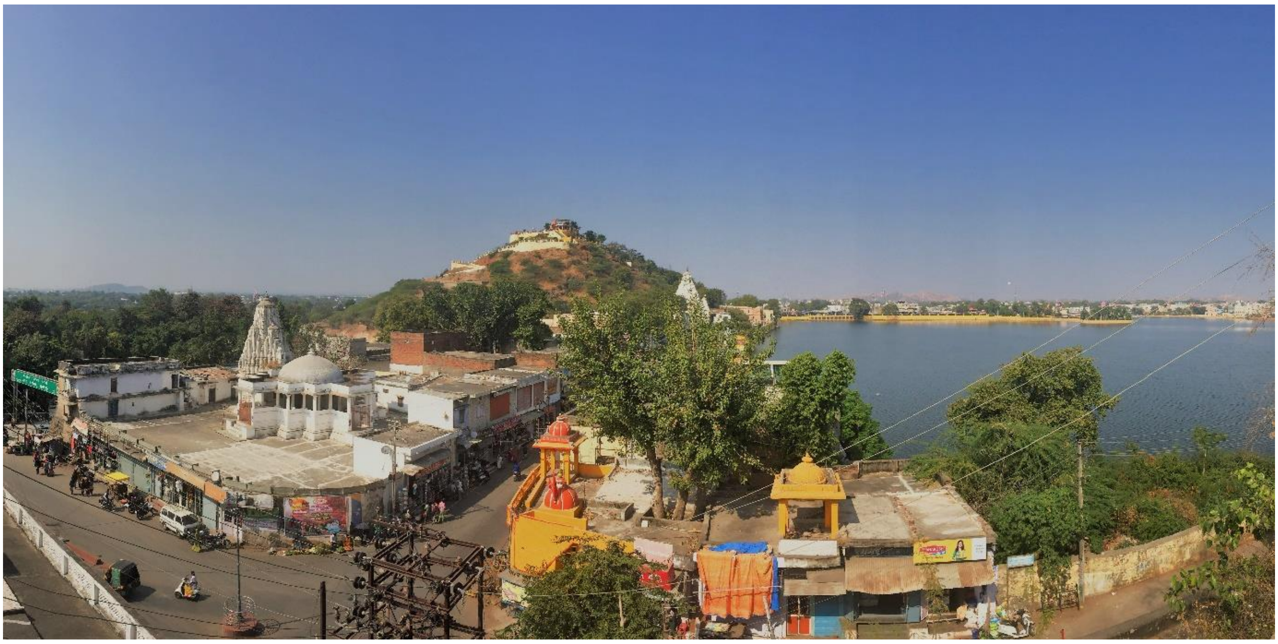
Sanitation Capacity Building Platform

INTEGRATED WASTEWATER & SEPTAGE MANAGEMENT PLAN

Dungarpur City



National Institute of Urban Affairs

ECOSAN SERVICES FOUNDATION

Integrated Wastewater & Septage Management Plan for Dungarpur City, Rajasthan under the Sanitation Capacity Building Platform

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List of abbreviations

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ABR	Anaerobic Baffled Reactor
AF	Anaerobic up flow Filter
AS	Anaerobic Settler
BMGF	Bill and Melinda Gates Foundation
CAPEX	Capital Expenditure
CT	Community Toilet
CTP	Co Treatment Plant
CPCB	Central Pollution Control Board
CW	Constructed Wetland
DTS	Decentralized wastewater Treatment System
HDPE	High Density Poly Ethylene
IEC	Information – Education – Communication
IHHT	Individual Household Toilet
IWSM	Integrated Wastewater and Septage Management
MBBR	Moving Bed Biological Reactor
MoUD	Ministry of Urban Development
NIUA	National Institute of Urban Affairs
OHT	Over Head Tank
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PHED	Public Health and Engineering Department
PT	Public Toilet
RUIDP	Rajasthan Urban Infrastructure Development Project
SBM	Swachh Bharat Mission
SBR	Sequential Batch Reactor
SCBP	Sanitation Capacity Building Platform
SBR	Sequential Batch Reactor
SLB	Service Level Benchmarking
SOP	Standard Operating Procedure
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
ULB	Urban Local Body
WTP	Water Treatment Plant

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1 Introduction

The Sanitation Capacity Building Platform (SCBP) is an initiative by Ministry of Urban Development (MoUD). The purpose of the platform is to support the and build the capacity of the cities to plan and implement decentralized sanitation systems. Decentralized sanitation is the key solution to accomplish the Swachh Bharat Mission (SBM), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Smart City schemes.

The National Institute of Urban Affairs (NIUA), under the MoUD, was appointed to build the capacity of governments at all levels and other sanitation actors, on decentralized sanitation. A sanitation capacity building platform was created in March 2016 at NIUA, which acts as a hub for knowledge sharing, collaboration and training among local organizations and government bodies.

The Bill and Melinda Gates Foundation (BMGF) is supporting financially in establishing, and strengthening this sanitation capacity building platform. This platform is pivotal to ensure urban local bodies and other actors in the sanitation system obtain the knowledge and skills required to effectively implement decentralized sanitation. This will not be a "one size fits all" approach. Rather, the platform will work with cities and states to analyse their situation, and to develop and offer appropriate capacity building activities addressing each area's unique needs and ambitions, walking alongside each urban local body (ULB) as they plan, implement, and maintain decentralized sanitation systems.

The activity of developing an Integrated Wastewater and Septage Management (IWSM) plan for cities and towns is integrated into the SCBP with an aim to provide hands on experience to the ULBs in holistic planning of the sanitation systems and services for the city.

1.1 Objectives

The objective of the process of creating an IWSM plan is as follows;

- To assess the existing infrastructure and proposed projects with respect to sanitation and wastewater in the ULB boundary.

- To provide an intermediate plan to the ULB until it has the financial and institutional capacity to have sewerage and centralized Sewage Treatment Plant (STP).
- To develop an integrated approach to help the ULB to extend the sanitation services to masses in limited time available.

1.2 Scope of work

The scope of work of this study is limited to preparing an integrated wastewater and septage management plant for the city which will act as an intermediate solution for the city until the city is ready in terms of financial (operation and maintenance (O&M)) and institutional aspects to have sewerage and centralized STP.

1.3 Organization of the report

Chapter 1 *Introduction*	Presents the introduction to overall objectives and scope of work. It also describes approach and methodology.
Chapter 2 *Project Area Description*	Describes the project area with respect to demography, climatic conditions and geotechnical and hydro geology of the region.
Chapter 3 *Assessment of water supply*	Details the current situation of the water supply in the town pertaining to source of water and supply details.
Chapter 4 *Assessment of Wastewater Management*	Details the assessment of the wastewater management in the city across the entire value chain ranging from the collection to the disposal of the wastewater including the links of conveyance, treatment, reuse and recycle, if any. Evaluates the potential for reuse and recycle of wastewater in the local context given the agrarian dependencies and local citizen needs
Chapter 5 *Potential reuse/recycle of wastewater*	
Chapter 6 *Project Concept & Design*	Depicts the feasible project concept and design based on the studies and assessments carried out within the contextual framework of the city.
Chapter 7 *Project structuring*	

1.4 Methodology

One of the objective of the process of drafting this action plan was to provide hand holding to the ULB officials. It is of utmost importance to understand the wants and the demands of the city before initiating the planning process. This helps to conduct the planning process in the right direction. The methodology adopted to create this document is as follows;

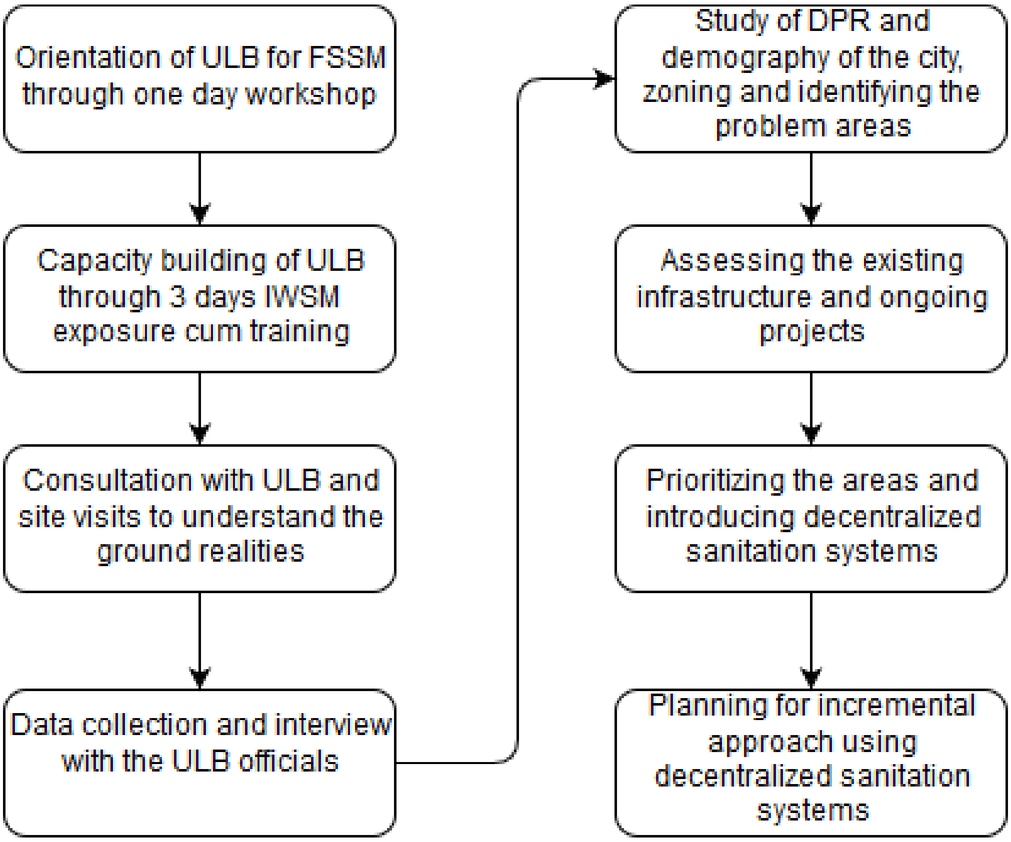

FIGURE 1: METHODOLOGY FOR CREATING THE IWSM PLAN

The ULB officials were part of the orientation workshop on FSSM held in Udaipur on September 19th, 2018. The orientation workshop helped the ULB officials to understand how to make the city ODF and how to sustain the ODF status once achieved.

The commissioner and the A.En. of the Dungarpur Municipal Council was also part of the three-day IWSM training cum exposure visit at Pune. This training was held on 9th – 11th October 2017.

Accordingly, consultation visits were arranged to the city of Dungarpur. The technical experts along with the associates from NIUA visited the city three times. The details of the visits along with its objectives are listed below;

Table 1: Details of the visits conducted under SCBP for the drafting of IWSM plan of Dungarpur City.

Date	SCBP team	ULB officials	Objectives
September 18th 2017	Mr. Dhawal Patil (ESF) Ms. Jyoti Dash (NIUA) Mr. Mohit Kapoor (NIUA)	Mr. Kharadi (Commissioner) Mr. Gupta (Ex. Commissioner) Assistant Engineer Sanitary Inspector	• To introduce the SCBP project and objectives of drafting the IWSM plan for the city of Dungarpur. • To conduct preliminary assessment of the city and its potential for being taken up for the IWSM plan. • Collect preliminary data, DPRs and conduct site visits to various initiatives taken up by the city.
November 27-28th 2017	Mr. Dhawal Patil (ESF) Ms. Jyoti Dash (NIUA) Ms. Amita Pathria (AIILSG)	Mr. K. K. Gupta (Chairman) Mr. Kharadi (Commissioner) Mr. Vikas (A.En.) Mr. Lokesh (J.En.) Mr. Prakash (A.En.) Mr. Kuldeep (Accounts)	• To meet honourable chairman, Mr. KK Gupta to understand his vision towards making Dungarpur a model town. • To collect service level benchmarking data from the ULB. • To collect the financial and institutional data from ULB. • To conduct site visits to solid waste management plant and decentralized wastewater treatment system sites.
January 11th 2018	Mr. Dhawal Patil (ESF) Mr. Mohit Kapoor (NIUA)	Mr. Kharadi (Commissioner) Mr. Gupta (Ex. Commissioner)	• To present the draft of IWSM plan prepared under the SCBP project.

	Ms. Ankita Gupta (NIUA)	Mr. Vikas (A.En.) Mr. Prakash (A.En.)	• To take their inputs in the observations made during the site visits and the assumptions made for the planning process. • To consult regarding the conveyance option, treatment option and disposal/reuse option available in the city. • To have inputs in the prioritisation matrix of the action plan.

FIGURE 2: PICTURES FROM THE THREE VISITS TO DUNGARPUR CITY

2 Dungarpur City

The District Dungarpur is named after the town of hillocks and the capital of the former princely State of Dungarpur.As shown in Figure 3, the district is roughly triangular in shape. In East and North its borders on Banswara and Udaipur District respectively while it adjoins the State of Gujrat in South & West. The Mahi river runs along the western edge of the district, forming the boundary with Banswara district. The Som river, a tributary of the Mahi, runs along the northern edge of the district, largely forming the boundary with Udaipur district.

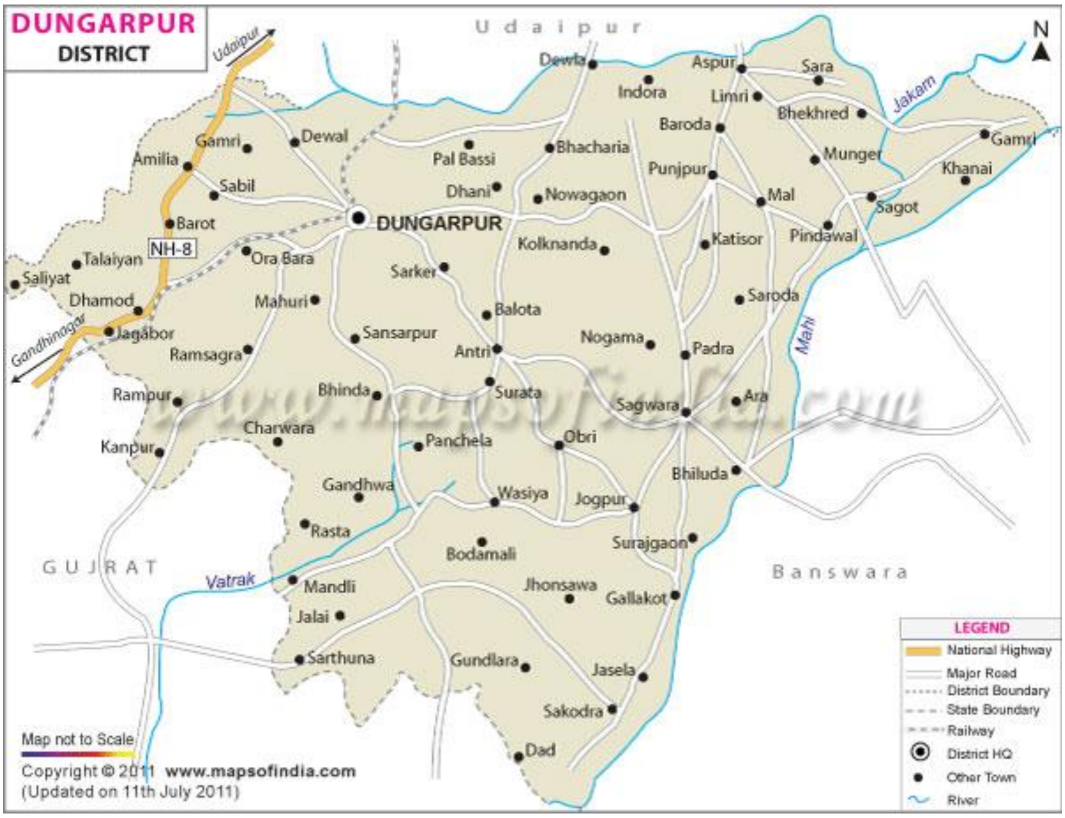

FIGURE 3: MAP OF DUNGARPUR DISTRICT (SOURCE: MAPS OF INDIA)

Dungarpur is a city in the southern part of Rajasthan state of India. It is the administrative headquarters of Dungarpur District. It was founded by Dungariya bheel king in the 13th century. The rail line between Udaipur and Ahmedabad in Gujarat runs through the town, shortest distance to the National Highway 8 from Dungarpur town is 20 km. The most of the part of district is hilly. The elevation is 225 m (738 ft) above MSL. The municipal area of the city is about 10.32 Sq. Km.

