between the departments. The Institutions are very siloed in India that way. Not just Karnataka, most of the states and there is no collaboration. My job is xyz I will only do that. The plans and programs from these departments are also siloed. There is no complete solution coming out even in the technical part of it. I will stop with that.

Q: What is the role capacity building in changing the current situation?

A: It has been happening for the past 10-15 years in both urban and rural, there are lot of programs. So why still we feel that there is a lack of understanding. It is because, new technology is coming, new bylaws are made, but there is no transfer of information from the top to the bottom. There is a big gap in terms of people who are working on ground. The trainings are designed with the principles of adult learning including interactive elements. It is not a one way training like the SBM training, which are done because they are forced to do it. They are not taking anything from there. Therefore the impact it has is very less.

Q: What about the water quality standards?

A: Why the standards of water has changed is again a question. Because there are lot of issues, contamination of groundwater, water quality of wells in Bengaluru – urbanwaters. It is in a very bad stage with contamination. It said about fluorosis happening, nitrate contamination based on untreated sewage, high use of fertilizers in

periphery. Urban residents are more and more using groundwater, and the contamination is so much. RO is not effectiveness and still has fluoride and the bacterial coliform is there. I was even saying about the lake nearby right and we checked the nearby wells and the total coliform count was very high. This well is where the tankers take water inside the complex. So the seepage is happening everywhere. Standards say we should not have coliform. Simple filters are not removing it. An extensive study by ATREE, it is called **“Bengaluru drinks poisoned water”.** I know Bengaluru from these reports and the quality is very bad. 3M water is also not able to kill the coliform so I boil it every time, you can see it in the vessels too. When you boil it, the salts.

Q: Indicators for the waterbody health?

A: It is important to have strict laws to prevent sewage entering the lake. Natural streams entering into the lake should have a treatment unit before it enters the lakes. I’m not saying, water quality fit for drinking into the lake, but water quality fit for the life forms. It should not be you are destroying what’s there already. The treatment has to be to the extent that facilitates that. There are lot of natural treatment technologies available but to out that, there is a lot of space. There should be research to come up with less energy driven technologies so that the water treatment can be easy and monitored. I will also make lake warriors and important to involve the community. They need to be given certain powers so that they can go and check what is happening on ground. Friends of lakes is doing work but they have no power right. They can't go and say stop the work. There should be a task force with roles and responsibilities. They can be voluntary but they should be given powers to do it which makes a lot of difference.

Reference code	Recorded?
ESI-12	Y

Q: Need for sustainable transitions?

A: We have some accelerating pressures in this sector specially in the global south. I like to look at it in under an integrated approach because everything is interrelated. For the sanitation sector, first of all we find ourselves in the water sector. Sanitation protects public health and the environment and water is a very important source all of living being. If you look at the available water resources, you can see that in India, the population is way higher that the we are very quickly heading towards water crisis which you can see in Bengaluru already. Where we bring water from 120 kms away, into the city. So there is not enough direct supplies of water and there are inequalities during the water crisis.
Basically, wastewater is a transport medium, which contains many many resources but ofcourse contaminants as well. Here we have the benefits and also the means to also look at it from a recycling perspective. We have an accelerating food insecurity, this is also driven by water crisis and the transport of nutrients from soil elsewhere to the urban areas where they are processed by human beings and flushed into waterbodies where they pose an harm to the aquatic environments. So if you return them to an environment which is sensitive, it is of disadvantage. So, if we want to envision sustainability in such cases, we need to have close loop systems. Wastewater has a lot of nitrogen, phosphorous, these are the major resources that are looked at as of now, but it also has a lot of micronutrients, which are not in the attention so far. To close the nexus, wastewater itself has a lot of benefits, it also enables to produce energy. So all these three benefits can be harvested from wastewater if we change our perspective. It needs a paradigm shift.

Q: Wastewater situation in Bengaluru?

A: Beedi colony is for marginalized people located in the edge of the city and that's where I work. Very often, marginalized people are not served with public infrastructure, we can see that CDD Society has constructed a Decentralized wastewater treatment system there. However the community grew way larger and most part of the communities were not served. Mariginalized communities have a high risk with respect to public health. Which starts like a vicous cycle. Because when they get ill, they cannot work, which makes their situation even worse. CDD did a study in the community and found that there are many children who are stunting and suffering from food insecurity. What I could see during my work, many inhabitants don't have piped water supply in the community. They depend on borewell, the water is contaminated but I'm not sure about the extend and they are dry during the summer.

They have to order the water from outside which has a high price. They have additional burdens attached to it.

Q: wastewater treatment regulations and standards

While the lakes are getting dry in Bengaluru, it is reported that some of the rivers are perennial right now. These rivers were reported to carry water only 3 months in a year during the monsoon season. Now with the generation of wastewater, these rivers have become drains. But in a water scare environment, it becomes a water resource for agriculture. So basically, in reality, there is a huge reuse of wastewater that is happening. Thus, it requires a regulation which protects the farmers and end consumers, because it can be a major health risk along the whole chain.

Thus, it needs to be looked at with technological options, what could be the standards which needs to be fulfilled. Reuse is a new step for regulation and only very few countries manage to do it. Important to see which application area you are looking at, Bengaluru has a zero liquid discharge regulation meaning that, all communities within a predefined limit have to reuse all their wastewater. So it is not only used for irrigation, it can used for toilet flushing, car washing, construction sector. So if you look at risk management, we need to look at all these application areas. But the reuse standards are mainly focused on irrigation application because there is a pressure on the ground due to water scarcity in a wide range.

There is no explicit standard for reuse in Bengaluru.
My experience of history of changing standards in India

1. In the beginning I found it very very difficult, to understand what are the applicable ww discharge standard.
2. The standards changed several times in the lasy years. They changed from different sets for application areas to one fixed set. The parameters changed. In addition to that, there is a big incoherence between the central and state regulations.
3. If you ask about Karnataka and Bengaluru, there is a water reuse policy which was published in 2017 and included all the responsible bodies including PCB. But pollution control measures in India are formed by central level under the ministry of forest and environment by their body CBCP. This represent the minimum but the state can formulate tighter standards but not relaxed.
4. The ww reuse policies (2017) relates to ministry bodies who are not responsible for formulating the standards, they look at regulations and recommendations for housing for urban development. They have a manual. They share the responsibility to develop infrastructure with the ministry of environment. But they don't share the responsibility in formulating the standards. So their standards are not applicable.
5. The general normal is the formulation of 1986. It has 4 different applications including **overland.** Over a period of time, they noticed that the rivers are polluted and it was initiated to look at the standards once more. A draft set came out and it was publish which was stricter and it was only one set. So in 2017, the standards we revised again by MOF without consulting the other responsible ministries. They saw that there were major financial constraints so they did it.
6. There was a relaxation, and it was devised for metro cities and non-metro cities. They are a form of load based standards, like which is found in Europe often.
7. In response to this, a case was formed against it, arguing that it is too relaxed in order to protect the environment. Mr. Deshpande, it went through the National green tribunal. An expert committee was formed to review and come up with recommendation. But some of it were not followed.

8. The current regulations followed is formulated in 2019 by NGT and it is comparatively strict. It has 7 parameters included. If you look into the set, the BOD is low, limitation for nutrients. We have one fixed set but it explicitly says that wastewater reuse should be checked.
9. The problem with this is, the wastewater sector is not widely developed. There is also water scarcity, and irrigation sector takes up 70-80 %. So wastewater is reused mainly for agriculture. Here, nutrients are beneficial in this case, for the crops to grow. You eliminate these nutrients at very high costs from the wastewater.

Q: Why is the wastewater sector is not developed?

A: Rapid urbanization – So dense and drastically changing. It is out of the management, we never faced such situation in Europe.

I might not know how to come up with quick solutions for this case. There are ploy centralized solutions which might offer holistic solutions.

Q: How does waterbodies fit in the picture?

A: When we talk about sanitation, the wastewater is mostly released into the aquatic environment these days, so it has a very major role. Every waterbody is a water resources, it has many functions. For environment, for the population, it is closely connected. Nowadays, when we talk about wastewater, the aim behind it is to protect the environment and to protect the water resources.

Q: What is important in terms of practice?