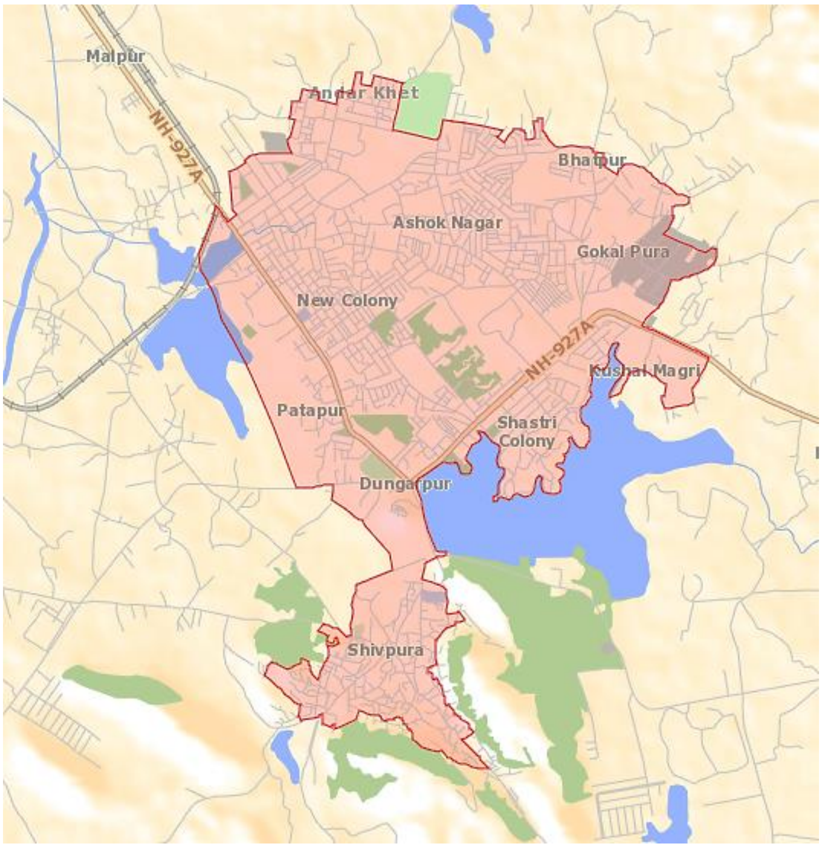

FIGURE 4: MAP OF DUNGARPUR CITY (SOURCE: GOVERNMENT OF RAJASTHAN, RAJDHARA GROUND WATER GIS)

The city of Dungarpur is divided into two parts connected by a bottle neck as shown in the Figure 4. The Shivpura area (south part of Dungapur City) is triangular in shaped and is flanked by hills on the east and the south. It is the oldest part of the city with particularly closely spaced houses and narrow roads. The houses here are mostly double storey. There are lot of old temples and markets in this area. During the ULB consultation it was mentioned that this area is prone to water logging due to heavy runoff from the hills. Henceforth, this area is termed as old city in the report.

FIGURE 5: MAP OF SHIVPURA (OLD CITY), DUNGARPUR CITY (SOURCE: GOOGLE MAPS)

The north of the Dungapur city consists of areas such as Patapur, New Colony, Ashok Nagar, Shashtri Colony, Kushal Magri, Gokul Pura, Bhatpur and Andar Khet etc. This part of the city is relatively well-planned infrastructure and bigger plot sizes. The houses here too are again 2 storeys and in some cases, have more than one family residing in the property. Henceforth, this area is termed as new city in this report.

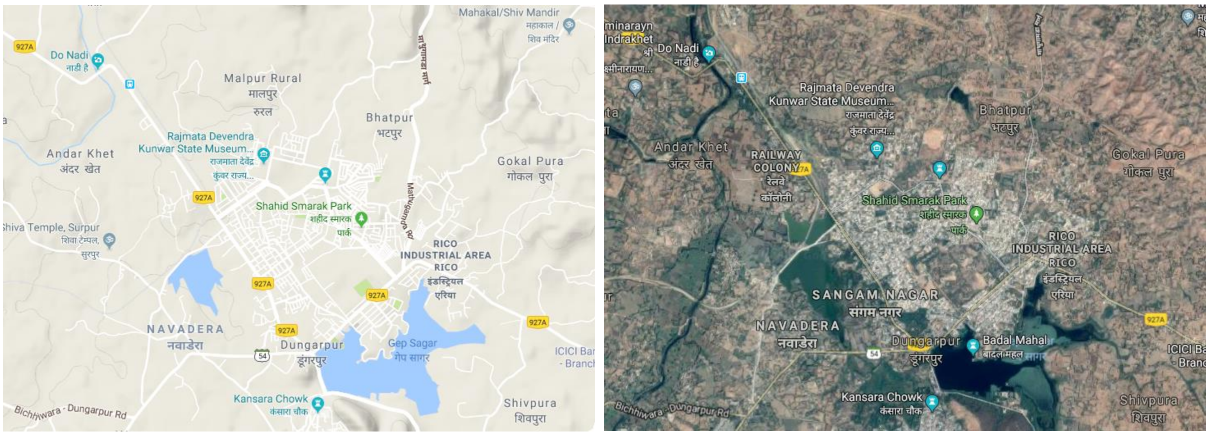

FIGURE 6: MAP OF NORTH PART OF DUNGARPUR CITY (SOURCE: GOOGLE MAPS)

There are three noticeable features in the new city. As shown in Figure 7, there is a railway colony, police colony and a RICO Industrial Area in this part of the city. The biggest industry in the RICO Industrial Area is a dairy industry coupled with small scale industries.

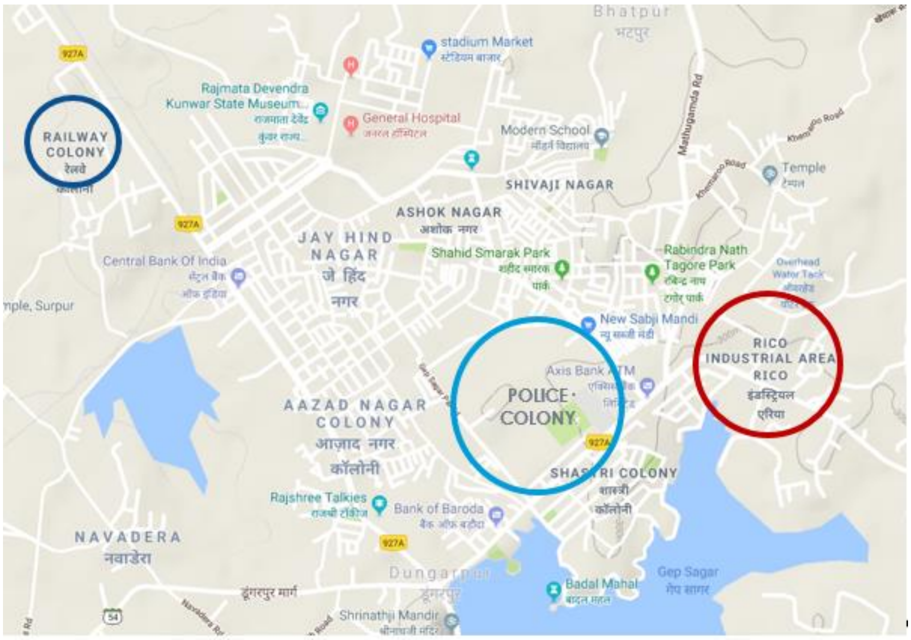

FIGURE 7: LOCATION OF RAILWAY COLONY, POLICE COLONY AND RICO INDUSTRIAL AREA IN DUNGARPUR CITY (SOURCE: GOOGLE MAPS)

2.1 Demographical assessment

Demographics as of 2011 India census, Dungarpur had a population of 47,706. Males constitute 24,900 of the population and females 22,806. There were in total of 13,507 households in the city. There were six slums with total of 1,455 households in it.

Dungarpur has an average literacy rate of 89.03%, with male literacy is 94.38%, and female literacy is 83.24%. In Dungarpur, 11.34% of the population is under 6 years of age. Total children (0-6) are 5,411 as per figures of Census India report 2011. Female Sex Ratio is of 916 against state average of 928.

The current population of Dungarpur City is reported to be close to 51,522 with total number of household approximately 14,720. The average number of person per household is 3.5.

There are 30 wards in the city and the major languages spoken are Bagria and Hindi.

The growth of the Dungarpur City in terms of population is less than 20% which is low as compared to other cities of similar size. The literacy rate is higher than the state average which indicates that effective Information – Education – Communication (IEC) program can translate into creating awareness on larger scale.

Inference can be drawn that the average age of the city is quite less and hence the ULB can develop IEC campaigns targeting this section of the society for effective implementation of the water and sanitation projects in the communities.

2.2 Climatological assessment

The climate of Dungarpur is quite dry. The summer season is hot, but milder than most of the other Rajasthan cities. The average temperature in summers falls in the range of 43 C (max) to 26°C (min). Climatic conditions of Dungarpur, Rajasthan in winters are quite cool. The average temperature ranges between 25°C (max) to 9°C (min). Dungarpur weather experiences average rainfall hovering between 47 cm to 76 cm. The rainfall is limited to 12 –18 days during the monsoon months of July to September.

The climatic conditions favour the biological activity required for anaerobic digestion of the organic load (solid and liquid). The temperature range also favours natural drying process (solids) for at least 10 months of the year.

2.3 Geotechnical and hydrogeological assessment

According to the Rajdhara Groundwater GIS mapping tool of Government of Rajasthan, the aquifer system present in Dungarpur City is of Phyllite. The Geology is mostly Aravalli super group (pink colour) with a strip of Extrusive/Intrusive rocks across the city. Figure 8 shows the details of the aquifer and geology across the Dungarpur City marked in red outline.

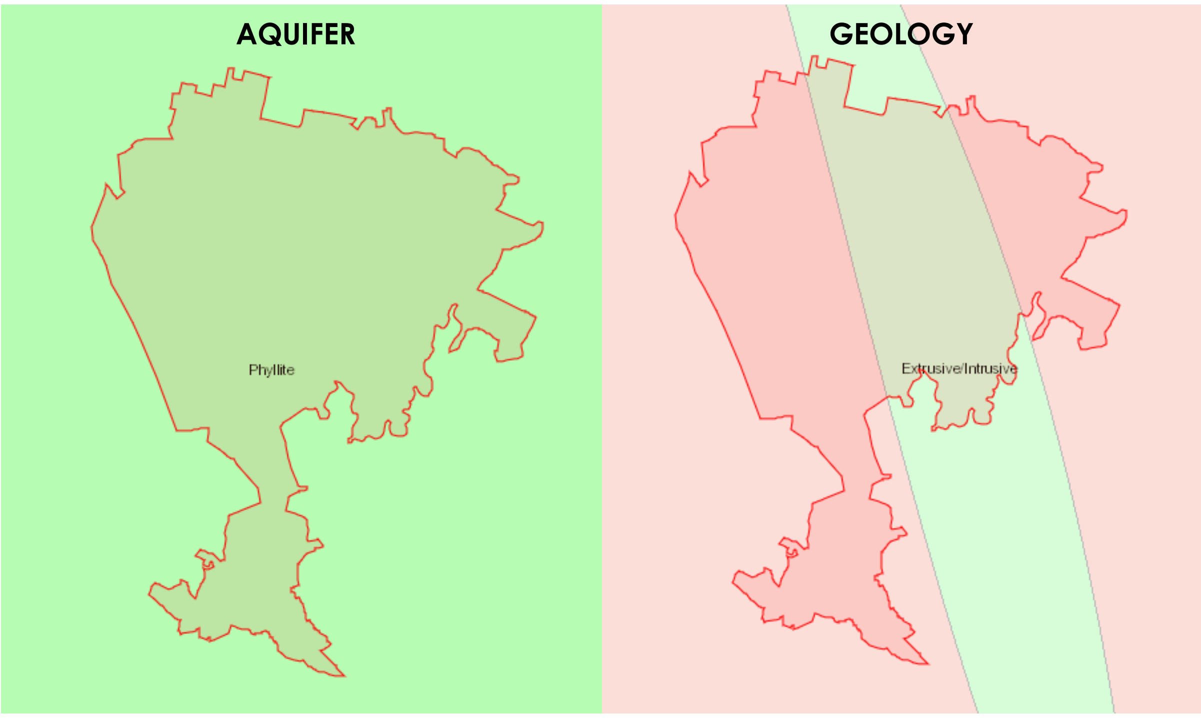

FIGURE 8: AQUIFER AND GEOLOGY DETAILS OF DUNGARPUR CITY (SOURCE: GOVERNMENT OF RAJASTHAN, RAJDHARA GROUND WATER GIS)

The extrusive/intrusive geology suggests the presence of basaltic rock. This is one of the main reasons for formation of Gaib Sagar Lake. The basin retains water dues to its rocky strata. It can be inferred that there is less aquifer recharge though this lake.

The Phyllite aquifer are characterised by; (1) existence of water only in fractures, (2) sustainability of wells is big issue, (3) natural rainfall recharge is very slow and (4) specific yield is less. It can be inferred that the ground water wells are not getting recharged at expected rates and hence in near future there is a possibility of the aquifers running dry.

2.4 Hydrological assessment

There are mainly four lakes in Dungarpur City, (1) Gaib Sagar Lake, (2) Sabela Lake, (3) Sunheriya Lake and (4) Patela Lake.

The main lake is Gaib Sagar which is the biggest of all and is also the main point of interest in the city. The lake has one of the main tourist attraction called "Badal Mahal" and a Boating Jetty. Being the centre of the attraction in the Dungarpur City, the ULB has developed a ring road along the lake and is developing the lake front. The stormwater runoff from the RICO Industrial Area reaches the Gaib Sagar Lake at point 1 through the stream marked in black (Figure 9). This stream also carries septic tank effluent, grey water from part of ward 24, 25, 26 and 27. It also receives industrial effluents to the lake during other seasons, however the quantities are very less as compared to the volume of water in the lake. The natural runoff from the land joins the lake at point 2. The wastewater (septic tank effluent and grey water) from the households located in ward 21 enter into the lake from various small streams located at point 3.

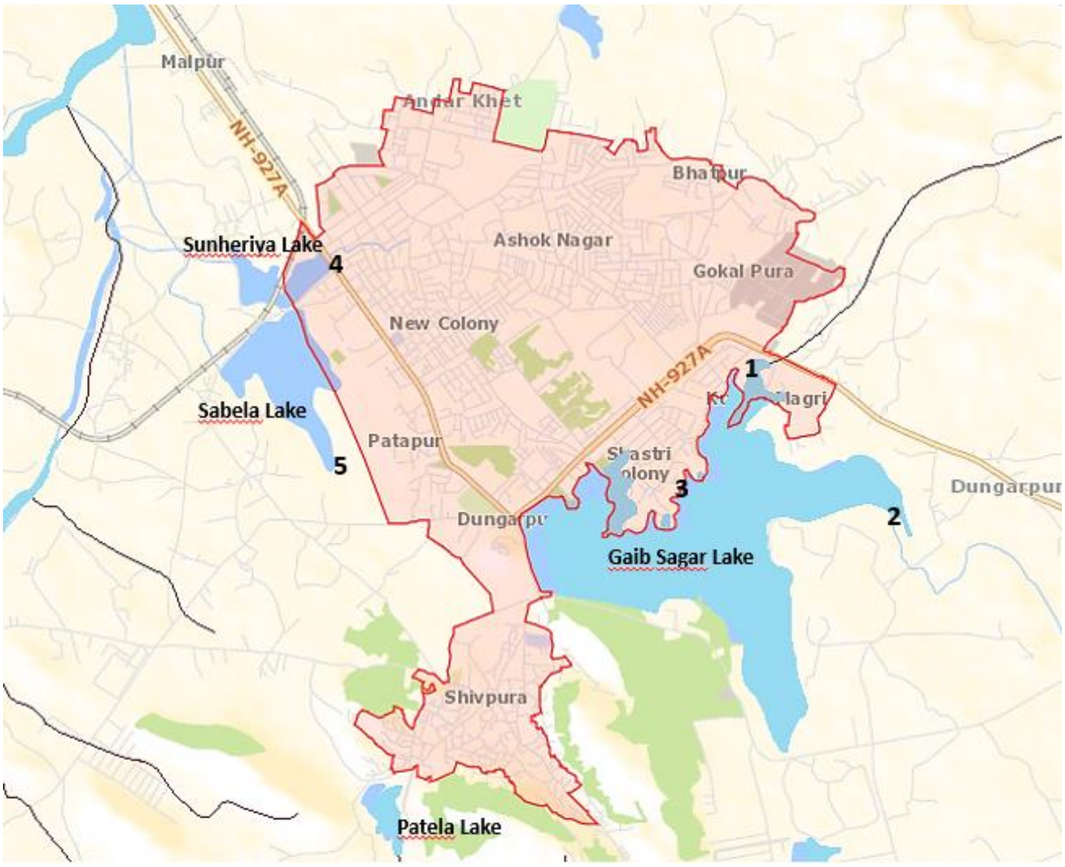

FIGURE 9: LOCATION OF WATER BODIES AND STREAMS IN DUNGARPUR CITY (SOURCE: GOVERNMENT OF RAJASTHAN, RAJDHARA GROUND WATER GIS)

The second biggest lake is Sabela Lake. This lake receives wastewater (septic tank effluent and grey water) of approximately 22,000 persons (2011 census) on a daily basis from households in the wards 5- 20. The stream of the wastewater reaches the lake though open land reserved for park space. During the consultation, the ULB member mentioned that the during summer season, the water drys up and does not reach the lake. The lake is eutrophicated due to organic loading received by the water body. The overflow from this lake flows into the Sunheriya Lake.