A: We are working in this sector to protect the environment, it would be nice if we treat the water where there is no pollutant at all. But, there are two approaches, the best available technology and best practice. We have to distinguish here, because the current wastewater standard focuses on best available standard, where there is only 30 % of wastewater being treated. So, in order to fullfil the standards, it would require to retrofit the systems with high technologies, resources and smoother O&M. If you look at the finances, the Tertiary treatment is in the range of 60% of the capital cost. While the reduction in BOD is slightly different. It focuses mainly on nutrient removal, which is not even given in the new standards. So you may risk the development of the whole sector. You may only build one treatment system in the city where you could afford 3 of the systems. The overall pollution rate could drastically increase. There is no doubt that the environmental protection on a global scale is under financed. It would be nice if the finance would increase, however we have to look at it from the feasible point and discuss with all the sectors and come up with a development plan which is also not available. In order to have an object, an aim to know when I can have an overall coverage of the wastewater treatment.

So, sustainable develop the wastewater sector, Why decentralized technologies are important is already in consensus and considered in global agendas.

If we combine the issues with rapidly growing cities and water scarcity, reuse. The reason for decentralized options is, they evolve out of low operation and maintenance

technologies and they often are in the space of nature based solution. They were serving marginalized communities in the beginning. Additionally, in terms of reuse for agriculture, the industrial pollutants are averted when we locally manage the wastewater using decentralized solutions. They focus more on gravitational flow and eliminate pumping of the flows. They are not reliant on electricity and less O&M, often also require less finances.

Hi-tech solutions “which they have to be” in centralized technologies, they require a lot of O&M and electricity. It is reported that these systems very often fail due to electricity breakdown and outsourced to private operator who looks into the economic dimensions and there don't have knowledge of the complex operations.

Q: What are some observations in the waterbodies ?

A: They are contaminated, by obvious sources like solid waste, algae growth, the lakes are covered. Which indicated that there are a lot of nutrients coming in, so there should be some pollution.

There are dying industries are releasing their wastewater into the river and the burning lakes got global attention.

On the other hand, you can see, wherever the waterbodies are rejuvenated they are often fenced. While people like to go for a walk near the waterbody, enjoy the environment, the access is restricted partially. It is to protect the waterbodies but also, to take the population away from the water quality you find in the waterbody.

If you look at the public health indicators, only diarrhea itself is taking so many lives each year. Then there is cholera. We have to secure the environment and also the lives it is taking.

Q: Indicators of a healthy waterbodies?

A: It depends totally on the waterbodies, the volume of water, the species, organisms that is living there, the whole environment it supports. The indicators can vary a lot, this is why we need an integrated approach. We need to find the function of the waterbody and the quality standards should be set for that. There are bio indicators for the water quality. Simple indicators which are already in use by bottom up approaches. In Bengaluru, the support citizen research approach where they look into specific organism which can be counted in waterbodies, for example dafnea which can indicate the water quality to you. Also BOD, COD, nutrients which can cause eutrophication and the collapse of the waterbody. Also consider the industrial wastewater which is coming in, so it is a wide parameter set to look at.

Q: What do people in Bengaluru want from waterbodies?

A: Recreation in a densely packed city, we enjoy to be in nature, at a lake and see some birds and trees.

Reference code	Recorded?
ESI-13	Y

Transcript:

Q: Background of your company?

We restrict ourselves to private clients, we are not on the same wavelength with the government clients, due to ethical business practices.

We may help the government in many other ways, but not in transactions involving money. But we make presentations, give training and write reports for them free of cost as social responsibility.

Decentralized STPs with in private hands, 25 KLD to 3 MLD.

The 30 households thing keeps changing, sometimes they say 20 apartments and more, sometimes they say 50 apartments and more. There is not enough clarity, this is the problem with the government and even within the government, there are different agencies pulling in different directions.
BWSSB which has no jurisdiction on who should have STP makes rules saying 20 apartments and more should make an STP, but it is the role of KSPCB.

Q: What is your observation on STP in Bengaluru?

More than 80- 85 % of these decentralized STP don't work, dysfunctional and I'm sure it is the same with government sector although I have not seen any of them. I saw a few many years ago and it was totally dysfunctional and I don't have reason to believe they have improved in the recent years.

If the design is for 300 KLD and to meet certain quality, only 50 % is treated and the rest is left untreated by bypassing. The other thing is treating the entire quantity and not being able to meet the standards therefore not being able to recycle and reuse.

Finally, totally bypassing STP. If the STP is not working, giving any returns, why spend so much money and run it, people don't wish to operate it, they employ a plumber to switch on the pump and discharge it.

Q: Is it legal? Monitored or not?

Definitely not legal. Environmental protection act specifies everything. In the books everything is fine, its only in the implementation, it is all lacking.

Assessment of various STP technologies on the website gives you a fair idea on why this dysfunctionality exists.

1.Right technology depending on size,

2. design features for the technology
3. engineer the STP
4. O&M

You can fail in any one of these four aspects. And the probability very very high. And I don't think anybody has the perfect skill in all four aspects in Bengaluru, Chennai or Hyderabad.

Q: Reasons?

Total incompetence and lack of knowledge on what the technology can deliver. SBR is excellent on a large scale with uniform flow. You will have multiple SBR tanks because the flow is uniform and doesn't need equalization tanks. But with domestic sewage, there is peak hour flow which has 40 to 50 % of the daily flow coming in during 3 hours. Inherently it is unsuitable. People do not understand that, they go by what google says “SBR is a fine technology and it occupies less footprint”

I have seen tender documents for 300 KLD, **see the website.**

Why should the consultant give a list of technologies to the vendor, a consultant should guide the client with a framework. This is what I call, design a STP with a bit of help from google.

O&M and good practices, **see website**

Lack of skilled operators, there has to be excellent back end support with an environmental engineer, mechanic, electrician, training officer, quality officer, logistics offer providing the right spare parts, chemical at the right time. It has to be a team effort. None of the agencies in India as far as I know have this kind of a support system.

The procedure is simple,

1. Get NOC, Consent for establishment: Submit WW generation, treatment scheme and they approve it. This is where the second mistake happens, they approve anything and everything that the consultant submit. They certainly know it won’t work. I have challenged the consultant and PCB to show me SBR STP working to full potential. The consultant is looking for his agenda (commission) and the government has a different agenda. Nobody has the focus on putting up an STP which works. For the builder it is getting the clearance soon. There is no long term thinking in all these things.

Q: Benefits of STP

A: With all the factors I mentioned,

1. Water security – 50 to 60 % of the requirement (toilet flush, gardening, car wash, common area wash) for apartments, 85% for commercial complexes for air conditioning, we are doing it in phoenix mall and Meriott hotel in Bengaluru.
2. Economic benefit – Water is 80 - 100 rs/ KL in 500 – 600 KLD plant the operation cost is 12 – 13 Rs / KL for recyle and reuse. This gap is the saving. The saving in purchase of freshwater alone will be 28,500 rs. per day. We work

out these ROI and the payback. Typically it is 1 year and 3 months (all for 650 KLD). Existing projects also, if you spend 30-40 lacs, the payback is 5-6 months.

We get 1 surgery project in 2 months. We have done 50 such surgeries in the last 10 years. They are usually not working and they come to us. They are SBR or MBBR technology, even MBR and anaerobic reactors. We recommended straight extended aeration but it is important to have the right design and engineering.

Why do they want to fix it?
It depends on the leadership in the communities, who are committed and they take it up as a challenge. They understand the STPs worth and the long term benefits. People are getting more and more sensitized to the upcoming water stress situation. We get more projects from Pune and Chennai than in Bengaluru. Even the builders are more progressive there.

What is the role of STP in Bengaluru?

2800 such STPs in Bengaluru (good estimate), smallest one we operate is 25KLD and largest is 3 MLD; in these 2800, more than 400 MLD is treated everyday which is roughly 25 % of the water supply by BWSSB in Bengaluru. If it is treated and reused, you can see the difference, you don't have to depend on Cauvery for water. Cauvery is actually dwindling, there is competing users as well. So it is not going to be the solution.

Secondly the groundwater is depleting, the next stores is not the guarantee, so we have to make the STPs work.

Opinion on standards?