The Sunheriya Lake adjoining the Sabela Lake receives similar type of wastewater of approximately 9,000 persons (2011 census) on daily basis from the households of ward 22, 23 and 24. The drain joins the lake at point 4 as shown in the Figure 9. The drainage network here is lined and covered and hence the wastewater reaches the lake though out the year. The size of the lake is small and the organic loading is high; hence, the condition of the lake is in highly eutrophicated state.

The ULB is taking up a project to rejuvenate the Sunheriya Talab. In this project balls made of enamel infused with a particular type of the bacterial culture will be introduced in the lake. These bacterial cultures will help to improve the rate of degradation of organic content in the water. Once the bacterial culture is released from the ball, the balls will float and can be reused.

The Patela Lake is in the south and on the outskirts of the Dungarpur City. Although it receives some wastewater from Shivpura area, the main source of water of the lake is runoff from the nearby hills. Hence the lake is relatively in better condition.

Given the daily inflow of wastewater is reaching the lakes and the water quality is declining at a steady rate, it is important the inflow must be either stopped by implementing a collection network or at least treated before disposal in to the lake. Given the aquifer type and the geology, the water from these lakes will eventually reach and fill up the Phyllite Aquifers in the region and pollute the dug wells and bore wells in the new city.

3 Assessment of water supply

This chapter talks about the existing freshwater management in the city of Dungarpur. The main source of water for Dungarpur city is surface water bodies in the form of reservoirs and ground water reservoirs. Since there was no information available with the city about the water supply, assistance as sought from Public Health and Engineering Department (PHED). The team met Mr. Alok Gupta, Assistant Engineer who sits in the PHED office in Dungarpur. Due to non-availability of the Water Supply DPR, the following information is made available through the interaction with Mr. Gupta.

3.1 Details of existing water supply

Currently the freshwater demand of the Dungarpur city is of 3.5 MLD. Raw water is drawn from two reservoirs namely, (1) Edward Reservoir and (2) Dimiya Reservoir. THe Edward Reservoir is the largest among the two with total capacity of 135 million cubic feet where as the Dimiya Reservoir is approximately 4.5 million cubic feet. The raw water from Edward Reservoir is conveyed to Water Treatment Plant (WTP) located at Bori Village through gravity. This WTP was built in 2009 and its capacity is 3.25 MLD.

FIGURE 10: LOCATION OF THE WATER SUPPLY ASSETS OF DUNGARPUR CITY

The raw water from the Dimiya Reservoir is sent to the WTP located near Udai Vilas Palace using pumps. The capacity of the this WTP is 4.5 MLD and it is approximately 20 years old now.

The water from the WTPs is conveyed to various Over Head Tanks (OHTs) at various places in the cities from where the water is distributed to the houses by gravity. Current water supply at the consumer end is of 70 LPCD. There are approximately 10,000 domestic connections and nearly 1300 commercial connections in Dungarpur City.

3.2 Proposed action plan

A DPR has been prepared for augmenting the water supply to 135 LPCD in the city of Dungarpur. The DPR has been prepared by Ramky Enviro Engineers approximately two months ago. The DPR is submitted and awaiting technical approval.

The DPR suggests to augment the water supply by drawing excess water from Som Kamla Dam. The dam is located towards north east to the city. The Figure 11shows the location of the Som Kamla Dam with respect to the city of Dungarpur.

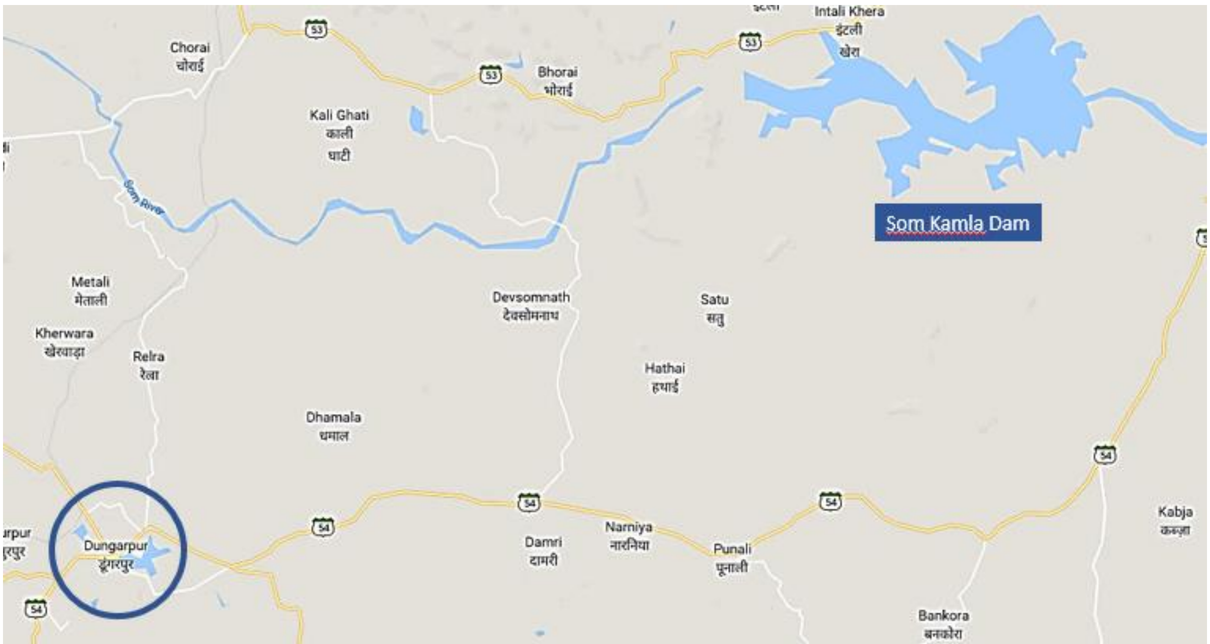

FIGURE 11: LOCATION OF SOM KAMLA DAM WITH RESPECT TO DUNGARPUR CITY

The assistant engineer said even though the DPR is prepared and submitted, it will take substantial time for its implementation. He also said it will be quite a challenge to maintain the continuous supply of 135 LPCD in the city.

4 Assessment of wastewater management

This section will describe the current scenario in the Dungarpur City with respect to five functional groups; (1) User interface, (2) Storage and Collection, (3) Conveyance, (4) Treatment and (5) Reuse and Disposal.

The user interface talks about the access to sanitation in terms of Individual Household Toilets (IHHTs), Community Toilets (CTs) and Public Toilets (PTs). The type of toilet prevalent in the city.

The storage and collection describe the kind of collection system present for the toilets such as twin pits, septic tanks etc. The conveyance talks about how different types of wastewater are collected and conveyed from the consumer end to the treatment point. The treatment functional group talks about the treatment facilities available for different type of wastewater produced in the city. The reuse and disposal section talk about how the treated/untreated wastewater is being disposed of.

4.1 Technical assessment

4.1.1 User interface

According to the 2011 census, there are in total 14,320 households in Dungarpur City. Out of these 14,320 households, 14,230 households have IHHT and the rest 110 households are dependent on CTs. During the site visit to one of the IHHT in the slum it was observed that the standard 4 feet by 3 feet toilet is combined with a bathroom of approximately same dimensions. The black water from the toilet goes in to the septic tank located below and the grey water from the bath fall outside near the outlet of the septic tank as shown in Figure 12.

FIGURE 12: PHOTOS OF IHHT BUILT IN A SLUM IN DUNGARPUR

There are in total 5 CTs in Dungarpur City; the details of which are given in Table 2. The cost of each IHHT is approximately INR 12,000 – 16,000 per toilet and the cost of CT is approximately INR 52,000 per seat.

TABLE 2: DETAILS OF THE COMMUNITY TOILETS IN DUNGARPUR CITY

Ward No.	Location	Number of seats			
		Male	Female	Children	Handicap
Ward No. 19	Basadwara	5	5	1	1
Ward No. 10	Chamanpura	4	4	1	1
Ward No. 16	Bhoiwara	6	7	1	1
Ward No. 7	Khantwara, Maliwara	4	4	1	1
Ward No. 14	Patela, Yadav Basti	5	5	1	1

Dungarpur City also has 8 number of PTs at different public places. The details of PTs are given in Table 3. The cost of PT is approximately INR 52,000 per seat.

TABLE 3: DETAILS OF THE PUBLIC TOILETS IN DUNGARPUR CITY

Ward No.	Location	Number of seats			
		Male	Female	Children	Handicap
Ward No. 23	Old Bus Stand Sulabh	8	4	1	1
Ward No. 29	New Hospital Sulabh	7	5	1	1
Ward No. 3	Syntex Chouraha	3	3	1	1
Ward No. 22	Lakshman Ground	1	1	1	1
Ward No. 22	Collector office	1	1	1	1
Ward No. 25	Outside SBP College	1	1	1	1
Ward No.20	Maharawal School	1	1	1	1

FIGURE 13: PHOTOS OF PUBLIC TOILET (SULABH) LOCATED NEAR THE BUS STAND IN DUNGARPUR CITY

The type of toilets being implemented in the city are flush toilets, either pour flush or cistern flush. These types of toilets are termed as more hygienic and safe for use as compared to any other type of toilet. However, one needs to understand that the basic functionality is dependent on availability of water.

The Dungarpur Municipal Council has developed IEC campaign with a unique strategy. The IEC material developed is being distributed among the households though the school children and competitions were linked to proper utilization of the IEC material. This ensured that the school children as well as the households read the message and followed it on daily basis.

The City of Dungarpur has 100% access to sanitation and is declared as an Open Defecation Free (ODF) City by the Government of Rajasthan. This implies that the citizens are quite aware about the benefits of having toilets how having one enhances the personal health and hygiene.

4.1.2 Collection and storage

As observed during the consultation process with ULB officials, out of the 14,230 households in Dungarpur City, IHHTs of more than 80% households are connected to septic tanks, less than 5% are connected to twin soak pit and rest are connected to kui. It was told by the ULB officials that the septic tanks built under SBM are all three chambered septic tanks.

The Rajasthan Urban Infrastructure Development Project (RUIDP) has prepared a Detailed Project Report (DPR) on wastewater system through consultants Exceltech Consultancy and Projects Pvt. Ltd., Jaipur, Rajasthan. In this DPR although the gravity based separate sewer is proposed, there is not mention of making the septic tanks dysfunctional which is usually recommended in order to efficient treatment system.

4.1.3 Conveyance

According to the Service Level Benchmarking (SLB) 2016, there is only 4.2 km of pucca covered drains in the city. ULB does not have record of kuccha drains and hence it is assumed that the length of drains in total is equal to length of roads i.e. 219 km. During the consultation with ULB it was revealed that during peak summer season very less water actually reaches the Gaib Sagar lake and Sabela lake through point 1, 3 and 5 as shown in Figure 9.

The ULB also has one vacuum truck for emptying of septic tank on demand basis. The ULB provides the septic tank emptying service to the households. The household has to raise the request and pay the money and the ULB office and retain the receipt. Post payment, the ULB dispatches the vacuum truck to the household within next 48 hours. The vacuum truck empties the septic tank and takes away the septage to a faraway site for indiscriminate disposal.

The details of the plan proposed in DPR on wastewater systems for Dungarpur City are given in the Figure 14. According to the hydraulic design, there are ten zones created to have 100 % coverage of the sewerage in the city. The sewerage system is designed like a usual gravity based system and there are in total seven Sewage Pumping Stations (SPSs) in the sewerage network.

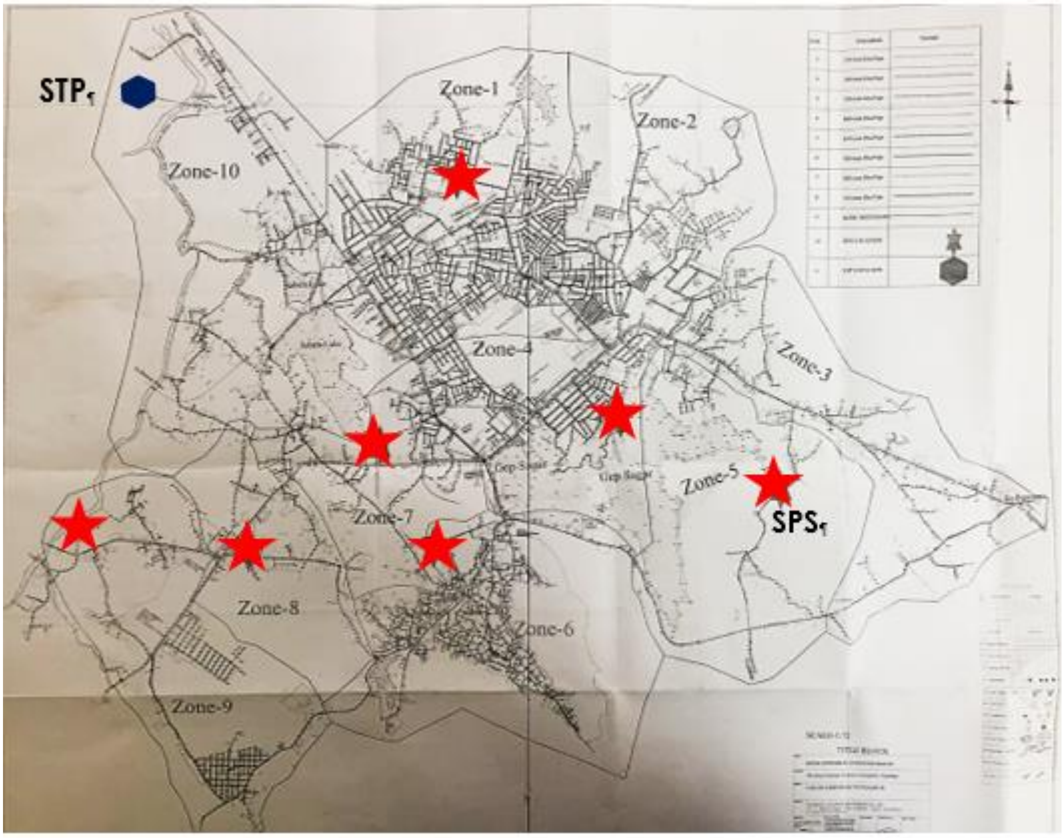

FIGURE 14: HYDRAULIC ZONES, DPR WASTEWATER SYSTEM, DUNGARPUR

Recently the ULB has issued a public notice stating that the private service provider should get empanelled by paying a fee of INR 100 and submitting a form with photo of the vacuum truck and the registration details of the truck. The truck has to be emptied at the solid waste management plant where the new biomethanation plant is being implemented. The tipping off fee is INR 500. It was also notified that a fine of INR 5,000 will be implied if any rules are not obeyed. The ULB offer the service at INR 2,000 for the first trip and INR 1,500 for the consecutive trip. The picture of the notice is shown in the Figure 15.

कार्यालय नगर परिषद डूंगरपुर (राज.)

सूचना

सर्व साधारण को सूचित किया जाता हैं कि नगर परिषद क्षेत्र में बिना लाइसेन्स के सेप्टीक टेंक खाली करना कानूरी अपराध हैं। ऐसा करते हुए पाये जाने पर उसके खिलाफ कानूनी कार्यवाही की जाएगी।

यदि कोई सेप्टीक टेंक खाली करने हेतु लाइसेन्स प्राप्त करना चाहता है तो निम्न शर्तो के अन्तर्गत नगर परिषद में आवेदन कर सकता हैं।

1. आवेदन शुल्क 100/- रू. जमा कराना होगा।
2. सेप्टीक वेस्ट खाली करने वाले वाहन की फोटो एवं आरसी की कॉपी जमा करानी होगी।
3. गाडी के साथ के सभी मजदूरो को सुरक्षा साधन उपयोग में लेने होंगे।
4. सभी मजदूरो एवं वाहन का इंश्योरेंश करवाना होगा।
5. सेप्टीक मल का निस्तारण नगर परिषद के कचरा निस्तारण केन्द्र पर करना होगा। प्रति टेंक खाली करने पर 500/- रू. नगर परिषद में जमा कराना होगा।
6. उक्त नियमों का उल्लंघन करने पर 5000/- रू. जुर्माना होगा एवं कानूनी कार्यवाही की जाएगी।

शहरवासी नगर परिषद से भी सेप्टीक टेंक खाली करवा सकते हैं, जिसका शुल्क 2000/- रू. होगा। एक ट्रीप से ज्यादा मल होने पर प्रत्येक अतिरिक्त ट्रीप पर 1500/- रू. जमा करवाना होगा।

सभापति
नगर परिषद डूंगरपुर (राज.)

आयुक्त
नगर परिषद डूंगरपुर (राज.)

FIGURE 15: NOTIFICATION FOR PRIVATE SEPTIC TANK EMPTYING OPERATORS IN DUNGARPUR CITY

It can be inferred that the unlined drain is the main reason why most of the wastewater percolates in the soil and might be contaminating the phyllite aquifers. Consequently, the stream dries up in the summer season. It is important that the ULB should start lining the drains and covering them properly. In future if the sewerage plan is executed, these drains will act as storm water drains.

Since the ULB practices "on demand" desludging, one vacuum trucks is adequate. However, there is need of scheduled desludging in order to avoid failure of septic tank and contamination of the groundwater aquifer. In the old city, it is quite impossible for the vacuum truck to function.

4.1.4 Treatment

According to the SLB 2016, there is not treatment facility for wastewater and sepage what so ever. During the consultation with ULB, it was noted that two new Decentralized Treatment Systems (DTSs) for wastewater are being set up in the city. Both the systems are identical in terms of working and provide completely ecological treatment without requirement of electricity.

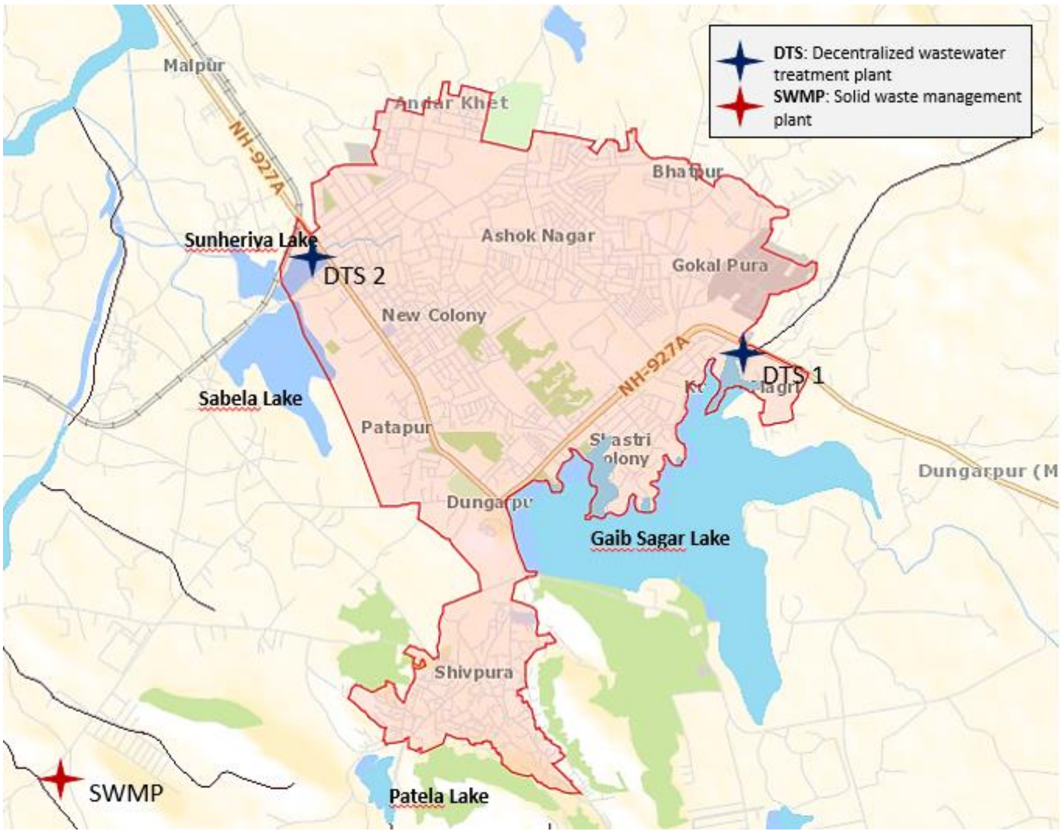

FIGURE 16: LOCATION OF DTS AND SWMP OF DUNGARPUR CITY

One of the treatment system is located near Gaib Sagar Lake at location marked DTS 1 in Figure 16. It will be treating all the water coming from RICO Industrial Area and the grey water - septic tank effluent. The treatment chain implemented at this site is shown in Figure 17.

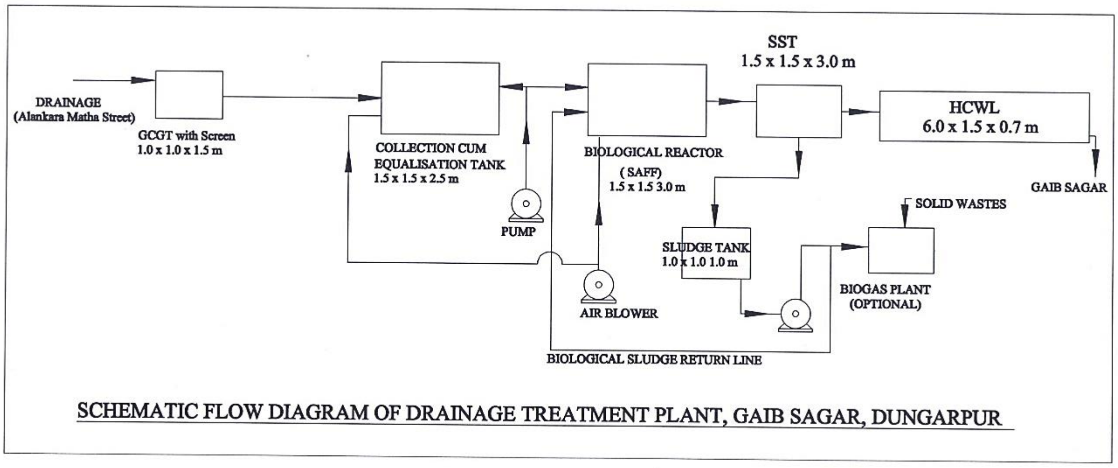

FIGURE 17: DECENTRALIZED TREATMENT SYSTEM TO BE IMPLEMENTED AT GAIB SAGAR LAKE

FIGURE 18: SITE FOR THE DECENTRALIZED TREATMENT SYSTEM NEAR GAID SAGAR LAKE

The second treatment system is located near Sunheriya Lake at location marked DTS 2 in Figure 16. This system will treat all the wastewater flowing into the Sunheriya Lake on daily basis. The treatment chain implemented at this site is similar to the one at Gaib Sagar Lake.

The ULB is also undertaking a project to set up a bio methanation plant where the organic solid waste and septage will be fed to produce methane gas. The plant promises to generate 300 m^3 of methane gas on a daily basis. The plant is located in the Solid Waste Management Plant (SWMP) of the Dungarpur City. The details of the plant are given in the Figure 19.

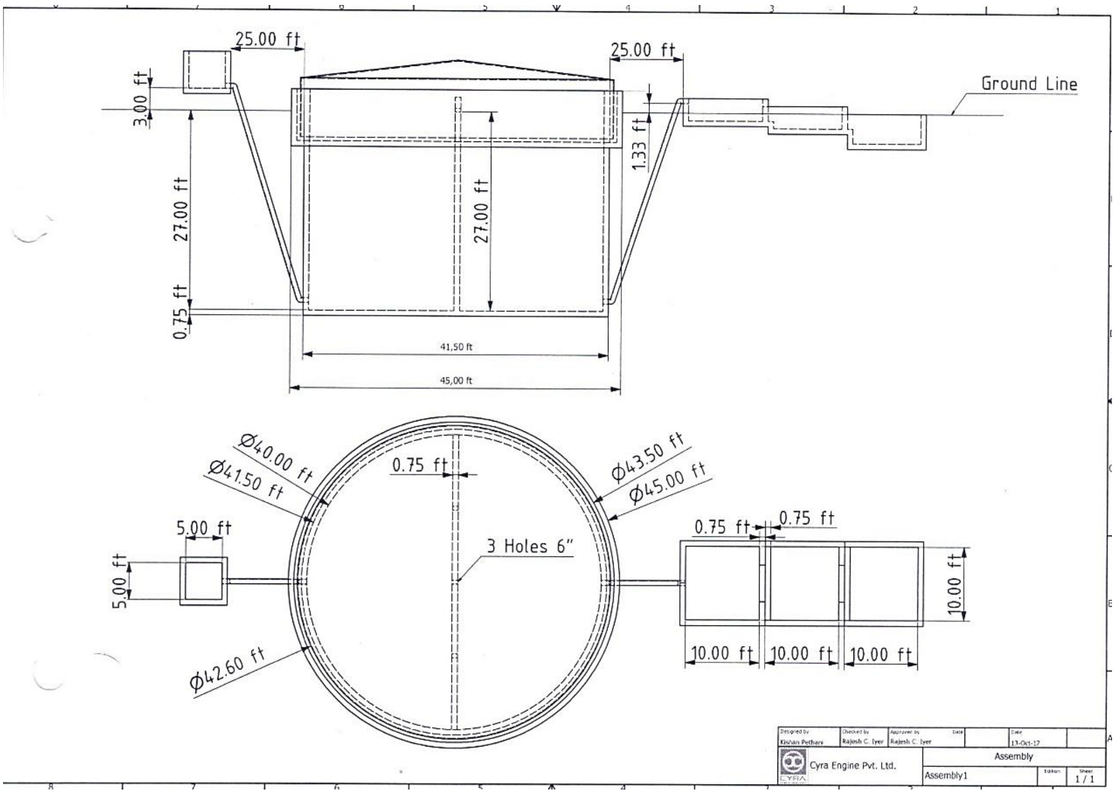

FIGURE 19: DETAILS OF THE BIO METHANATION PLANT UNDER IMPLEMENTATION AT DUNGARPUR CITY

FIGURE 20: BIO METHANATION PLAN AT SOLID WASTE MANAGEMENT PLANT, DUNGARPUR CITY

The Wastewater System DPR made by RUIDP proposes a plant of capacity 6.9 MLD at the location near Do Nadi Bridge. The capacity suggested is as per the CPHEEO norms of design period of 15 years (2036, assuming base year as 2021). The location is marked in the Figure 14. The technology proposed for this STP is Sequential Batch Reactor (SBR).

FIGURE 21: LOCATION OF THE STP (PICTURE 2) NEAR THE DO NADI BRIDGE (PICTURE 1) IN DUNGARPUR CITY

It is huge step that the ULB has taken to introduce decentralized treatment system as precautionary measure to stop contamination of the surface water bodies. However, it is very necessary that the ULB simultaneously develops the capacity to operate and maintain these treatment systems on their own. In case of Gaib Sagar Lake, the ULB should also consider treating the several streams joining the lake at point 3 as shown in the Figure 9.

In case of bio methanation plant, it should be noted that the septage emptied by the vacuum trucks is completely stabilised and diluted and hence there is not requirement for it to be digested. The septic tanks are emptied at an interval of more than 5-8 years and hence the faecal sludge is well digested and stabilised.

4.1.5 Reuse and disposal

Since there is not treatment of wastewater happening, there is not reuse taking place. However, there is a huge potential for reuse of treated wastewater at public parks and gardens.

4.2 Institutional and governance framework

The Dungarpur Municipal Council has been allotted 275 positions in total out which the council has filled 175 positions. The top most position is that of Commissioner, under which are several verticals like accounts, engineering, sanitation etc. The details of the positions relevant to this study and their details are given in Table 4.

TABLE 4: DETAILS OF HUMAN RESOURCE AT ULB LEVEL

Position	Sanctioned posts	Actual on pay roll
Commissioner	1	1
Executive Engineer (X. En.)	1	0
Assistant Engineer (A. En.)	1	1
Junior Engineer (J. En.)	2	2
Health Inspector	1	0
Sanitary Inspector	2	1
Safai Jamadar	1	0
Safai employee	168	112

There are different agencies who are involved in infrastructure projects in the state of Rajasthan. Out of all the environmental sanitation services to be provided to the masses, the ULB is only responsible for implementing and O&M of solid waste management projects. PHED is responsible for implementation and O&M of the water supply in the city. RUIDP is responsible for implementation of the wastewater and stormwater management in the city. Post implementation the assests are handed over to the ULB for its O&M.

4.3 Legal and regulatory framework

According to the new regulations passed by the Central Pollution Control Board (CPCB) the standards for discharge of treated effluents are as follows;

Industry	Parameter	Standard for New STPs (Designed after November 2015)
Sewage Treatment Plant	pH	6.5-9.0
	BOD	
	Metro Cities*, all State Capitals except in the State of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Union territory of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and Lakshadweep	20
	Areas/regions other than mentioned above	30
	COD	30
	TSS	
	Metro Cities*, all State Capitals except in the State of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Union territory of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and Lakshadweep	<50
	Areas/regions other than mentioned above	<100
	NH_4-N	5
	N-total	10
	Fecal Coliform (MPN/100 ml)	<1000

Note:

1. All values in mg/l except fr pH and coliform.
2. These standards will be applicable for discharge in water resources as well as for land disposal.
3. The standards for faecal coliform may not be applied for use of treated sewage in industrial purposes.

4. These Standards shall apply to all STPs to be commissioned on or after the 1st June, 2019 and the old/existing STPs shall achieve these standards within a period of five years from date of publication of this notification in the Official Gazette.
5. In case of discharge of treated effluent into sea, it shall be through proper marine outfall and the existing shore discharge shall be converted to marine outfalls, and in cases where the marine outfall provides a minimum initial dilution of 150 times at the point of discharge and a minimum dilution of 1500 times at a point 100 meters away from discharge point, then, the existing norms shall apply as specified in the general discharge standards.
6. In case of discharge of treated effluent into sea, it shall be through proper marine outfall and the existing shore discharge shall be converted to marine outfalls, and in cases where the marine outfall provides a minimum initial dilution of 150 times at the point of discharge and a minimum dilution of 1500 times at a point 100 meters away from discharge point, then, the existing norms shall apply as specified in the general discharge standards.
7. Central Pollution Control Board/State Pollution Control Boards/Pollution Control Committees may issue more stringent norms taking account to local condition under section 5 of the Environment (Protection) Act, 1986".

TABLE 5: DISCHARGE NORMS FOR SEWAGE TREATMENT PLANTS BY CPCB

No standards have been set for the treated septage till now, however according to the criteria of Class A Bio Solids of US EPA;

A faecal coliform density of less than 1000 MPN/g total dry solids

Salmonella sp. Density of less than 3 MPN per 4 g of total dry solids WHO (2006) suggests Helminth egg concentration of < 1/g total solids and E coli of 1000/g total solids in treated septage for use in agriculture.

MSW rules (2000), India has recommended the following quality for compost:

Parameter	Concentration not to exceed (mg/kg dry basis, except for pH and carbon to nitrogen ratio)
Arsenic	10
Cadmium	5
Chromium	50
Copper	300
Lead	100
Mercury	0.15
Nickel	50
Zinc	1000
C/N ratio	20-40
pH	5.5-8.5

In the absence of any standards, it is recommended that these be adopted until such time standards are notified by the Central Pollution Control Board.

5 Potential reuse/recycle of wastewater

Although RICO Industrial Area is situated in Dungarpur Area, the industry there is mostly small scale and do not consume much water. There are agricultural lands on the outskirts of the Dungarpur City where the treated water from either the upcoming STP or the DTSs could be utilized. It is believed that faring is done either on groundwater or on the flowing steams of wastewater. The reuse possibility is in the Railway Colony and Police Colony, however the location of these two stakeholder is away from the proposed STP and hence conveyance of treated water will not be economical.

In this case the policy regarding the non-potable purposes (irrigation and landscaping) should be revised with respect to use of use of ground water and wastewater. The cost of the treated wastewater should be kept as low as possible so that it promotes use of treated wastewater in the city.

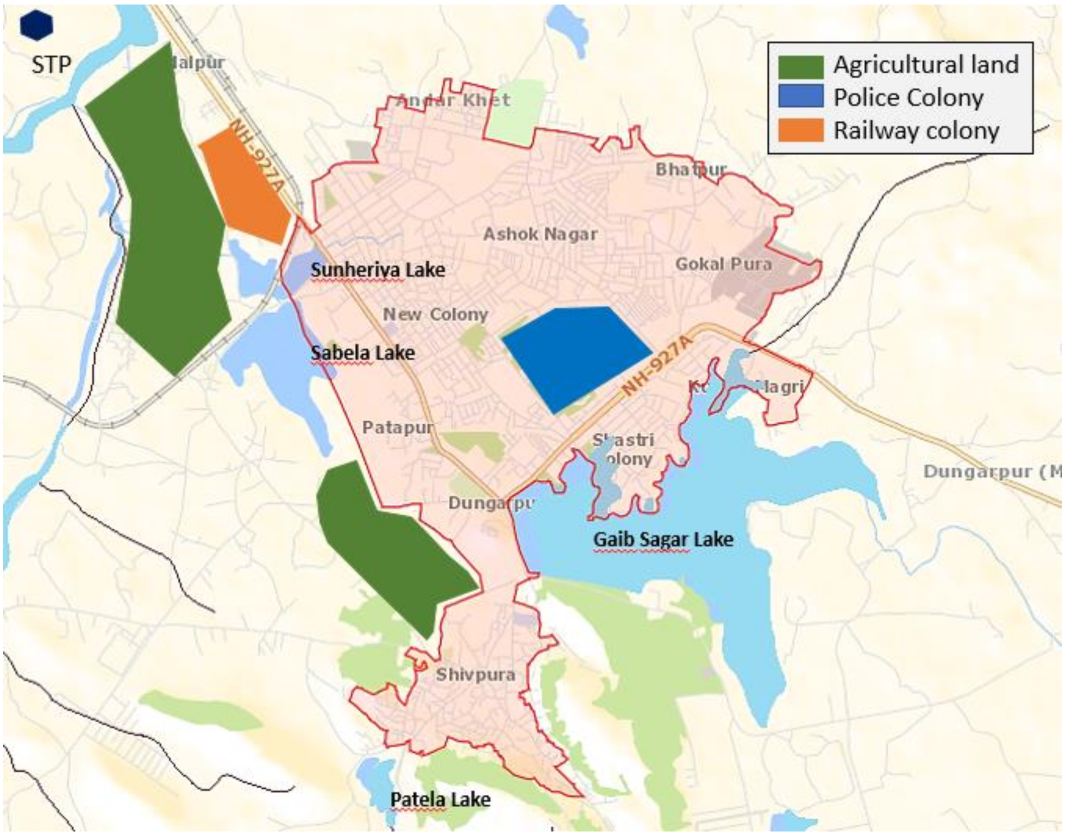

FIGURE 22: POTENTIAL USERS OF TREATED WASTEWATER IN DUNGARPUR CITY

6 Project concept and design

This section is dedicated to Integrated Wastewater and Septage Management (IWSM) plan. The city of Dungarpur will be classified into different zones with respect to the base data available. The project concept described in following sections are made with respect to ULB's institutional and financial strengths.