I'm happy with what Karnataka state implemented 15 years ago even before the CPCB introduced it which is the US EPA standards for urban reuse. It is perfectly safe for toilet flushing, gardening and other secondary uses. Even in the case of irrigation and people come in contact it should be harmless, this is what we use. Although the PCB and MOEF have relaxed it and come under great criticism by NGT. We still use the strict standards for recycle and reuse. It was better when it was 10 BOD, now it is 20 BOD and it is not safe to recycle and reuse. All our plants we are achieving BOD 5,6,8 or less. We have 100 plants and all are extended aeration. In all our plants we meet these quality standards. This is one reason I'm against ultra-filtration. Many consultants by default give the UF and when SBR or MBBR fails, the UF gets clogged up. It is double whammy for the end user.

Lake in Bengaluru?
You can clearly see the deterioration in terms of the increase in population, number of apartment complexes and STPs. It is not only the municipal STP which are getting overloaded, all these 2800 STPs also adds to the pollution load. Even if 200 MLD out of the 400 MLD comes into the lakes, it is going to cause damage to the lakes. Sewage is entering into the lakes. If we fix this, 50% percent of the pollution load into the lake can be relieved. The balance 50% could be small industries, household industries and

the municipal STPs. It is being monitored alright, but it is not prevented. Enforcement is not there.

Was there any project which was discharging into a lake or a pond?
Yea yea, we are allowed to discharge, as long as we meet this 10 BOD discharge standards, it helps to the lake rejuvenate itself. One of the plants, the municipal corporation has laid the pipeline to discharge into the lakes for us. As long as we meet the standards, people are happy for lakes to receive it.

Lake rejuvenation definition?
Lakes are dry during summer. I can see totally the lakes under eutrophication due to sewage. Sewage has high amount of nitrogen and phosphorous, it is good for eutrophication. If you treat less than 10, the lakes themselves will take care of it naturally beyond that.

No, I don't get into the small things (pits and septic tanks) we take care of larger problems, The amount of time I spend for 5 KLD is the same as 500 KLD plant. The size of these STPs are getting bigger day by day.

Institutional aspects?
KSPCB gives as few assignments now n the for STP operators training. Not enough trained STP operators.

Why there was no change even though we had the reuse standards 10-15 years ago?
Everything remains on paper here in India, it is not being enforced. Initially when they enforced it, I opposed it. The BIS standards for drinking water of 5 NTU they put it as a standard. I was against it initially, later I realized it is a good thing. Put the figures, then try to enforce it.

The 100 plants we operate and maintain, all meet the standards. We can’t be touched or harassed by any agency. If all the treatment plants in Bengaluru work, there is no work for the PCB. We will attend to STPs only if it will work. The client has to be prepared to spend the work. For the say the management committee changes, the new management committees intention changes and he wants to cut the maintenance cost of the communities, we need proper support from the client also, so voluntarily withdraw.

O&M costs
100 KLD, typically, 4500-4800 rupees per day;
650 KLD typically 8000 rupees per day;

Definitely reasonable costs. Lesser than 100 KLD we don't look at because they could spend more than what they get back. No matter how educated people are, they finally look at the financial aspects. They are not interested in saving the environment, saving the freshwater resources, that is the last thing on their mind. But the water security is going to drive it rather than economics. So far no, but I’m trying to educate them.

If BBMP comes for advice I’m more than happy to co-operate, but most of the times, I give advice and its thrown to the bin. Even KSPCB comes to me asking for my reports and advice but I don't see it being followed. So I don't stop giving advices.

In fact the STP guide authored by me is published by KSPCB, we did a detailed study for 6-8 other technologies, but nothing has changed, none of the recommendations are followed. It depends on the chairman at that time, or member secretary at that time. What happens right at the top might not percolate to the bottom, there it might be a different mindset.

If it is predominantly SBR in Bangalore, it is predominantly MBBR in Pune and Maharashtra. There are historic reasons for this.

Categorized STPs according to the scale. Up to 5MLD we strongly recommend extended aeration. One STP technology does not fit all sizes. The consultants are commission agents. So we don't respond to tender documents, quotations to these commission agents. Only if the end user comes to us, we respond. It is a one on one interaction.

Government agencies have failed in multiple fronts. They can't deliver it day after day after day. So these decentralized one is the best. You have the source of the water right at the doorstep. If you have to do a centralized system, you also should do a return with recycling and reuse. Which is beyond the competence of government agencies at the moment. As on date, decentralized units are the best one. We don't have to depend on government agencies. More and more I’m seeing, I’m losing faith in the government agencies. Because of lack of governance, quality of bureaucrats. It is all in their hands. In fact, they are forcing the citizens to take up everything they have to do. For instance, the STPs, why did the STPs come into the citizens hands in the first place, because the government was not able to handle it.

Education is key, discipline is very critical. If the apartment sees that the STPs are not working and I have seen this with reputed builders, they make an STP which doesn’t work. Their next objective is, how to reduce the operation and maintenance cost. They are not trying to make it work. How do you reduce it? You don't run the plant and you manage it with the government agencies. It is as simple as that. It is all a management thing. You can either run an STP and get the benefits out of it or you can manage an STP.

There are plenty of brokers and middlemen, they have the least competence and least capacity. For O&M we charge the highest fees, but that is the difference.

Certainly, the NBS are not the solution for the urban metro situation. You need the speeded-up treatment technologies. What happens in nature, we are artificially compress in a small system.

Reference code	Recorded?
ESI-14	Y

How do you define rejuvenation?
A: We study the lake to understand the current situation. State the problem, discuss it with the stakeholders and chose few problems where we get into in detail to solve it. If they say water pollution is the main issue, we try to completely solve it. At the end of it, there is a report and the custodian can take it to a funding agency to get it approved for the rejuvenation we suggested. Rejuvenation plan is not just the civil works, it involves community involvement, stakeholder involvement and looking at the biodiversity.

Why is it important?
In Bengaluru, the lake rejuvenation work is done by BBMP and for them it is most likely civil oriented works, they divert the wastewater, desilt it, construct hydraulic structures and stop the wastewater. So the lake becomes empty unless there is a rain. Because of that the biodiversity, microorganisms, birds and fishes becomes completely becomes zero. So it takes time to come back right? So we say rejuvenation is not a one-time activity. You need to consider biodiversity and the lake ecosystem (flora, fauna and the public who are dependent on the lake like fisheries, vendors). We need to consider all of them and what is their willingness.

Roles of lakes in Bengaluru?
They are man-made lakes for irrigation and domestic needs. Today we got freshwater from Cauvery so the dependence on these lakes are really reduced. The other major source is borewells, I feel the lakes are actually helping to build groundwater in these wells. The borewells got a good yield when the lakes were rejuvenated when biome did a study.

Lakes are providing flood mitigation because they are connected and in series. The main reason for flooding is, the channel that was carrying water into the lake was blocked or encroached. It plays a major role is flood management.

It has helped in the microclimate, its pleasant environment attracts people and everyone wants water in the lake. Thus, there are lake view apartments and all which helps in real estate and everything.

Lot of lakes in Bengaluru when we did a study, are polluted, the stormwater is majorly carrying wastewater. Because of issues with sewer lines and there is a leakage or the sewer connection itself is not there. This is the common thing we see in always all the lakes.

Encroachment is the second major problem in Bengaluru. Not much of the maps are available. So BBMP struggles to find the actual lake area.

In terms of hydraulic structures it has improved recently, but it requires a little contextualization. What they do is a standard design/conventional design which

creates bad effects on the lake. Most of the works done by BBMP, they pay some consultants to do, they do a conventional method of designing, the design in the DPR is different from what happens on the site. The contractor wants to save some money or low cost structure. There are no monitoring systems, the civic bodies lack technical capacity, there might be 2 engineers and they have to monitor 20 lakes. The lack of monitoring benefits the contractor to do whatever he wants. You know the other part of the other condition.

STPs

Most of the STPs in Bengaluru are located at the banks of the lakes. For example, Kormangala STP is located at the bank of Bellandur lake. Many STPs in Vrishabavathi bank. When the STP is designed for 10 MLD, when the wastewater coming in is 20 MLD, the remaining 10 MLD will be bypassed to the drain. Even treated water is also let into the drain. It is because there is not much reuse is happening. You know that in some of the places treated water is sold and the Bengaluru airport is completely built with treated water. We don't have much examples where people can use it. It is more of a psychological issue and they are not sure about the quality. The kind of documentation required by the person who is bringing the treated water is a lot, so they end up going for fresh water.

I have seen most of the STPs in Bengaluru, it depends on when it is built, who is operating, there is some STPs which are Hi-Fi technology. In Cubbon park there is an STP with MBBR and it is operating for 10 years and it is operated by the same company which built it. So, it is working well with good quality. But I have seen examples where the design was done by somebody and the operation is given to somebody else. There are issues of transfer of knowledge. The don't understand the operation to be made and they start doing it by themselves. For example, if the tank has to be cleaned once in 60 days, they might go with their knowledge and do it once in 3 months. Sometimes, the issues with electricity, pumps and end up treating under capacity.

Stormwater

The storm water is not allowed to carry the wastewater, the BWSSB, KPCB has made stringent norms not even allowing treated wastewater. for 3000 sq.m area you should have your own STP and reuse the treated water. Only the excess which is tested can be allowed to storm water. But it is not followed. It is the issue with monitoring systems and lack of awareness and the willingness from the community. If there is already a UGD line, they say I can easily just discharge it.

Why did the government make a rule that apartments should treat their own wastewater?

I heard that BWSSB is going to these apartments and saying if you are not reusing your wastewater, we will be cutting your freshwater and electricity lines. They are trying but it may not help. The kind of load that they receive is more and also that you can reduce the dependency on freshwater that they supply.

Healthy lake?

One is the water, the second is the ecosystem that depends on the water, fishes, birds in the area. Lot of studies indicate that the water quality and bird migration. Clear water

means the colour, if it is black in colour then I'm pretty sure it is anaerobic water and not really clean. Blue or green is okay.

What do clients want?
We are contacted by many,

1. The lake should have water
2. A pathway where people can come, do jogging
3. Recreational purposes, they have gym, sitting arrangements.

So they usually come for community uses and only few people come for environment, ecology and biodiversity. One is government bodies, the second is NGOs who got fund, the third is CSR who are willing to spend for the environment. When it is rejuvenated you can immediately see benefit where people start walking and using the lake.

What do government want?
One opinion that they have is because we work in wastewater sector, they look for pollution reduction. Majority of the enquiries are on the pollution abetment.

Wastewater management
The core part of Bengaluru has sewer lines and connected to STPs outside the core areas. Recently there are 20 STPs added to the 110 villages which are added to BBMP areas where currently they have on-site sanitation systems. The UGD works are still going on but what they have done is that the STPs are built already with the available funds from worldbank and Jaica. But the sewer lines construction is still going on. This is due to land issues. Most of the STPs are underperforming because the connections are not completed yet. The one in Kengeri is built for 60 MLD where only 20 MLD is being received.

What is the problem with on-site systems that BBMP wants to create sewer systems for these villages?
It is not like onsite systems are bad, the kind of on-site systems is what that matters. These are pits and not septic tanks, so if it's not constructed and maintained properly they go and reaches the groundwater. The second thing they struggle with FSM. In Bengaluru, no STP(BWSSB) is allowed to receive the feacal sludge. Either they have to discharge outside the city or they need to have their own STP. So managing and maintaining these systems becomes an individual priority. But everybody finally wants sewer line. They want to flush and forget. Even when the villages were added, their willingness is to have sewer line. Because it is easy for them for managing.

FSM
Neither BBMP or BWSSB manages the on-site sanitation system. It is done by private player. Because of that, they take the sludge from the systems and dispose it outside the city. Earlier BWSSB used to allow the sludge into their STP. There was a case, instead of this, they brought chemical waste and it collapsed the whole stp. So they stopped it and no sludge it allowed into the STPs. If it is primarily treated with less than 1% solids, they do allow. This is allowed in one STP, after testing the quality. If I have an apartment, I have approach BWSSB saying, I have treated wastewater which I don't want to reuse. This is the volume and this is the quality. Kindly check and approve. You have to pay 6 months in advance (Rs.50/KL i.e. 50*6*30*volume). This

is a contingency if anything happens to the STP. Other than that, you will pay on a daily basis. For other cases, If you have a retention tank, it is allowed.

Currently 1400 MLD is the generation of which we have STP of capacity 1000 MLD and the working capacity is only 700 MLD and the rest is to be connected.

Links between parameters and the indicators
If you look at the water quality index that the PCB has given, BOD is one of the parameters because of the organic matter. Ammonia for the fishes and pH BOD and Nutrients (Ammonia and phosphates) will give you a better understanding. If some industrial effluent is entering, then the heavy metals are important parameters.

Ammonia represents the anaerobic conditions and BOD represents the organic matter and so it can be linked to sewage. Some studies also indicate the microbiological indicators like E.Coli testing, again the issue is the numbers. The lake water will have the numbers of 10 to the power of 6 and 7 and all. So I don't know, there is current numbers on this is what is required for the water quality. If you use it for drinking water only then it becomes an important criterion. But for like in the case of Bengaluru, where is it not used for public consumption, E.coli is not important.

Birds and parameters
Not very directly, I have read about some kind of birds, where they come when there is clear water. If the water is completely filled with water hyacinth there are some indicators and also some fishes.

Governance:
The kind of water quality should be dependent on what you use it for, What they have done is, because most of the lakes are polluted, the water that comes in should be of high quality. They say that the self-purification capacity has gone and only treated water should come in. It depends on the quantity and quality of water that is comes in. If you have secondary treated wastewater with 30 BOD and 50 ammonia, I'm pretty sure the lake can do a good job. The government says how can I monitor this, I can't give everyone separate standards, so it is better to go with a stringent standard so that the lake water is at least saved in the future.

The catchment area approach is important than the lake level. So if anything happens in the catchment area if affects the lake. So their approach has to change from lake to catchment area. They should not think lake rejuvenation is not just civil works and include every part. Including biodiversity, ecosystem, community involvement and holistic.

Why biodiversity is important?
When you say biodiversity, there are fishes, reptiles and microorganisms, etc. Lake is not just human beings, we have to balance the whole ecosystem. Their habitats are destroyed and the species are endangered.

Community involvement
One side there are the civic bodies who want to protect the lakes, other side, because of their willingness it is adversely affecting the public who are located in the area. Because the lake communities living around the lake are direct beneficiaries. If they

do a hydraulic structure, it is because the people are affected by flooding. They are becoming more activist than environmentalist. Their ideas are good but the way the put it, they become like activist. Overall, it has improved the lakes in Bengaluru. When public goes and demands, most of the cases, the government will provide. The communities are going to court n all because there are some unscientific way of things that are happening. Other way also, the community is also lead by 1 or 2 people and their ideas. And if their understanding is wrong, it can be a challenge.

Reference code	Recorded?
ESI-015	Y

Q: What is happening in Bengaluru with respect to sanitation?

A: Bangalore if you look at how it is grown, Bangalore is the capital of Karnataka, there were good investments in particular types of good infrastructure where sewers are considered, I would say, the most, popular among sanitation systems. So in a way, Bengaluru has had, at least the core of Bengaluru has had a sewer network for a long time, though treatment plants have been new, Bengaluru has close to 14 treatment plants and new treatment plants are under construction. But just like any other city in India, Bengaluru grew pretty quickly towards the end of 20th century and in the beginning of 21st century, the growth was so rapid that the sanitation infrastructure has not been able to catch up. Not just sanitation infrastructure, even roads for that matter or many other core infrastructure has not been able to catch up with the growth of the city. The lack of planning has led to bludgeoning of huge number of pits and septic tanks on one end and on the other ends, wherever there have been new sewer infrastructures, they don't carry sewage all the way to the treatment plant, so they end up in Rajkalvu as the call it, which ends up in the lakes. For Bengaluru, finding sewage in these Rajkalvu is so common. People don't even question. And as a city, it doesn't treat faecal sludge, though 30% of Bengaluru, heavily relies on septic tanks and pits. It just disposes faecal sludge quite openly, but also, there is also an interesting reuse practice in the periphery of Bengaluru, wastewater is reused, faecal sludge is reused. All of that is happening, but most of Bengaluru is still contaminated because of this flow of sewage into them. There have been several initiatives, some of the lakes have been reclaimed, some of them are still being reclaimed. There is an interesting bourgeoisie environmentalism attached to lakes when you think about how people want to claim lakes for themselves. And there have been several people, directly dependent on lakes for their livelihoods, for example fishermen, washermen. Now they are being pushed back because of this bourgeoisie environmentalism**,** but in general, the overall sanitation in Bengaluru has not been that great. But because of the altitude of the city, it is very easy for the city to find exit points for the Bengaluru to send out its waste. Because it is at an elevation of about 3000 feet. There have been several natural water streams, which are no longer, freshwater streams but a sewage stream can easily follow and move out of the city.