6.1 Project concept

IWSM plan envisages, management of all possible waste which are generated in the city such as black water, grey water and septage. Following are the important key inferences from the base data analysis;

1. Dungarpur is growing at a moderate pace in term of population,
2. Old city is quite saturated and development is happening mostly in the north and west of the new part of the Dungarpur City,
3. Climate favours the use of natural treatment technologies for solid and liquid waste management,
4. The presence of extrusive/intrusive strata and phyllite aquifer does not provide sufficient storage and treatment of the groundwater,
5. The ULB is not financially strong in terms of recovery of taxes. This implies O&M of the highly mechanized, centralized systems will be difficult.
6. The ULB does not have enough qualified human resources. 36% of the positions are still vacant.

Dungarpur City will experience depletion of good quality groundwater resources due to high water consumption and recharge of contaminated water of the lakes. This becomes the main reason for providing the city with an appropriate wastewater management system which is not only sustainable but can be implemented immediately.

It is very difficult to provide 100% coverage of sewerage in a centralized approach in less time especially when the strata comprise of hard rock in most of the cases. The centralized approach also does not address the local needs and focus more on the collection of the wastewater a single point increasing the liability in terms of SPS which adds to the O&M cost of the complete system.

Given the literacy rate and the awareness among the citizens of the Dungarpur City, decentralized systems are much more favourable as they allow incremental development keeping the choice if technologies simple and cheap in terms of O&M.

According to the CPHEEO Manual on Sewage and Sewerage Treatment 2012, there are eight methods to perform population projection for the city. However, the statistical methods require population of at least 5-6 decades. In case of Dungarpur it was not available with the city and hence the population projection performed by the consultants of DPR on wastewater systems for Dungarpur City was used. The base year for this plan is taken as 2021 and the population is projected for 2021, 2036 and 2051.

According to the CPHEEO Manual on Sewage and Sewerage Treatment 2012, the design period for onsite, decentralised and centralised systems shall be 5 years, 5-15 years and 30 years respectively.

Sl. No	Component	Design Period, Years (from base year)
1	Land Acquisition	30
2	Conventional sewers (A)	30
3	Non-conventional sewers (B)	15
4	Pumping mains	15
5	Pumping Stations-Civil Work	30
6	Pumping Machinery	15
7	Sewage Treatment Plants	15
8	Effluent disposal	30
9	Effluent Utilization	15 or as the case may be
(A) Typical underground sewers with manholes laid in the roads (B) All types such as small bore, shallow sewers, pressure sewers, vacuum sewers		

FIGURE 23: DESIGN PERIOD OF SEWERAGE COMPONENTS (SOURCE: CPHEEO MANUAL ON SEWER AND SEWERAGE TREATMENT 2012)

The zoning is done in the Dungarpur City keeping the hydraulic map of DPR on wastewater management system as base. The zones are demarcated based on the first two key points. The choice of technology is based on the third, fifth and sixth key point.

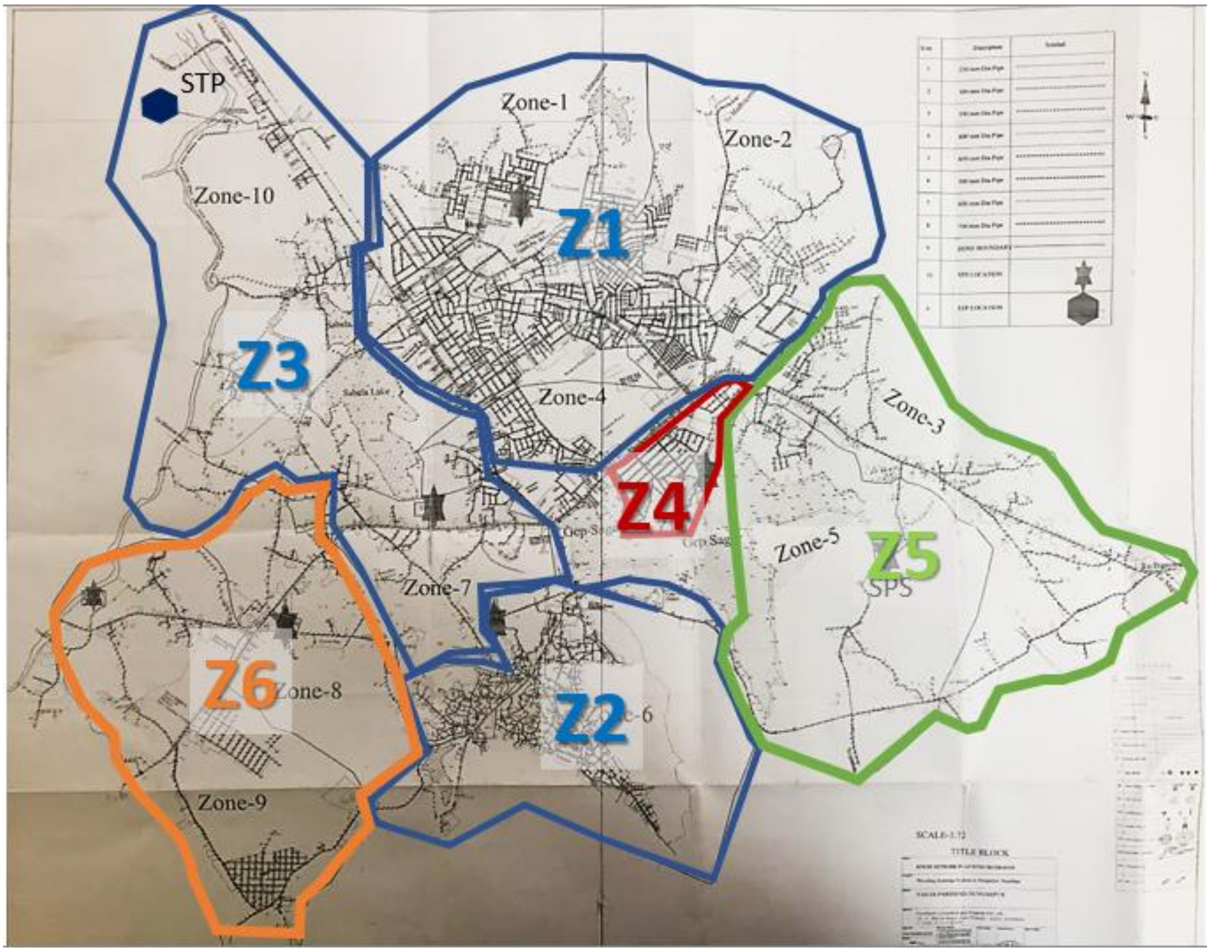

FIGURE 24: ZONING FOR IWSM IN DUNGARPUR CITY

The following logic diagram has been used to develop the project scenario for each zone. Wherever the small-bore sewer is uneconomical (due to low population density and topography), a complete decentralized treatment system is recommended on the site. This will encourage reuse of the treated wastewater locally.

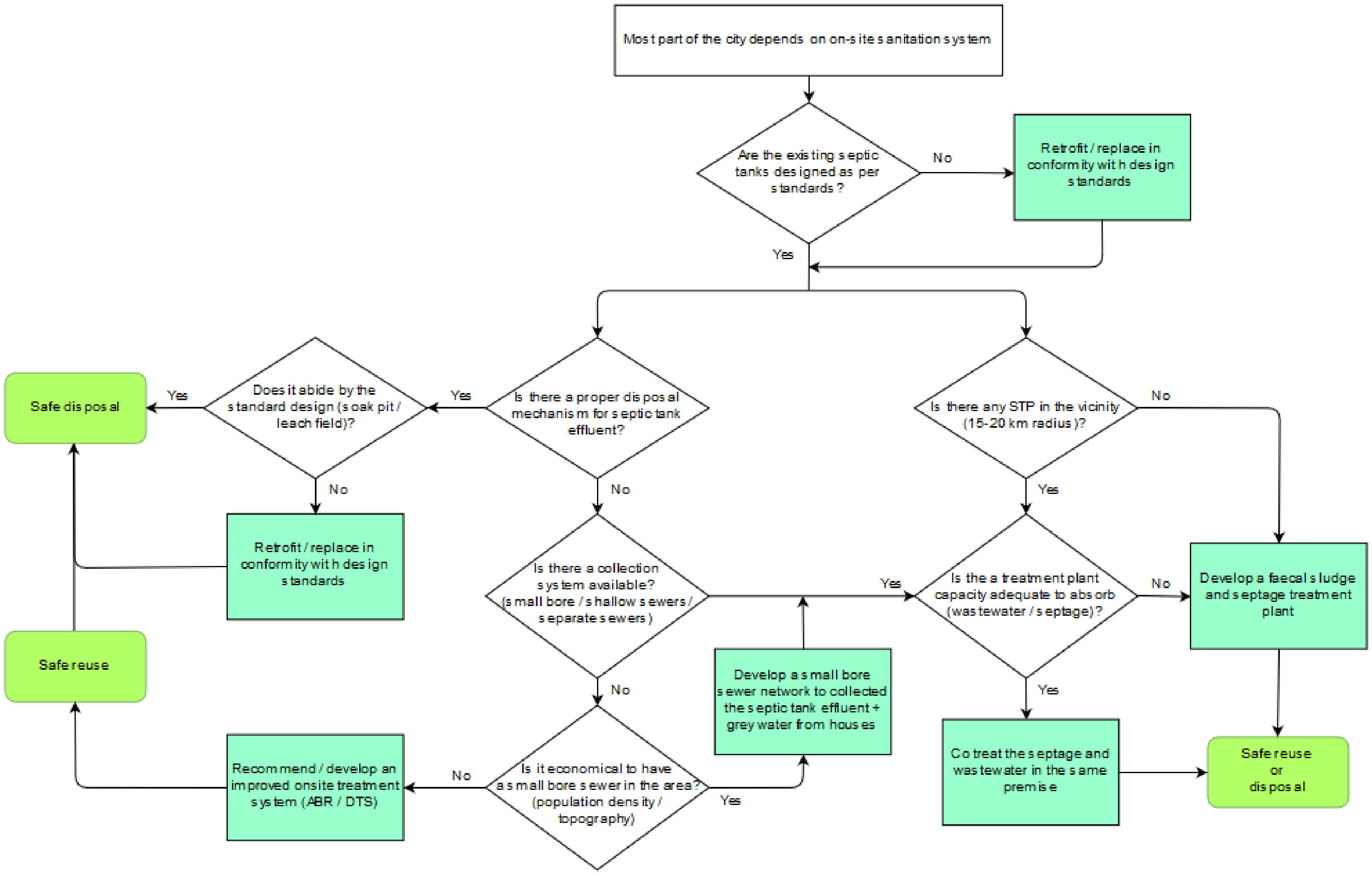

FIGURE 25: LOGIC DIAGRAM FOR CONCEPTUALIZING THE PROJECT IN EACH ZONE

6.1.1 ZONE 1, 2 and 3

Zone 1 (Figure 24) will experience higher growth rate in terms of urbanization as it provides more organized infrastructure. The proximity to the RICO Industrial Area will cause more housing schemes to come up in this region. The total population (census 2011) in this zone was around 14,454 with an average density of 55 person per ha. However, it is expected to rise to more than 150 person per ha by 2051 due to multi storey building and each property consisting of multiple households.

TABLE 6: PROJECTED POPULATION FOR ZONE 1

Zone	Ward No.	Area in	Census Population	Projected Population		
		Ha.	2011	2021	2036	2051
Z1	22	102.43	1058	1386	1784	2072
	24	62.96	1275	1442	1645	1792
	25	264.23	2440	3612	5039	6068
	26	61.93	2798	3038	3329	3539
	27	21.17	1860	2014	2201	2337
	28	33.19	2265	2463	2705	2879
	29	58.88	1946	2233	2581	2833
	30	78.64	1870	2325	2879	3279
Total	**8**	**683.43**	**15512**	**18513**	**22163**	**24799**

FIGURE 26: GLIPMSES OF ZONE 1, DUNGARPUR CITY

Zone 2 (Figure 24) consists of old city and is already saturated. According to the census 2011, the average population in this zone is approximately 300 persons per hectare. Since this zone is land locked by two hills, there is no scope for growth in the east and south. Hence the population density will not increase much in the upcoming years.

Having a centralized system is recommended as one can achieve higher number of connection per unit length of sewer.

TABLE 7: PROJECTED POPULATION FOR ZONE 2

Zone	Ward No.	Area in	Census Population	Projected Population		
		Ha.	2011	2021	2036	2051
Z2	6	5.2	1118	1181	1258	1313
	7	4.17	1362	1403	1454	1490
	8	8.35	1849	1910	1984	2038
	9	4.19	1592	1592	1592	1592
	10	6.47	1482	1541	1613	1665
	11	5.13	1066	1131	1210	1268
	12	4.98	1138	1197	1269	1321
	13	4.01	1291	1333	1384	1421
	14	3.52	740	804	883	939
	15	35.07	1661	1718	1788	1838
	16	13.81	1289	1289	1289	1289
	17	2.67	1037	1037	1037	1037
	18	3.21	881	930	990	1034
	19	2.85	1665	1665	1665	1665
Total	**14**	**103.63**	**18171**	**18731**	**19416**	**19910**

FIGURE 27: GLIMPSES OF ZONE 2, DUNGARPUR CITY

Zone 3 (Figure 24) has open plots and will experience urbanization due to its proximity to the highways and railway station. According to the 2011 census, the population density in this region is approximately 70 persons per hectare and is expected to double in upcoming years. Moreover, having a gravity based conveyance system is recommended as there is no requirement of SPS in this zone due to its topography and location of the STP.

TABLE 8: PROJECTED POPULATION FOR ZONE 3

Zone	Ward No.	Area in	Census Population	Projected Population		
		Ha.	2011	2021	2036	2051
Z3	1	95.23	1246	1505	1819	2046
	2	53.19	1804	2003	2246	2421
	3	176.47	1670	2242	2938	3440
	4	115.41	1107	1671	2358	2853
	5	161.93	2688	3014	3411	3697
	20	17.55	909	974	1054	1111
Total	**6**	**619.78**	**9424**	**11409**	**13826**	**15568**

FIGURE 28: GLIMPSES OF ZONE 3, DUNGARPUR CITY

Due to the above reasons, following sanitation system (Figure 29) is recommended in all the three zones. The user interface will be mostly flush toilets (pour flush/cistern flush) followed by septic tank. The cost of construction septic tank will be borne by the household. This will be followed by a small-bore system (also known as solid free sewer). The design principle of this sewer system is different than the usual gravity based sewers as the solids are already retained in the collection/storage unit. The small-bore sewer needs less gradient hence saving cost of implementation of conveyance system. The septic tank effluent plus grey water from households located in Z1, Z2 and Z3 will be conveyed using a small bore system to point near Do Nadi where a STP is proposed.

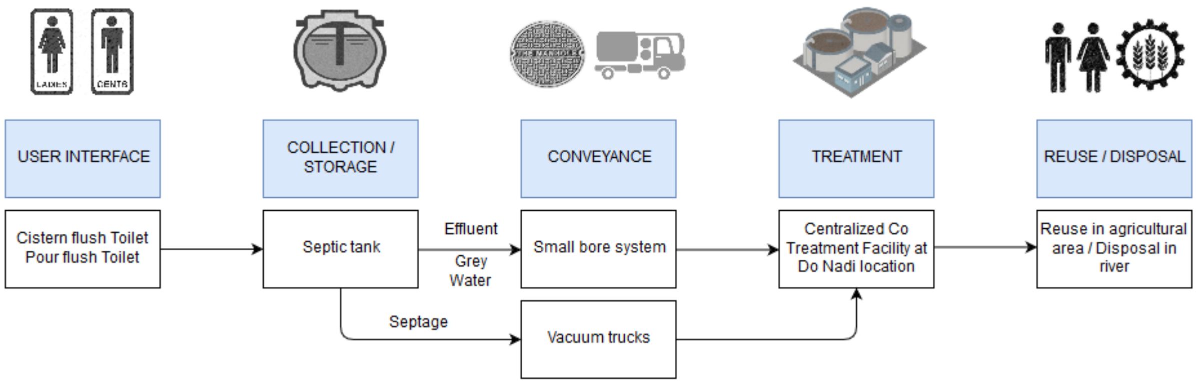

FIGURE 29: SANITATION VALUE CHAIN FOR ZONE 1, 2 AND 3

The STP in this case should be a Co Treatment Plant (CTP) i.e. treatment of the wastewater collected through small bore system and septage brought in by the vacuum trucks. The septage (solids retained in the septic tank) from the households will be conveyed by vacuum trucks to the CTP for further treatment followed by reuse in agriculture as soil conditioner.