Q: You mentioned Bourgeoisie Environmentalism, can you explain?

A: So what is happening these days is that, more and more people are laying claims to lakes. The challenge has been that when these people lay claims to these lakes, it is mostly because it look good, they need a running track, they want to go and do bird watching, when that is the type of claim and also, this understanding that lakes should be touched by anyone else, you know, what I mean by that is, when fisherman and washer men use it, people don't tend to understand that they have been used to doing that for several decades, and just because there is a new apartment complex and the neighborhoods has changed, doesn't mean that these new comers have the most hierarchally the first claim as to how these have to be managed. So that is what I mean by bourgeoisie environmentalism where our idea of a lake is just aesthetic in nature

rather than trying to understand, lake has so many more functions attached to it. There is also a religious function attached to it, for worshiping or some other type of ritual. Where our life Is not dependent on lake, but just that it adds aesthetic value when I run or it looks nice when I sip my coffee in the morning, that kind of a thing.

Q: Is this predominant in Bengaluru? In your observation?

A: Yeah!! It is picking up right? If you go around these lake, you will see these apartment, “Raj Lake view” or “Lakeside …. …. ” all these apartments have these nice names as if they are actually claiming or appropriating the view for the rest of the society. And automatically, the community around these lakes, the new community, they think that they have a claim to these places. And they becomes organized or involved and it is picking up quite seriously. One good thing is that, since they are also upper middle class society, they know how to put pressure on authorities to get certain things done. But it is also easy for them to further marginalize and render certain people voiceless. But it is happening quite seriously in Bengaluru. Any good-looking lake, has so many claims on it.

Q: What did you do on field for your thesis work on FSM?

A: So what I did was, I was interested in understanding, where do these people actually take these waste, since there is no place to technically dispose them safely. So I wanted to know how do you choose the place of your dumping. Now that there is no designated place to dump. I just followed the truck operators to observe what they do.

Q: What were some of the places they were dumping the faecal waste?

A: So, they were all very random, it all depends on where the house they are going to empty is. For example, I don't know whether you could go through one of my photo essays on truck operators, how they empty it and transport it. There I take it and dump it in a nalla which is a Rajkalvu as you know. And in some cases, they dump it in a farm field which is great. But not always. Or an open plot on the periphery or a stormwater drain. Or even a central sewer system. It all depends on the time of the day, the locality and so many other factors. And as a reason it ends up in a storm water drain or a sewer line, eventually some of it ends up in a lake.

Q: What are your comments on co-treatment which was suggested in Bengaluru?

A: It was supported at some point, but it was only for people who would empty certain commercial buildings and certain apartment complexes. You have to get a license from BWSSB after certain application processes and what not. So not every truck operator was allowed to dump it there. Then BWSSB got really worried because some of the chemicals and effluents were also dumped. That's where talking Jayalakshmi from BWSSB can be very helpful for you. All of this was happening under her administration. She can give you more ideas in terms of the dates and the reasons and the challenges they had while they were operating. But the sewage treatment plants would accept these faecal sludges at 50 rs/ kilo liter for emptying. Only two of

the treatment plants allowed it. One was Kadubisanahalli and the other was in Mylsandra. Then they stopped it altogether.

Q: These on-site sanitation systems, how are they designed?

A: Now there has been several designs and standard operating procedures on how they should be constructed and emptied and how frequently it has to be done and all of that. The pollution control board has come with that, the National Faecal sludge and septage alliance is also promoting such practices and standards, but the reality is very different, since the septic tanks cost quite much, most people go with some or the other type of pit. Because people are thinking if not today, in 5 years from now, sewer lines are going to come to their neighbourhoods. So why invest in building a septic tank, which is actually safe, when you can use the same money to build an extra room or upgrade the tile fittings or whatever, you know. So they continue to think that way.

Q: What is the difference between a pit and septic tank?

A: It is the number of chambers and how it is built, usually the pit is built with an understanding that the water should seep out as much as possible, so there is usually a hole or a gap between the circular rings that are stacked on top of each other. And the bottom is usually not lined because they want the water to seep out as fast as possible.

Septic tank on the other hand is not a single compartment tank, where you have movement from one compartment to another compartment where it takes time and because of that it also, has some type of treatment. So as a result, emptying a pit is different from emptying a septic tank. Because when you empty a septic tank, you are emptying quite well decomposed and partially decomposed waste, while, a pit based on its design can really carry fresh waste from toilet. So in that sense, the septic tank is much easier to empty and it's relatively safer to empty compared to a pit.

Q: Did you encounter people with people health issues in the users of such systems?

A: So, the challenge is this right, wherever they have these pits and septic tanks, people also have tube wells, and in Bengaluru, tube-wells, go so deep, that it is really difficult for people to understand whether it is contaminated or not. But there is a good probability that, they may not be contaminated because they are 800 feet, 1000 feet, 1200 feet. So waster from septic tank wouldn't leach to that depth. So in that way, they are not seeing any direct relationship. And also in my case, I didn't come across such issues. For me the issue was the disposal and not the source to be honest because these people would get water from a tanker, or borewell would be so deep that there is no direct impact from the septic tanks.

Q: Was there an incentive for the truck operators to go to a treatment plant or a designated disposal location as instructed by local NGOs or government for that matter?

A: See, the incentive was that certain commercial complexes and apartment complexes were asked to get the services from licensed truck operators. That itself

created a market niche. So that way, these truck operators would get the license from BWSSB, go and empty these apartment complexes and commercial complexes, bring it back to BWSSB. That record keeping ensured that both the apartment complex and the truck operator, they stuck together. So that was the only incentive.

Q: What are your comments on sewered sanitation in Bengaluru?

A: In terms of the capacity, of course, some of them are not operating at their, design capacity, it is because, the infrastructure to being sewage into these treatment plants is not complete. On the other hand, the level of treatment is very hard to verify. Because they have their own log books and I don't think there is any third party verification of the treatment quality. But the interesting part is that the amount of sludge that is being generated by each of these treatment plants, only very few of them allow the sludge to be taken out of the treatment plant and there is a huge demand. For the treated sludge that is generated in wastewater treatment plants.

Q: You said that FSM is centered around reuse in farmlands and that it has it's pros and cons. Can you expand?

A: So when we talk about reuse, faecal sludge can be reused in two ways right? Reuse based on its calorific value as a fuel or you can reuse it as a fertilizer based on its nutrient value. So in terms of reuse , it's a great organic fertilizer with a very good ratio of NPK , and also every city has to generate waste, either as septage or wastewater, there is a constant source. Unfortunately the barrier has been that it is very hard to know the level of pathogens that could exist in these things and also, though it kind of gets treated because of drying and advanced treatment, it is very hard to say it is completely safe or not. So that way, It is a challenge and also, carrying waste to the farmlands, which are in the outskirts of Bengaluru is an issue because of transportation and traffic, the truck operators are not easily incentivized for it. Also there is another challenge, now that farm owners are very excited about reusing treated waste, but workers are not. India being a "caste society" it is workers they feel they don't want to touch human waste. They would be relegated to the caste that deals with human waste. So there is push back from these works while the workers they love to use the treated waste. As a result, there have been instances where owners disguise by mixing treated sludge with common manure or sometimes they are forced to apply faecal sludge in their farmlands using some machinery. So such practices are there. In a way it is exciting to look at the opportunities because India is heavy dependent on phosphorous imports. So reusing human waste would be a wonderful way to atleast offset some of that demand. The flip side to that is as I said, India being a "Caste society", the risk of human waste falls on these farm workers. The farm labor is becoming more and more female oriented now. This might change because lot of the people have gone back to their villages because of COVID. And there is a huge influx of male worker, labor. My earlier worry, during my dissertation was that most men they migrate out of their villages and its usually women who are working in these farmlands and who are exposed to these things and who then have to go home and cook for their children and take care of the elderly and things like that, so the risk would be continued to spread. But now I think, it's going to change a bit. Another opportunity is that if we learn to treat faecal sludge as a resource, some of the money that you can make out of that could actually help reduce cost of the emptying. Or increase the overall profitability of the business itself.

Q: Do you have a comment on the choice of technology, Centralized Vs. Decentralized.

A: I really believe, centralized sanitation system is great, but also very expensive, in a situation like COVID perhaps, sewer systems are wonderful, But on the other hands, they also run parallel to our water pipelines. And I know that our water pipelines have cracks and sewer pipelines have cracks and we don't really build good quality sewer lines. So they easily contaminate our water network also, So I would say that, a very dense region which can afford to pay for a very advanced treatment plant, centralized system seems great. But on the other hands, the challenge is managing that expensive infrastructure. So in that way, I think going for a decentralized sanitation systems, with well-designed ways to empty the sludge and treat and reuse it would be a much better solution. Because even the countries which promoted the centralized system are now rethinking, their solution is also hard, because they don't know, what could be the alternative to be honest. But in India, we can rethink. Because we have to accept the fact that not every household is going to get sewer lines, it's not going to happen. India will continue to grow. So we need to put more emphasis on decentralized wastewater systems or FSM systems. So in that way, if a city already has the infrastructure to manage sewer lines, which should go with upgrading sewer treatment plants or making sure that we reach the maximum capacity of the treatment plants. But I'm not a huge fan of building new treatment plants. They are so expensive. I think we can just go with decentralized systems.

Q: As an urban expert, what is your view on the roles that lakes play in the city of Bengaluru?

A: Bangalore had quite of a number of lakes, some people claim it to be close to 1000. Today there are very few lakes of a good quality. In terms of overall role of lakes. They help regulate temperature, they attract bird, they also act as wetlands, because Bangalore also receives huge amount of rainfall. So also provide livelihoods, also supper ritualistic traditional roles of lakes. In that way, lakes have played a huge role and some of the neighbourhoods have been built after lakes. Some of our bus stations and train stations have been built on lakes as you know. And as a result, water logging is a huge challenge in some of the result in some of the neighbourhoods. There is a huge environmental .. Okay is a very anthropocentric way to think about it, but in terms of aesthetic and environmental value of lakes cannot be debated at all. But on the other hand, managing a good lake, at the end of it, very much relies and depends on managing our wastewater. That takes money, and India as a society is interested in paying for everything else, we are happy to pay for our mobile phone plans, our cable television, eating out in these fancy places, buying things, whatever. But when It comes to paying for sanitation services, I don't think India as a society has realized the value of proper human waste management, because COVID itself can turn into something ugly. Right now, sewage is not contributing to the spreading which is very nice, but let's say if it mutates and sewage becomes a major carrier. Sewage ends up everywhere in India. So, there is that challenge. So that way I think people have to start seeing sanitation as a fundamental right, it is also the duty of citizens to pay for those services. In a society where everything gets politicized. Our politicians, they don't want to charge for sanitation. So almost 85 percent of the utilized water when it enters as wastewater, why is it that, 10% of your water bill is for sewerage

management you know. It's time that we start paying for real sanitation services. But that also means that certain sections of the society who will not be able to afford. As you can see, because of this, our lakes will continue to suffer, and they will continue to smell. Our fish. You think of lake as an ecosystem and if the lake is not going to be healthy, the whole ecosystem is going to fall apart. So, it is very essential that we rethink, the necessary conveyance and treatment infrastructure.

Q: Citizen involvement in lake rejuvenation

A: Lake rejuvenation as I said, have been mostly because people have to live right next to the lakes. Feacal sludge on the other hand, is transported and disguised and dumped in ways people wouldn't even know. But you can clearly see sewage flowing into your lake and you can trace it back. So in that ways, people say, “Ok I have to live next to these bodies” and also several people have been going back to India and they have seen what it could be when it comes to a lake. Like you have seen right? How in Europe a look could be a wonderful place for a community. So there is this alternate vision that many people are getting. “Oh, you can actually manage a Lake really well, a community could be strengthened, even healed or nourished by lakes” And there are these ornithologists and bird watching hobbyists who are realizing the value of lakes. And Bengaluru is becoming hotter and hotter day by day, so there is that and there are also people who are contending, “Had we managed our lakes well, we would not have required to being water all the way from Cauvery, Mysore” Bangalore had enough lakes to manage its water. So it’s also an issue of water security, if you think about, managing lakes properly.
But I don't really see the way, how citizens are getting involved in reclaiming the lakes that type of participation is not there when it comes to faecal sludge management. Though faecal sludge management has an impact on lakes, people don't see that as.

Q: Finance in FSM or sanitation?

A: Faecal sludge management, there is nothing. The city has not set aside anything. But on the other end, BWSSB gets its money directly from its state government. Now it’s not even through BBMP. It is very politicized, it all depends on, there is no real transparency on how BWSSB plans to expand its infrastructure or prioritize the expansion of infrastructure. Also there is a huge politicization of example you might know that 110 villages are going to get sewer and drinking water. How are you going to choose these villages, then MP DK Suresh, he decided to go with some of the sets of his villages. And the other villages now have to wait till certain reservoirs are built, and they will not give water connection unless there is sewer connections. So if you are getting water connection, automatically sewer infrastructure will also be laid out for you. It's a usual disaster of lack of planning, or any type of vision when it comes to our own political entities. And right now lakes as you know, is still divided when it comes to its administration. BDA, LDA, BBMP, Forest department, PCB, they all continue to work on lakes. I think couple of years ago they might have simplified their administration of lakes. I don't know if that has been implemented or not but is also a challenge.

Q: What are some indicators of a healthy lake?

A: I don't think my indicators are going to be any different from, scientifically established indicators. But a social indicator would be for me, more than the environmental indicators, A social indicator would be that, how, people will value and understand that not one particular community has a claim over the lake. For me, a good harmonized balanced claim over a lake would be to understand that lakes have continued to provide livelihoods for certain communities. Lakes have existing before these apartments have and these communities have been relying on these lakes for a long time. So trying to create that balance, for me a good indicator is understanding different utilizations of the lake by different stakeholders shows how engaged these communities are with respect to that lake and also, that engagement shows that how much these people are really involved in its management. And also, the management should be such that, one thing our government or society is doing is that, they think the community should manage these things, I don't think communities should manage these things. Government is there for a reason; BBMP is there for a reason. This whole idea of participatory governance, I don't think I should be responsible to manage the lake in my neighbourhood. Yes, ask me certain question, help me decide whether I want fishing to be allowed or I want boating to be allowed, but don't dump the responsibility of managing the lake on me. Why should we have government then. That is also a good indicator for me wherein the community continues to benefit or enjoy, it also has a say in how the lake needs to be managed. But it doesn't do the complete management. By management, finance, everything. Now you have the lake development committees, right? Why should they exist? As if they have nothing else to do in life? The reason why they exist is that there is a lack of governance and these government bodies use that as an opportunity to evade their responsibilities further.

Reference code	Recorded?
ESI-016	Y

Q: While you worked in Bengaluru, what did you observe in terms of wastewater management in the city?

A: My first observation is sewage treatment plants which they claim to be functional and operational are actually either running under low capacities or they are poorly operated. That's the reflection you see in terms of waterbodies, in terms of pollution that is happening.

When it comes to small-scale sanitation systems, nobody knows how many systems are there and many of these systems are not functioning very well, there is no proper institutional ownership of these systems. So many of these systems are not functioning and in the absence of sewerage network, most of the wastewater is connected to stormwater drains. As storm water drains are designed to discharge, water into urban waterbodies, it is resulting in contamination.

The second thing. When it comes to the functioning of these systems, when systems don't function yes, waterbodies get contaminated. And when waterbodies get seriously contaminated, when the news hits headlines everywhere, that's when they react more violently, in the sense that institutions impose strict standards and start monitoring heavily. Even though KSPCB is responsible for monitoring all the systems, they have extensively monitored only systems around Bellandur and Varthur lake. There are lot of small-scale systems around and they consider that they don't function very well. That's one of the reasons these lakes are contaminated. If you go the PCB and ask them a list of the systems or the monitoring status, what they have is very recently conducted monitoring reports. And more often visited these plants, about 600 odd around and Bellandur and the other lakes. But they do not consider the slow contamination that's happening in the rest of the lakes. Again, for the same reason that these small scale systems are not functioning well.