6.1.2 Zone 4

Zone 4 (Figure 24) consists of residential plots and few government buildings whose water due to natural topography is drained in the Gaib Sagar Lake. The natural drains are existent which take water from these households to the Gaib Sagar Lake. According to the 2011 census, the population in this zone was 2,292 and the population density of 85 persons per hectare.

TABLE 9: PROJECTED POPULATION FOR ZONE 4

Zone	Ward No.	Area in	Census Population	Projected Population		
		Ha.	2011	2021	2036	2051
Z4	23	33.64	2292	2451	2644	2784

It is recommended that the small-bore sewer can be laid in this zone collect the septic tank effluent along with grey water and take the water to the proposed decentralized wastewater treatment plant near Gaib Sagar Lake. An intercepting sewer should be laid along the boundary of the lake to collect the water and divert it to the treatment plant. After treatment the water can be put into the lake.

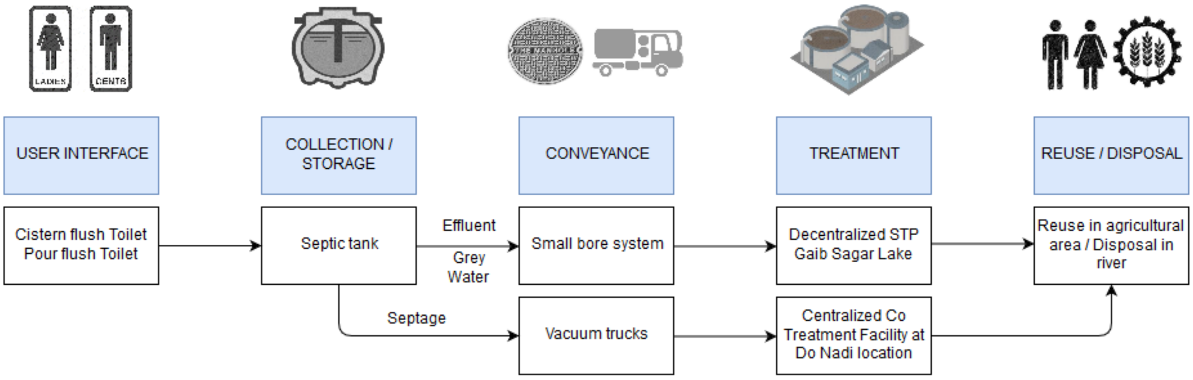

FIGURE 30: SANITATION VALUE CHAIN FOR ZONE 4

The septage from the septic tanks from the households will be conveyed to CTP using vacuum trucks. Post treatment the treated sludge can be reused in the agriculture as soil conditioner.

6.1.3 Zone 5

Zone 5 (Figure 24) consist of part of households in ward 21 and other areas which are outside the limit of Dungarpur Municipal Council. According to 2011 census, the population of Z5 was 2,307.

TABLE 10: PROJECTED POPULATION FOR ZONE 5

Zone	Ward No.	Area in	Census Population	Projected Population		
		Ha.	2011	2021	2036	2051
Z5	21	24.11	2307	2434	2589	2701

The zone is sparsely populated and will not be urbanized in near future. It is recommended to have decentralized systems here. Decentralised systems are more favourable of incremental approach and does not demand investment in one go.

In the new households which will come in this zone, Anaerobic Baffled Reactor (ABR) should be recommended in each household. This will ensure a better degree of treatment of black water. The treated black water along with grey water can be directly sent to soak pits or dispersion trenchs for disposal. The septage from the onsite treatment system i.e. ABR in this case can be conveyed to CTP using vacuum trucks. Here the septage can be treated and sent for reuse and disposal.

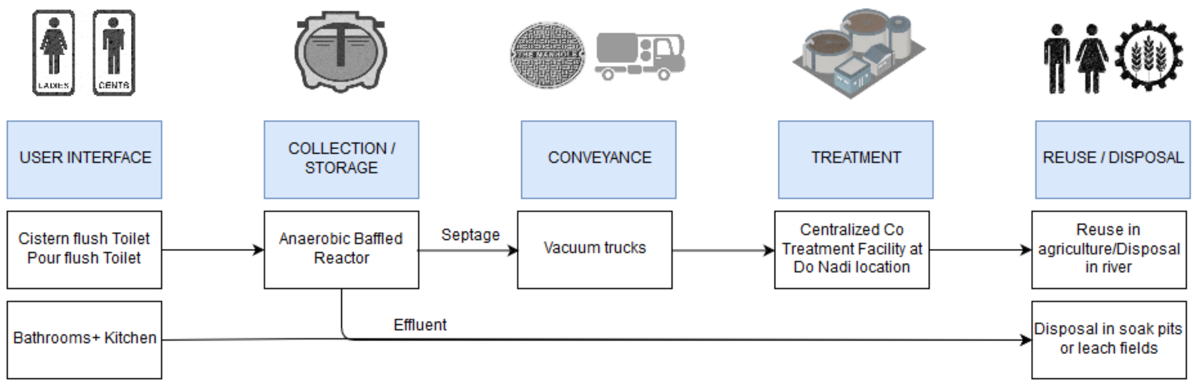

FIGURE 31: SANITATION VALUE CHAIN FOR ZONE 5

In few decades when the density increases, a small bore system can be installed which will take all the households effluent to decentralized treatment system serving the population in this zone.

6.1.4 Zone 6

The zone 6 (Figure 24) consists extended areas of the Dungarpur Municipal Council. Currently only one ward falls in this zone. However, some organized development is taking place in this region. During the consultation with ULB, it was noted that a colony is being developed in the bottom left corner of the zone 6 (Z6). The colony is named Vasundhara Colony and it is being developed under the Mukhya Mantri Jan Awas Yojana. The colony is going to have 88 apartments of 500 sq ft each for lower income group and 272 apartments of 325 sq ft. The colony will be fully developed in next three years. Assuming four persons per family, it is estimated that the number of people living in the Vasundhara colony will be around 1,440.

FIGURE 32: GLIMPSES OF ZONE 6, DUNGARPUR CITY

It is recommended to have a DTS at a community level at Vasundhara Colony. The DTSs will allow to treat the wastewater generated in this colony to the permissible limit and recycle and reuse at the local level.

At other individual houses, the solution mentioned for Zone 5 can be replicated. It should also be noted there is a Sri Rajasthan Sintex Mill Ltd. The treated wastewater can also be sold to this industry; however, the quality of the treated wastewater should be as per the industry requirement.

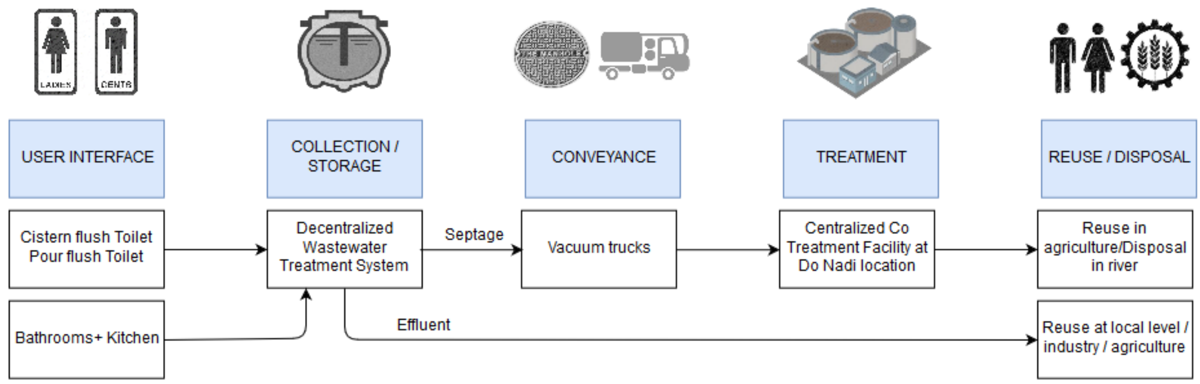

FIGURE 33: SANITATION VALUE CHAIN FOR ZONE 6

The septage from the decentralized wastewater treatment system will have to be emptied at a design frequency and need to be conveyed to the CTP. The septage will be treated here and safely reused in agriculture or disposed off in the nature.

6.2 Project design

This section elaborates the project design for concept put forward for the zones in the previous section. The project design will draw out quantitative estimates for the components of the sanitation value chain i.e. collection & storage, conveyance, treatment and reuse / disposal.

Collection & storage

It is a necessity of a small bore system to have an interceptor tank. The interceptor tank can be a normal sedimentation tank, septic tank or any on site treatment system which arrests the solids. The effluent of this on site treatment system should be free from solids which can potentially choke the small bore sewer system. Hence in the current set up where most of the houses have either septic tank or kui, there is not requirement of retrofitting or replacing of on site treatment systems. However it is recommended that the ULB should issue a notice to get the tanks lined from inside and check for leakages if any.

For more details on septic tank and its dimensioning, refer to Annexure 8.1.

ABR is also one kind of collection and storage option. It is an improved version of septic tank and produced treated water of better quality than a septic tank. It is recommended that the ULB issues an order that all the new properties being developed in the Zone 5 and 6 should have ABR instead of the septic tank. This will allow safer disposal of treated wastewater in the environment until the population density increases.

For more details regarding ABR, please refer to Annexure 8.2.

Decentralised treatment system is an onsite treatment system capable of producing treated wastewater as per the standards laid down by the CPCB mentioned in section 4.3. The ULB should issue a notice to recommend such treatment system to the bigger colonies being developed in the Dungarpur City, especially in the Zone 5 and 6. This will also encourage people to use the treated water locally for non-potable purposes.

For more details on DTS, please refer to Annexure 8.3.

Conveyance

Due to the absence of the data like length of, open/close unlined drains, lined drains, covered drains and length of road, it was not possible to estimate the length of the drains required for 100% coverage of the conveyance system.

According to the CPHEEO Manual on Sewage and Sewerage Treatment 2012, the design period for non-conventional sewers is taken to be 15 years. The sewerage hydraulic map produced by the consultants of DPR on wastewater systems for Dungarpur City was used to draw estimates for length of small bore sewer system.

For more details on small bore sewer system, please refer to Annexure 8.4.

One 3,000 lit capacity vacuum truck making 5 trips per day can serve up to 20,000 population. In case of desludging, this assumption is made to estimate number of vacuum trucks needed for desludging. Since procurement of vacuum truck is a quicker process, the requirement of the trucks is calculated as per the base year 2021 population.

Treatment

The characteristic of the wastewater collected in this case would be significantly different than the domestic wastewater collected in a conventional sewer system which does not have an interceptor tank. The characteristics such as BOD, COD, TSS, NH4-N, N Total and Faecal Coliform will be higher in the domestic wastewater as compared to the wastewater collected from small bore system.

The BOD/COD ratio will be low in the case of wastewater as compared to domestic wastewater and this will have an impact on the design of STP to be set up.

The volume of the wastewater collected from households is estimated using assumption that the water supply to the households will be at the rate of 120 LPCD and that 80% of the water consumed at the household will be converted into wastewater. According to the CPHEEO Manual on Sewage and Sewerage Treatment 2012, the design period for sewage treatment plant is taken to be 15 years.

The volume of septage generated is calculated using the septage generation rate of 230 litres per person per year. The septage to be treated per day is calculated assuming 300 working days. Hence the septage to be treated is 48 cum per day. However, it is to be noted that this quantity will be arriving at the STP if scheduled desludging is implemented by the ULB.

The STP to be developed in the city will be a Co Treatment Plant as discussed in section 6.1.1. The technology to be implemented for the wastewater treatment and sludge treatment is discussed further in the section 6.3.

A brief concept of a co treatment plant has been explained in the Annexure 8.6.

Reuse/ Disposal

Since the STP is located on the bank of the river, disposal of treated wastewater is the most convenient option for the ULB. However, looking at the value of the nutrient rick treated wastewater, it is recommended that the ULB promotes reuse of treated wastewater in agricultural areas. The agricultural area is located close to the STP.

ULB can also practice afforestation around the city in order to increase the green cover and aesthetical value of the city. The treated wastewater can be conveyed using water tankers to specific places for irrigation.

6.2.1 ZONE 1, 2 and 3

Conveyance

The total projected population for all three zones for the year 2021 and 2036 is 48,653 and 55,405 respectively. The total length of the small-bore sewer system is estimated for Zone 1, 2 and 3 is 101 km. Depending on the 2021 population, each zone will require at least one vacuum truck, so in total three trucks are required. The wastewater generation is estimated to be 5.32 MLD for all the three zones. The septage generation from the septic tanks/ kuis will be 12743.15 cum per year.

Table 11: Estimate for conveyance and treatment for zone 1, 2 and 3

Zone	Census Population	Projected Population		Length of small bore sewer	Vacuum truck	Wastewater generation	Septage generation
	2011	**2021**	**2036**	**(km)**	**(no.)**	**(MLD)**	**(cum/yr)**
Z1	15512	18513	22163	37.09	1	2.13	5097.49
Z2	18171	18731	19416	8.60	1	1.86	4465.68
Z3	9424	11409	13826	55.61	1	1.33	3179.98
TOTAL	**43107**	**48653**	**55405**	**101.29**	**3**	**5.32**	**12743.15**

The wastewater generated here will be treated at the STP located on the bank of river Do Nadi as shown in the Figure 24. There will be requirement of at least 2 pumping stations in order to convey the wastewater to the STP using the small bore sewer system.

6.2.2 ZONE 4

The projected population for zone 4 for the year 2021 and 2036 is 2,451 and 2,644. The length of small bore sewer system required will be 13.70 km. The total wastewater generation and septage in this zone is approximately 0.25 MLD and 608.12 cum per year.

Table 12: Estimate for conveyance and treatment for zone 4

Zone	Census Population	Projected Population		Length of small bore sewer	Vacuum truck	Wastewater generation	Septage generation
	2011	**2021**	**2036**	**(km)**	**(no.)**	**(MLD)**	**(cum/yr)**
Z4	2292	2451	2644	13.70	0	0.25	608.12

The wastewater from this zone needs to be collected and intercepted before it enters the lake. The intercepted wastewater will need to be pumped through sewage pumping station located at point 3 shown in Figure 9. This wastewater should be treated at the DTS 1 being implemented at the Gaib Sagar lake as shown in Figure 16.

6.2.3 ZONE 5

The projected population for Zone 5 for the year 2021 and 2036 is 2,434 and 2,589. Since the base population is small, there is not ned of a separate vacuum truck to serve this zone. The wastewater and septage generation in this zone is 0.25 MLD and 595.47 cum per year.

TABLE 13: ESTIMATE FOR CONVEYANCE AND TREATMENT FOR ZONE 5

Zone	Census Population	Projected Population		Length of small bore sewer	Vacuum truck	Wastewater generation	Septage generation
	2011	2021	2036	(km)	(no.)	(MLD)	(cum/yr)
Z5	2307	2434	2589		0	0.25	595.47

The collection and storage option recommended for zone five is an ABR or a well-designed septic tank followed by dispersion trench. This will allow percolation of the treated water into the vadose zone of the strata. The small-bore system shall be installed with a decentralized wastewater treatment plant will be required when the population density increases considerably. The septage however needs to be collected and transported to the STP at Do Nadi.

6.2.4 ZONE 6

Since this is a newly integrated area in the Dungapur Municipal Council, there is no data available. However, information was available for the Vasundhara Colony as mentioned in section 6.1.4. Hence it is estimated that 1440 people will be staying in the colony. The collection system will be installed for the colony. The total wastewater generated in this colony is estimated to be 0.14 MLD and the septage generation will be approximately 331.20 cum per year.

TABLE 14: ESTIMATE FOR CONVEYANCE AND TREATMENT IN ZONE 6

Zone	Census Population	Projected Population		Length of small bore sewer	Vacuum truck	Wastewater generation	Septage generation
	2011	2021	2036	(km)	(no.)	(MLD)	(cum/yr)
Z6		1440		5.35	0	0.14	331.20

A DTS has been recommended to treat the 140 cum per day of wastewater generated at the colony. The treated wastewater can be reused for non-potable purposes, reducing the freshwater consumption of the colony.

6.3 Technology Selection

This section elaborates on various options available for wastewater treatment at various levels i.e. centralized and decentralised. The points discussed for each technology is the nature of wastewater it can handle, process, target or objective, advantages and disadvantages.

The technologies discussed in Table 16 are as follows;

1. Activated sludge process

2. Extended aeration technology
3. Oxidation ponds/Waste stabilisation pond
4. Moving bed biological reactor
5. Sequential batch reactor
6. Soil based technology
7. Fluidised bed biofilm reactor
8. Membrane bio reactor
9. Decentralised treatment system (AS+ABR+AF+CW)

The wastewater sampling was not carried out, it is assumed that the general characteristics of domestic wastewater (according to the CPHEEO Manual on Sewerage and Sewage Treatment (Part A)) will be as follows;

TABLE 15: CHARACTERISTICS OF THE DOMESTIC WASTEWATER IN INDIAN CONTEXT

Parameter	Range
Temperature	15-35 ^{0}C
pH	5.5 to 8.0
Colour	slightly soapy and cloudy appearance
TSS	100 – 300 mg/L
Nitrogen and Phosphorus	TKN: 20 to 50 mg/L Phosphates: 5 to 10 mg/L
BOD	100-400 mg/L
COD	200 - 700 mg/L

TABLE 16: TECHNOLOGICAL OPTIONS FOR CENTRALISED AS WELL AS DECENTRALISED WASTEWATER TREATMENT PLANTS

Treatment Process	Designed for	Not Suitable for	Process	Target	Advantages	Disadvantages	Fitment Assessment
Activated Sludge Process Treatment (ASP)	Domestic Wastewater	Industrial wastewater (induction of industrial wastewater only to a minimum possible)	Aerobic	• Reduction of COD / BOD values • Reduction of nitrogen (denitrification step) and phosphate • BOD removal performance above 90%	• Very good pollutant removal performance, if process is operated proper and technically correct • Well established process, O&M not complex	• Severe Hydraulic fluctuations might have negative impact (solids overflow) but can be mitigated through conservative design and possibly a balancing tank upfront.	**NO,** • The footprint will be higher, whereas cost of construction would be similar to SBR/MBBR.
Extended Aeration Technology (EAT)	Domestic Wastewater	Industrial wastewater	Aerobic	• Reduction of COD / BOD values • Reduction of nitrogen (denitrification step) and phosphate	• Good pollutant removal performance, if process is correctly designed and properly operated • Produces mineralized sludge that can be directly dewatered	• Higher energy consumption due to extended aeration • Increased energy consumption compared to ASP • No gas yield as no primary sedimentation • Severe Hydraulic fluctuations have negative impact (solids overflow) but can be mitigated	**NO,** The footprint and the cost would be higher than ASP or MBBR

						through conservative design and possibly a balancing tank upfront • High Investment & operational costs	
Oxidation Ponds / Waste Stabilization Ponds (OP/ WSP)	Domestic waste water treatment with small investment and moderate pollutant removal performance	Industrial wastewater & sludge treatment	Anaerobic / partially Aerobic	Moderate cleaning performance with minimum investments (BOD / COD)	• Low investments for construction and low operational costs • Low level of expertise required for operation • BOD removal performance of 40% - 60%	• Limited control possibilities of process • Large area required for construction • Moderate pollutant removal • Contamination of groundwater is possible (especially if monitoring is neglected)	**NO,** Not recommended due to higher foot print area and possible odour issues
Moving Bed Bio Reactor (MBBR)	Domestic Wastewater; With specific adaptations, system can be used for industrial wastewater (adsorption at carrier material)	Sludge Treatment	Aerobic / Anaerobic		• MBBRs have exceptional advantages for treatment of domestic wastewater	• High operational costs • Process not easy controllable Poor design of the aeration system leads to accumulation of media instead of uniform distribution of the media	**No** Although it can treat the settled sewage from septic tank. The foot print is similar to SBR and the cost of the media can out weigh the benefits.

						through the reactor volume	
Sequencing Batch Reactor (SBR)	Domestic Wastewater	Industrial wastewater (low blending of industrial wastewater sometimes is possible)	Aerobic	• Reduction of COD / BOD values• Reduction of nitrogen and phosphate	<u>Compact footprint</u>	• Difficult to operate manually, and needs PLC operation	**YES**, This process is simple to operate if automated in order to reduce human intervention.
Soil Based Technology (SBT)	Domestic Wastewater (small volumes)	Sludge treatment & industrial wastewater	Aerobic / Anaerobic	• Moderate treatment efficiency • Treatment of irregular inflow	Moderate cleaning performance with relatively low operational costs	• Process not easily controllable • Large footprint requirement	**NO**, This system is difficult to control and performs moderately.
Fixed Bed Biofilm Reactor (FBBR)	Domestic Wastewater; With specific adaptations, system can be used for industrial wastewater (adsorption at carrier material)	Sludge Treatment	Aerobic	Moderate to very good cleaning performance possible (BOD / COD, nitrogen (denitrification step), Phosphate)	This system is designed for high hydraulic fluctuations and irregular inflow	• Cleaning performance depends on inflow situation • High level of regular maintenance necessary • Construction investment is high	**NO**, The process is suitable but needs downstream filtration to achieve the effluent quality, and the cost of media can outweigh the benefits

Membrane Bio Reactor (MBR)	Domestic Wastewater (small volumes); industrial wastewater and desalination of sea water	Sludge treatment	Aerobic / Anaerobic	Very high pollutant removal and associated pathogen removal	• Very high pollutant removal • No need of downstream filtration to meet effluent quality • Modular installation is possible	• Very high investment • Maintenance is high • Operation expenses are high	**NO** The ULB does not have organizational and financial capacity to operate and maintain the system.
Decentralized Natural Treatment System (AS+ABR +AF+ CW)	Domestic Wastewater (small volumes)	Sludge treatment	Aerobic (Constructed Wetland – CW) / Anaerobic (ABR)	Moderate to very good cleaning performance possible (BOD / COD, nitrogen, Phosphate)	• Very good cleaning performance (w.r.t. to BOD, COD and nutrients). • Very low on O&M cost.	• Very high investment. • Demands more land area for implementation.	**YES**, Such technology is low on O&M cost and does not require daily supervision of the experts for its operation.

6.3.1 Centralized treatment system at Do Nadi

Wastewater Treatment Facility

The suitable technology identified by eliminating the choices through Table 16 is Sequential Batch Reactor (SBR) for centralized treatment system at Do Nadi location.

The Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems, in which the process can be operated in batches, where the different conditions are all achieved in the same reactor but at different times. Activated sludge reactors are aerobic suspended-growth type processes. Large amounts of injected oxygen allow maintaining aerobic conditions and optimally mixing the active biomass with the wastewater to be treated. Activated sludge systems are highly efficient for organic matter, though nutrient and pathogen removal is low. In order to achieve nutrient and pathogen removal, rapid sand filtration combined with ultra violet radiation or membrane filtration can be used.

The excess sludge will be mixed with the incoming septage (48 cum per day) in the process sludge tank and then sent for thickening. The purpose of thickening process is to remove the excess water and send it back to wastewater treatment facility. The thickened sludge is then sent for digestion. Where it gets stabilised and then is passed through centrifuge to dewater the sludge. The dewatered are then further stored to dry them completely before it can be reused for agricultural purpose. Figure 34 shows the treatment process for a SBR along with the sludge and septage management facility.

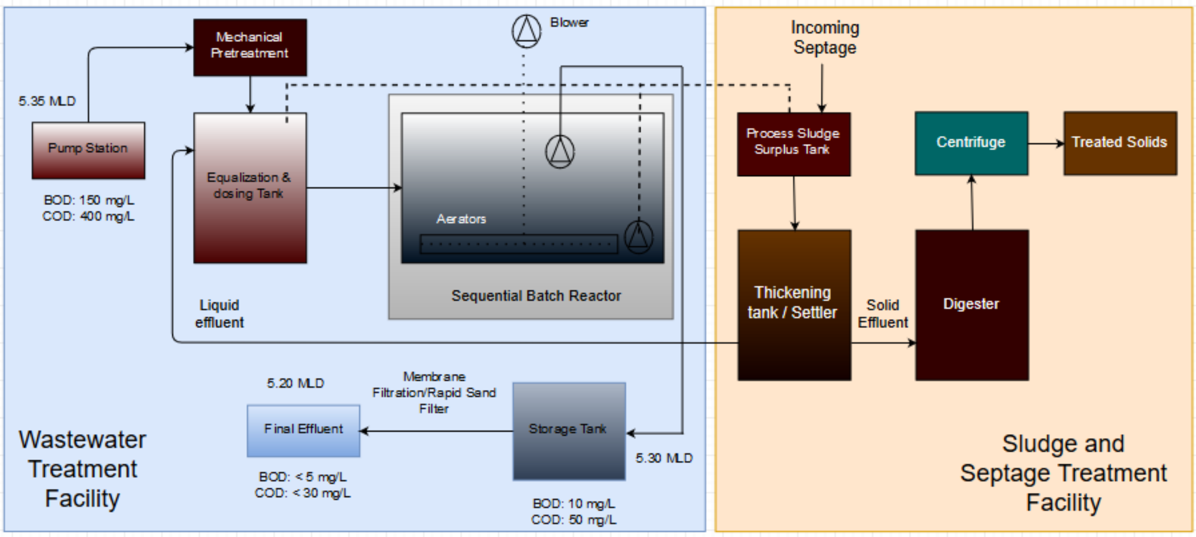

FIGURE 34: SCHEMATIC DIAGRAM OF SEWAGE TREATMENT PLANT WITH A SLUDGE MANAGEMENT FACILITY

TABLE 17: PERFORMANCE INDICATOR FOR SEQUENTIAL BATCH REACTOR

Items	SBR
BOD, mg/l	< 10
COD, mg/l	<50
TSS, mg/l	<10
TKN, P mg/l	+
Quality of Treated Effluent	++
Nutrient Removal Potential	++
Land Requirement	++
Area, hectares/MLD	0.15-0.25
Capital cost	++
Capital Cost, Lakhs/MLD	280
O&M Cost, Rs/m³	10-12
Power Requirement	+++
O&M Skills	++

Low	**+**	***Medium***	**++**	***High***	**+++**	***Very High***	**++++**

6.3.2 Decentralised treatment system at Vasundhara Colony

A decentralised treatment system supported by all-natural processes is identified as the most suitable technology for the Vasundhara Colony.

A DTS is a combination of specific treatment modules such as biogas settler, anaerobic baffled reactor, anaerobic upflow filter and followed by a constructed wetland. The combination of the treatment module depends on the site conditions and characteristic of wastewater to be treated. In case of black water, usually treatment module with anaerobic processes is used followed by an aerobic one and in case of grey water a module with only aerobic processes is sufficient.

The purpose of each treatment module is fixed and the complete treatment chain is capable of producing treated wastewater up to the standards laid down by the CPCB after disinfection.

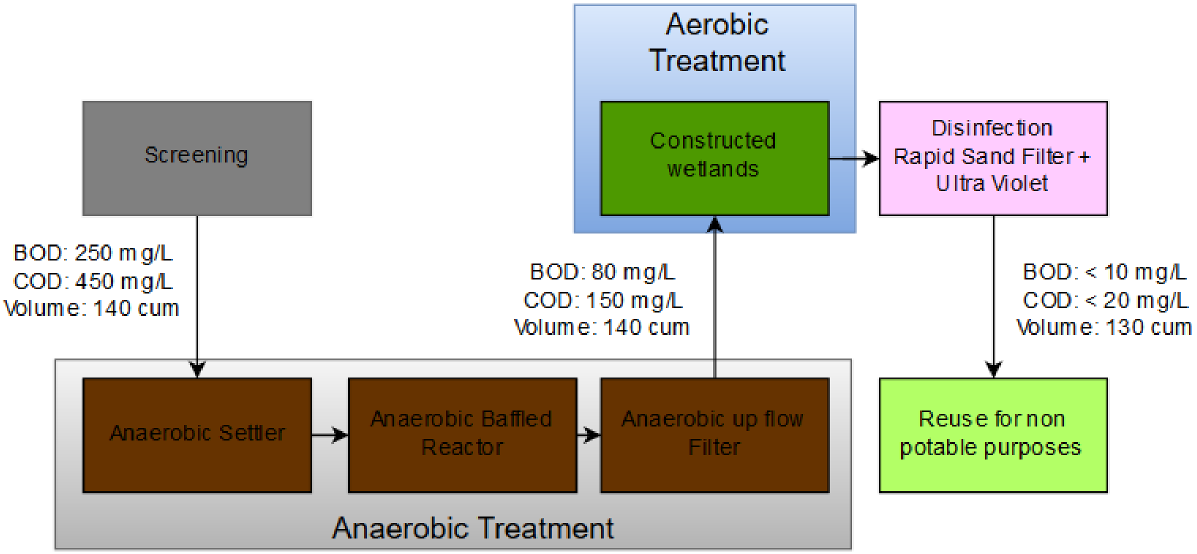

FIGURE 35: SCHEMATIC DIAGRAM OF ALL-NATURAL DECENTRALISED WASTEWATER TREATMENT SYSTEM AT VASUNDHARA COLONY

TABLE 18: PERFORMANCE INDICATOR FOR DECENTRALISED TREATMENT SYSTEM

Items	DTS
BOD, mg/l	<10
COD, mg/l	< 20
TSS, mg/l	<10
TKN, P mg/l	++
Quality of Treated Effluent	++
Nutrient Removal Potential	++
Land Requirement	+++
Area, hectares/MLD	0.30-0.35
Capital cost	+++
Capital Cost, Lakhs/MLD	350
O&M Cost, Rs/m³	3-6
Power Requirement	+
O&M Skills	+

Low	**+**	***Medium***	**++**	***High***	**+++**	***Very High***	**++++**

6.4 Financial estimates

This section deals with the cost estimates of project scenario described in the section 6.2. The rate estimates are based on the inputs given by various experts in the water and wastewater field. The rates used to arrive at the cost estimates are as follows;

- The cost of the small-bore system varies from INR 2200 to INR 4500 depending on the site conditions. This cost is inclusive of the pumping station and other appurtenances required for the system.

- The O&M cost of the small-bore sewer is estimated to be between INR 30 to INR 45 per meter length of the small-bore system.
- The cost of the vacuum truck depending on the model of the truck and the vacuum pump ranges from INR 12.00 lakhs to INR 18 lakhs. In this case we will assume the cost of basic vacuum truck which is INR 12.00 lakhs.
- The operation and maintenance cost of the trucks again varies depending on the usage however in this case it is estimated to be around 15.00 lakhs.
- The capital cost of SBR technology along with sludge and septage management facility is taken as INR 300.00 lakhs per unit capacity (MLD). The rate here has been inflated as extra septage handling capacity needs to be provided at the plant.
- The operational cost of the SBR technology is estimated as per the Table 17 i.e. INR 12 per cum of treated water.
- The capital cost of the DTS is estimated as per the Table 18 i.e. INR 350 lakhs per unit capacity (MLD).
- The operational cost of the DTS is estimated as per the Table 18 i.e. INR 4 per cum of treated water.

6.4.1 Conveyance

The total CAPEX of the small-bore sewer system is estimated to be INR 3,374.35 lakhs. This amounts to the INR 5,436 per capita according to the design population. The OPEX is the small-bore sewer network is estimated to be INR 46.02 lakhs per year. According to the design population, this amount is equivalent to INR 84 per capita per year.

For conveyance of septage to the STP, it is estimated that there would be requirement of three vacuum trucks. The total cost of these trucks will be INR 36.00 lakhs and the O&M cost will be INR 45.00 lakhs per year. The per capita OPEX is estimated to be INR 42 for one year.

TABLE 19: COST ESTIMATED FOR CONVEYANCE IN ALL ZONES OF THE DUNGARPUR CITY

Zone	Length of small bore sewer	Vacuum truck	CAPEX small bore sewers	CAPEX per capita	OPEX small bore sewers	OPEX per Capita
	km	no.	lakhs INR	INR/capita	lakhs INR / annum	INR/capita
Z1	39.45	1	1,183.50	5,339.98	14.99	74.76

Z2	12.40	1	558.00	2,873.92	4.71	26.82
Z3	55.61	1	1,223.35	8,848.18	21.13	168.92
Z4	8.30	0	249.00	9,417.55	3.15	131.85
Z5	0.00	0	-	-	-	-
Z6	5.35	0	160.50	11,145.83	2.03	156.04
TOTAL	121.11	2.75	3,374.35	5,435.66	46.02	84.20

6.4.2 Treatment

The land requirement for setting up the STP will be around 1.60 Ha. It is recommended that the ULB should already make the provision of this land for at least next 30 years as per the guidelines given in the CPHEEO Manual on Sewer and Sewerage Treatment 2012.

The CAPEX of the STP (location DO Nadi) with a co treatment facility running on SBR technology is estimated to be INR 1,596 lakhs. This amounts to INR 2,880 per capita according to the design population. The OPEX of the plants is estimated to be INR 232.97 lakhs per annum i.e. INR 420 per capita per year.

The OPEX of the STP can be brought down by including non-mechanized sludge treatment systems. However, this means more area would be required which in turn correlates to higher CAPEX in the initial phase of the project.

The land requirement of the DTS in the Vasundhara Colony will be around 400 sq m. This area requirement can be brought down by integrating the anaerobic treatment system under the parking and public utility space in the colony. Thus, virtually the area requirement would be for aerobic treatment which is close to 250 sq m.

The CAPEX of the DTS will be around INR 48 lakhs with per capita cost of INR 6,240 for design population of 1440. The OPEX of the system will be only INR 2.00 lakhs per annum which amounts to INR 140 per capita per annum for the design population. As the system does not require skilled manpower for its O&M, the OPEX can still be brought down by using the community's help to maintain the system.