So, in due course of time, I got into understanding the dynamics and mechanics of large scale systems as well. It's like when you open a window, dust and wind, they both come in. So, when you start digging about small-scale sanitation systems, eventually, you will also get to know about largescale systems and about their functioning. Because most of the time, the debate goes around "Small scale Vs Largescale" instead of "Small scale & Largescale".

Second observation is that, whenever these systems are functioning very well, both largescale and small scale, the end use/reuse is efficient. So if there is a profitable reuse, these systems are working very well. Let it be for sale, example the Yelahanka one which sells treated wastewater for the airport or the other ones which sells to Cubbon park. If reuse is covering some of the cost, the systems tend to be efficient because there is a demand from the buyer that the water has to be of a specified quality. In small scale systems there are many other factors that comes into play.

Q: What was your observation on the performance and ownership of the largescape systems?

A: I have limited information on the ownership, but in terms of performance, the systems which were sold as best practices when people went there to see how they were performing, many of these systems were not even running. Somehow the systems are having this status. And somehow it surprises me that the state government also believes that these systems are performing very well in Bengaluru. It has been portrayed that way, this is something I understood from my interview even though I couldn't document these points as it was not useful for our project.

Q: In a city like Bengaluru, where there is always a demand for water, why do some systems have a possibility to sell treated wastewater, while others don't?

A: This question, I would rather answer for small scale systems where I covered much ground. It is a mandatory enforcement of consuming all the treated wastewater which is the Zero Liquid Discharge. It is a bit of contrary because people claim it but on ground, we could not trace the original document of it. But this is the conception that still exists among all the private players as well as residential associations.

The second one is, wherever systems are functioning, some of them could see potential benefits of it. If the system is performing well and they can consume 25-30% of the treated wastewater the apartments, considering the water price which is higher for individual house.

The moment they made it a legal enforcement and you have this fear of penalizing, at least in the last 4-5 years, ever since the first Bellandur issue happened in 2014 or so.

There is no formal reuse market in the city. It requires mapping of all potential treated wastewater consumers at the same time BWSSB has to mandate the former to consume treated wastewater with enforcing legal and regulatory framework. Although organisations like CDD initiated platform like ‘Pani Danda’ due to less demand for treated wastewater it never really took off. Many states are drafting Reuse policies to ensure all STPs sell treated wastewater for economic returns (E,g. Tamil Nadu Wastewater Reuse Policy). Quality control of treated wastewater is another aspect.

Q: How are these systems being monitored? Is there a protocol for BBMP or BWSSB to check the systems?

A: When it comes to the monitoring the government protocol is, there are two ways of monitoring:

1. Declaring the status of your sanitation system once in 3 month, 6 months, 1 year. This depends upon the category the PCB has developed. Red, Orange and Green.
    a. Red – High polluted, industrial treatment plants | once in 3 months

b. Orange – 600/ 650 KLD systems (Subject to change, need to check) | once in 6 months. Please validate this information with KSPCB website. It keeps changing.
c. Green – once in a year

They are required to send NABL certified test laboratory reports of the treated wastewater.

Pollution control board also has to pay a visit because the pollution control board is also legally mandated to monitor these system as per the water act. They have to send out a staff as per their timeline. If it doesn't meet with the discharge standards, they are issued with a “show-cause” notice. The system has to be repaired in a given period of time. The pollution control board may or may not come after issuing the show-case notice. The PCB is staff crunched, they are financially independent because they have to run their organization based on the fines. That’s their major source of funds. They are of course exceptions but they always staff crunched. They do not have an appropriate consolidated database of the systems with the exact status of the systems. The number of these systems is also subjected to controversy. PCB on the one hand says there are only 900 such systems but the PCB in response to RTI act said there are about 4000 systems which applied for consent to establish. Based on my interviews with the private companies which implement these systems, there are at least 3000+ of these systems.
We don't know the exactly how many of these systems exist but definitely above 3000. That is something we were able to find out.

Who’s responsibility is this, is sometimes a question in other cities?

When an apartment is constructed, it is the responsibility of the real estate company to design a well-functioning treatment plant. When they hand over the responsibility to the residents’ welfare association, the residents are not even aware if STP is mandatory in an apartment complex. And even if is it there, how does it look like, there is no way for residents to verify and validate the STPs. Many cases, the residents were fooled, someone constructed two big water tanks and said “This is the STP” and they left. In cases they didn't even construct an STP. After 1 year when the apartment received electricity, KSPCB sent them a notice to construct an STP. Because the building was squeezed in a small space, they didn't have any.

Also they act vigorously when an issue arises. One of the outburst is that, all apartments 20 and above, existing and new ones, were asked to construct an STP. There was a Bengaluru RWA conducted protests and organized symposia to discuss this issue with BWWSB and Mr. Kodavasal. Finally, they came to their senses and changed from 20 to 50 households, but they did not skip the clause or exempt existing buildings. Out of compliance fear, some of the buildings were able to construct an STP. But many of the companies said that STPs can't be constructed because of lack of space. So it created chaos for a period of time. One case, when a private company from kerela was asked to construct a sewage treatment plant, they didn’t check for the space and dug up. And the next day, the building started to shake and they immediately the put back the excavated soil. So if the pollution control board when they issue something, it just has to be complied unless they themselves exempt it. Some cases, they gave exemption, although it was not documented.

Q: what is your opinion on the role of SSS on urban sanitation and waterbodies?

A: To begin with, if a city is built as per the masterplan, then largescale sewage systems can be recommended from a planning point of view. But for largescale systems to function effectively, you need:

1. 24/7 water supply and the 120 LPCD capacity
2. 24/7 electricity
3. Financial resources to run the treatment plant.

Unfortunately, the city is not being built as per the masterplan and while the city is sporadically growing, how one can rely on just one type sanitation system?
There is a kind of mixed urban growth when it comes to population density and income groups. Almost every city has not less than 20% slum dwellers, so when such inequality exists, there is always a need for different scales of solution. That way, FSM, largescale treatment, small scale sanitation systems have to be part of it. And if you have to link waterbodies, there are about 170-180 lakes if I'm not wrong. If you look at how lakes function, they have a cascading effect. One lake feed into the other one and they are interconnected. But of course, the interconnections have been largely disturbed by encroachments in many case.

Treated wastewater has to find its way. 100% of the wastewater can't be consumed, if 50 percent of the wastewater is consumed, that is really a record. Considering our domestic needs, there is only a certain amount that can be consumed for secondary uses like construction ect. For any of the commercial activities, there needs to be a platform for buying and selling treated wastewater or channels to distribute them. When reuse infrastructure does not exist, the better option is to discharge the wastewater as long as it meets the discharge water quality. I mean, desirable standards… standards is another issue. I will come to that later.

As long as they are discharging the treated wastewater into stormwater drains and storm water drains lead to waterbodies. That way they can help, but there is a small barrier to it. Storm water drains are controlled by BBMP whereas water supply and sewerage is controlled by BWSSB. So treated wastewater to be discharged into stormwater drains, they need permission for that, and this also one of our recommendations in the paper. Again, we need to reconsider the design of stormwater drains, because stormwater drains are generally designed based on the amount of rainfall. This also have to be factored in. And in Bengaluru, there are plenty of lakes where treated wastewater can be used to fill in. But then filling is not just one point. There are three layer on things.

1. There needs to be a robust monitoring to ensure treating the wastewater
2. Ensure local waterbody is not contaminated by other sources, there are other channels where industrial wastewater is contaminating the waterbody. This is exactly what is happening in Malaysia, all the treated wastewater from 8500 SSS are discharged into waterbodies. There the standards have been relaxed.

Q: In the past 5 years, the standards have been changing a lot in Bengaluru, what was going on? What were the implications of the same?

A: First when the Bellandur issue happened, the standards were set to 10 BOD and it was damn stringent. When we spoke to Sharath Chandra, the ex-chairman of the

pollution control board, who is retired now. He gave the narrative that, when we say 10 BOD atleast then systems will reach 30 BOD. So that's the premise for it. So if you say 30 BOD, you will reach 50. This is one narrative from their side. After that, NGT came into the picture and MOFCC again increased the standards, and they nationally made it 10 BOD.
X from the CPB himself said that 10 BOD is not possible and few months after his article the standards were revised. After that, someone filed a case in NGT that the standards are relaxed, and they wanted to impose stringent standards. The technical people who supported the argument from NEERI, IIT prepared a report and finally NGT issues new standards, 10 BOD but CPCB has to distribute it and circulate standards to everyone. But that hasn't happened yet to my knowledge. The whole point of changing standards is that they think it would make the systems efficient. With growing media covering all pollution related issues, it brings more pressure. There is also certain lack of understanding from purely educational institutions and hardcore researchers. They look at it completely from a research perspective, ASP reaches 20 and MBR reaches 10, SBR reaches 10, yes. But systems reaching under ideal conditions and systems reaching under this condition, reality is not taken into consideration.

Also, there is one standard for everything. For a country like India, where there is geographical diversity plus, diversity in terms infrastructure and inequalities. So one rule book doesn't work out. So, they should have different standards for different scenarios. In 1981 standards, they are very categorical, and they have considered different parameters and different contexts, that is something that is missing in the whole discussion.

Even after coming up with standard, how are they going to enforce it is the biggest question. Standards are relative. The system on Monday reaches 15 BOD and the same system on Tuesday it might reach 20 BOD. There are lot of variable factors which can influence the performance of the system.

Q: What is happening in the realm of FSM in Bengaluru?

A: One thing is that we know what happens when faecal sludge is collected from pits and transported through desludging trucks. Not all sewage treatment plants have permitted desludging trucks to discharge the Faecal sludge into their facility. So, the easiest and closest option for them is, and also from an economic point of view to travel 30 or 40 km to treatment plants if they allow it. So, what they do is that they dump it in waterbodies. It is a known thing and its known to everyone. So, it definitely it has an impact on waterbodies. There is no doubt about it. Personally, I witnessed desludging trucks FS in water body near Rajarajeshwari nagar several times despite the presence of an STP in less than 3 kms of distance. Like I said before, different scales of solution is required for cities, so FSM has been encouraged. Because around 30% of households in India are still relying on on-site sanitation systems including pit-latrines and septic tanks.

In small and medium towns, they have group housing systems, they either has septic tanks or they discharge in storm water drains. So that is one the reasons FSM has a prominent in protecting 4000+ cities.

Q: How are the guidelines from the CPEEHO manual being practiced?

A: The CPEEHO manuals are being revised. The city sewerage was revised recently in 2015. Now they are working on water supply and other manual to revise it. The implementation of CPEEHO guidelines, let's talk about septic tanks. There is a recent study done by CPR, Neha Agarwal is one of the core researcher. I recommend that report to you. I did not visit these systems. There are different sizes of these systems and the reason they build such big system is because they don't want frequent desludging. It depends on the financial ability of the houses sometimes. From this report I can already say that, in many cases, it's not following the CPEEHO guidelines.

Q: You as an urban planner, what is the role of waterbody in a city like Bengaluru?

A: For a city, greenery and urban waterbodies improve quality of life drastically. Greenery has its own benefits and waterbodies in terms of the aesthetics. Design and aesthetics have a huge psychological impact. If you see the issues of traffic congestion, congested streets, building bylaws and availability of space, all these create some form of stress. So, greenery and waterbodies have a positive attitude on the wellbeing of the people.

Q: Beyond that, what would be some of the indicators for a healthy waterbody to you? If you were a decision maker.

A: Let me put it a top-down approach. First all lakes need identified catchment areas. All construction in the catchment area needs to be stopped. If there is also a possibility to demolish existing construction.. I know I'm slightly going above and being less practical. If there is a possibility to rehabilitate the settlements, it has to be done. When it comes to storm water drains and footpaths, they can be designed in such a way that water can be percolated in to the ground. So instance, the systems that are built in Australia. The porous stormwater drains will reduce the flows, so while in the design phase this has to be considered. BBMP giving permission to all treatment units, if they treat and reach certain limits, permission has to be given. The monitoring of the lakes have to be carried out by third party or pollution control board with sustained financial resources. Just having a monitoring body with financial resources doesn't make sense, again it works the same way. The third party can be funded by CSR or lake groups or so. Ensure that they keep frequent reports of it and a checklist of water quality, encroachment, quality and measuring aquatic life.

Now coming to the association level, the associations around the lakes should have partial responsibility to monitor the lake. Every apartment has a RWA and the lake that is close to them, everybody would their waterbody to be clean. Whether they want their sewage to be treated or not, they definitely want the waterbody to be clean. Transferring financial responsibility wouldn't be viable because we are already taxing people. Taking the responsibility of monitoring and registering the status of lakes every month is important. Conducting competition for best lakes within the city. This competitive spirit will ensure that something at least happens.

Q: What determines a clean lake?

A: One is the physical & chemical parameters and the aquatic life. In one of the lakes (ambalipura) where interventions are being planted, there about 40 species of birds came back to the lake region. That could be a dependent factor.

For the competition, the RWS who are regularly updating the status of the lakes can be the grounds.

In lake rejuvenation programs, what can be done is, having a matrix of 4 different zones, Red, orange, yellow and green. Place the lakes based not only on pollution but also on effectiveness

If we have lake conservation plans and know where lakes can be allowed, it helps. CSR funds, many organizations are interested in spending money in beautification projects. There is a strong incentive for them. That way, identifying lakes which can be redeveloped so that CSR funds can be utilized.

If lakes are also made economically productive with BBMP converting it into recreational areas such as parking, boating, which can feed the whole monitoring costs and maintenance costs.

All the recommendations for institutional and policy without financial resources would be less practical.

Dumping of construction and demolition waste is another major source of lake pollution besides solid waste. Therefore, contaminants in lake are not always because of sewage. That's another aspect to be considered while linking wastewater pollution and urban water bodies. Every time a sewage treatment system is temporarily non-functional contamination levels increase in urban water bodies. In a year a few days to weeks many STPs (small-scale and large scale) can remain non-functional for various reasons leading to higher contamination of lakes. Absence of adequate monitoring system does not provide details on volume of wastewater discharged into water bodies. These pollution costs are never identified and collected. Countries like England also discharge untreated wastewater into water bodies (according an article on The Guardian), however there is some form of accountability and transparency in developed nations.

Reference code	Recorded?
ESI-17	N

Q: What was done by your team for the LHI

We created a method were citizens are not involved with chemical testing of the lake water.

We use visual inference for normal layman using the colour, smell ect. Another example is to take water in a jar and see if the green algae in the water settles or floats. In addition to that, we monitor the migratory birds. We realized that certain birds only stay near murky water.

Fishes are another important criterion for our assessment, the fishermen know well about the lake and we look for minor carps fishes such as tilapia, catla, rogu which indicates that the lake is good. But tilapia is an exotic species which survies in harsher environments, so it is a risk.

We also ask the citizens to check for pH using litmus paper.
We look for open sewer connections and effluents into the lake. We also see the presence of wetlands/ marshlands. They act as a major nutrient absorption system.

Based on all these, we send for experts to conduct the chemical analysis for nitrates, phosphates, sulphates, EC.

Q: What is the aim for starting this community monitoring plan?

Bengaluru is a city with awareness and activeness among the citizens, which is leveraged to create this program.
The alarming situation in Bellandur lake caused people to get informed and aware. The government also invests, but its only for infrastructure around lake like bicycle paths, bunds, walking paths, ect. People think government works so why we should get involved.
They see that the lake looks nice and they don't mind. But now there is an aware created among the people that it is the “quality of water not quality of ambience” which is important.

Reference code	Recorded?
ESI-18	N

Q: Lake rejuvenation activities by BWSSB

A: 7 stages of rejuvenation

- Create buffer zone
- Stopping the entry of wastewater
- Creation of wetlands or STPs for treatment

Q: What about citizen involvement?

A: Citizen involvement is good for rainwater harvesting and to identify leaks in the connection etc. but there is a major challenge with the tariff. They only pay peanuts for water and their willingness to pay is very less. On a scale of 1 -10, they score a 8.

Q: What is the challenge with sewer infrastructure for BWSSB?

A: No issues with sewer connection. Only the topography matters and it's a matter of time before they receive the connection.

Q: Main reasons for lake depleting?

- Untreated sewage dumping
- Lake encroachment
- Excessive groundwater extraction → It leads to drop in water level and hence encroachment is even more severe.

Q: Roles of lake in city of Bengaluru?

A: Initially there were 300 odd lakes but presently only 70-80 are liveable around them.

- Groundwater recharge
- For livelihoods
- Urban heat sink: Bengaluru’s celebrated climate is due to the lakes
- For stormwater storage → Groundwater recharge