TABLE 20: COST ESTIMATES FOR THE TREATMENT PLANTS TO BE SET UP IN THE DUNGARPUR CITY.

Zone	CAPEX Treatment Plants	CAPEX per capita	OPEX small Treatment Plants	OPEX per Capita
	lakhs INR	INR/capita	lakhs INR / annum	INR/capita
Z1 Z2	1,595.66	2,880.00	232.97	420.48

Z3				
Z4	NA	NA	NA	NA
Z5				
Z6	48.38	3,360.00	2.02	140.16
TOTAL	1,644.05	6,240.00	234.99	560.64

7 Implementation plan

This section deals with identifying the needs of the city to develop the infrastructure and systematic investment.

7.1 Prioritization matrix

The methodology adopted for this purpose if the Eisenhover's Urgent/Important Principle.

The Eisenhover's Principle says, "There are two types of problems: the urgent and the important. The urgent are not important, and the important are never urgent."

The Eisenhover's principal is one of the simplest way to prioritize the tasks to be carried out in the city. Table 21 is the Important Vs. Urgent Matrix for various issues identified at the city level.

TABLE 21 PRIORITIZATION MATRIX FOR INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT PLAN

	Important	No important
Urgent	• Pollution of Sunheriya Lake due to wastewater from Zone 1 and 3. • Pollution of Sabela Lake due to wastewater flowing from Zone 2. • Wastewater management system for Vasundhara Colony.	• Absence of policy regarding standardization of onsite sanitation systems.
Not urgent	• Pollution of Gaib Sagar Lake due to industrial effluent mixed with septic tank effluent and grey water in Zone 1. • Pollution of Gaib Sagar Lake due to septic tank effluent and grey water from Zone 4. • Groundwater pollution due to no management of septage and wastewater.	• Absence of policy regarding proper management of wastewater in the newly merged areas of the city (zone 5, 6)

7.2 Implementation plan

Based on the inferences drawn from the prioritization matrix, Table 22 is made. The tasks are arranged in the chronological way in the column i.e. the highest priority task comes first.

The Table 22 is colour coded for the tasks. The colour codes are as follows;

(green)	Decentralised wastewater management system
(blue)	Small bore sewer system
(yellow)	Policy and advocacy
(orange)	Centralised wastewater management system

During the last consultation with ULB officials where the first draft of the plan was presented, following were the points that we discussed;

1. The wastewater of the city naturally flows into four lakes i.e. Gaib Sagar, Sunheriya lake, Sabela lake and Patela lake.
2. There is a need of having a decentralized treatment system near each lake until the centralized sewerage is implemented.
3. Until the STP comes up, the city plans to manage the septage using the biomethanation plant.
4. The ULB officials feel that implementation of sewerage system will incur lot of indirect costs due to damage to the properties and roads.

TABLE 22: IMPLEMENTATION PLAN (SHORT TERM, MIDTERM AND LONG TERM) FOR DUNGARPUR CITY

Short term plan (2018-2021)	Midterm plan (2021-2036)	Long term plan (2036-2051)
Implementation of decentralised treatment system near the Sunheriya Lake.	Introducing scheduled desludging concept with building up of data base for same.	Implementation of small bore sewer system in **Zone 3.**
Implementation of Decentralized wastewater treatment system at Vasundhara Colony.	Execution of the IWSM policy at the city-wide scale.	Implementation of decentralised wastewater treatment system in Zone 3.
Implementation of decentralised treatment system near Gaib Sagar lake.	Implementation of small bore sewer system in **zone 1 & 2.**	Implementation of small bore sewer system in **Zone 5.**
Implementation of small bore sewer system in **Zone 4** with interceptor drains to divert the wastewater to the decentralised treatment system at Gaib Sagar lake.	Implementation of STP with Co Treatment Facility at Do Nadi location.	Implementation of small bore sewer system in **Zone 6.**
Carrying out a city wide survey for building a data base of households, IHHTs and collection and storage system.		
Drafting of IWSM policy regarding onsite sanitation system such as toilets, soak pits, septic tanks.		

Annexure

8 Technological options

8.1 Septic tank

A septic tank is a watertight chamber made of brick work, concrete, fibreglass, PVC or plastic, through which blackwater from cistern or pour-flush toilets and greywater through a pipe from inside a building or an outside toilet flows for primary treatment. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate. Effluent is infiltrated into the ground or transported via a sewer to a (semi) centralized treatment plant. Accumulating septage needs to be dug out the chamber regularly and correctly disposed of.

An illustrative structural drawing of a septic tank has been given in the Figure 36. Now a days integral septic tank with contact aeration are also available in the market. These septic tanks are made out of HDPE material and are quite durable and easy to install. Figure 37 shows an illustration of a compact integral configuration of an integral septic tank and contact aeration.

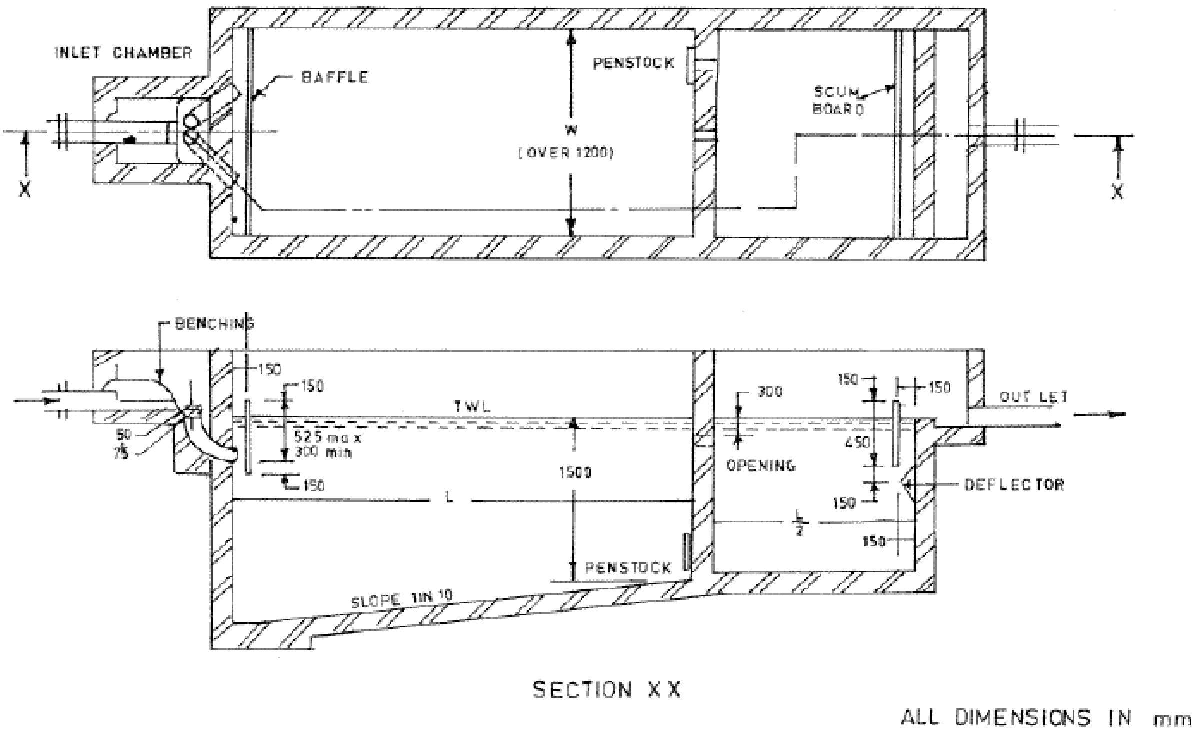

FIGURE 36: STRUCTURE OF A SEPTIC TANK WITH DIMENSIONS (SOURCE: CPHEEO MANUAL ON SEWAGE AND SEWERAGE TREATMENT, CHAPTER 9)

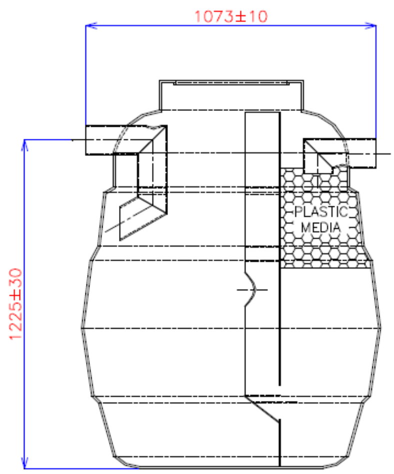

FIGURE 37: ILLUSTRATIVE CONFIGURATION OF AN INTEGRAL SEPTIC TANK AND CONTACT AERATION UNIT. (SOURCE: CPHEEO MANUAL ON SEWAGE AND SEWERAGE TREATMENT, CHAPTER 9)

The Indian Standard Code IS 2470 is the Code of practice for design and construction of septic tanks and IS 9872-1981 is the Code for Precast concrete septic tanks. Figure 38 & Figure 39 shows the sizing of the septic tanks for different number of users and cleaning interval.

The compliance of the existing septic tank should be checked against these dimensions. If the septic tank is non complaint, then the ULB should issue a notice to the household for either retrofitting or replacing the tank.

No. of Users	Length (m)	Breadth (m)	Liquid depth (m) (cleaning interval of)	
			2 years	3 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Note 1 The capacities are recommended on the assumption that discharge from only WC will be treated in the septic tank

Note 2 A provision of 300 mm should be made for free broad.

Note 3 The sizes of septic tank are based on certain assumption on peak discharges, as estimated in IS: 2470 (part 1) - 1985 and while choosing the size of septic tank exact calculations shall be made.

FIGURE 38: RECOMMENDED SIZE OF SEPTIC TANK UP TO 20 USERS (SOURCE: CPHEEO MANUAL ON SEWAGE AND SEWERAGE TREATMENT, CHAPTER 9)

No. of Users	Length (m)	Breadth (m)	Liquid depth (cleaning interval of)	
			2 years	3 years
50	5.0	2.00	1.0	1.24
100	7.5	2.65	1.0	1.24
150	10.0	3.00	1.0	1.24
200	12.0	3.30	1.0	1.24
300	15.0	4.00	1.0	1.24

Note -1: A provision of 300 mm should be made for free board.
Note -2: The sizes of septic tank are based on certain assumptions on peak discharges, as estimated in IS: 2470 (Part 1)-1985 and while choosing the size of septic tank exact calculations shall be made.
Note -3: For population over 100, the tank may be divided into independent parallel chambers of maintenance and cleaning.

FIGURE 39: RECOMMENDED SIZE OF SEPTIC TANK UP TO 300 USERS (SOURCE: CPHEEO MANUAL ON SEWAGE AND SEWERAGE TREATMENT, CHAPTER 9)

8.2 Anaerobic baffled reactor

An ABR is an improved septic tank with a series of baffles under which the grey-, black water is forced to flow under and offer the baffles from the inlet to the outlet. The increased contact time with the active biomass (sludge) results in improved treatment. ABRs are robust and can treat a wide range of wastewater, but both remaining sludge and effluents still need further treatment in order to be reused or discharged properly.

The illustration of an ABR is given in the Figure 40. As in the septic tank, the ABR also needs to be desludged and a required frequency. The frequency ranges from 2-3 years and septage obtained from the system should be taken for further processing at a FSTP.

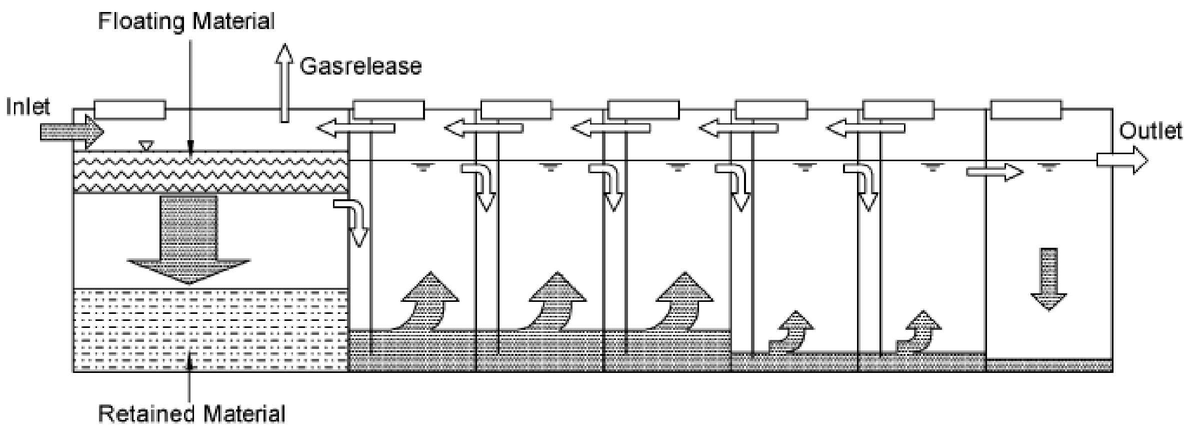

FIGURE 40: ILLUSTRATION OF ANAEROBIC BAFFLED REACTOR (SOURCE: CPHEEO MANUAL ON SEWAGE AND SEWERAGE TREATMENT, CHAPTER 9)

8.3 Decentralised wastewater treatment system

A DTS is a combination of specific treatment modules such as biogas settler, anaerobic baffled reactor, anaerobic upflow filter and followed by a constructed wetland. The combination of the treatment module depends on the site conditions and characteristic of wastewater to be treated. In case of black water, usually treatment module with anaerobic processes is used followed by an aerobic one and in case of grey water a module with only aerobic processes is sufficient.

The purpose of each treatment module is fixed and the complete treatment chain is capable of producing treated wastewater up to the standards laid down by the CPCB after disinfection.

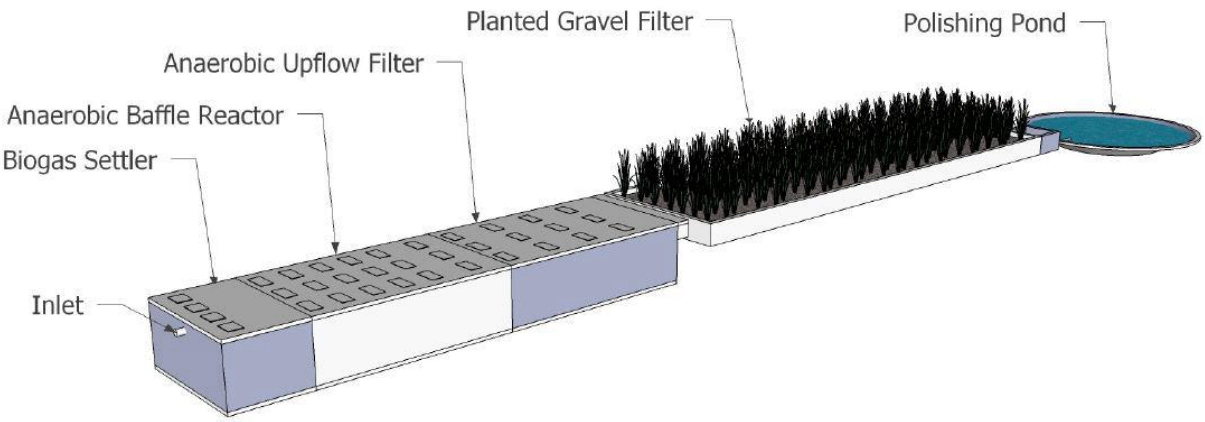

FIGURE 41: ILLUSTRATION OF A DECENTRALISED WASTEWATER TREATMENT SYSTEM. (SOURCE: ECOSAN SERVICES FOUNDATION)

Biogas Settler/ Anaerobic Settler

Working Principle	**Basically, a sedimentation tank (physical treatment) in which settled sludge is stabilised by anaerobic digestion (biological treatment). Dissolved and suspended matter leaves the tank more or less untreated.**
Capacity/Adequacy	Household and community level; Primary Treatment for domestic grey- and blackwater. Not adapted for areas with high groundwater table or prone to flooding.
Performance	BOD: 30 to 50%; TSS: 40 to 60 %; E. Coli: 1 log units, HRT: about 8 hours
Costs	Low-cost, depending on availability of materials and frequency of de-sludging.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly. Sludge needs to be dug out every 1 to 3 years and discharged properly (e.g. in composting or drying bed). Needs to be vented.

Reliability	When not regularly emptied, wastewater flows through without being treated. Generally good resistance to shock loading.
Main strength	Simple to construct and to operate.
Main weakness	Effluent and sludge require further treatment. Long start-up phase.

Anaerobic baffled reactor

Working Principle	**Vertical baffles in the tank force the pre-settled wastewater to flow under and over the baffles guaranteeing contact between wastewater and resident sludge and allowing an enhanced anaerobic digestion of suspended and dissolved solids; at least 1 sedimentation chamber and 2–5 up-flow chambers.**
Capacity/Adequacy	Community (and household) level; For pre-settled domestic or (high strength) industrial wastewaterhttps://sswm.info/glossary/2/letteri_-_term1050 of narrow COD/BOD ratio. Typically integrated in DTS systems; Not adapted for areas with high ground-water table or prone to flooding.
Performance	70- 95% BOD; 80% - 90% TSS; Low pathogen reduction, HRT: 1 to 3 days
Costs	Generally low-cost; depending on availability of materials and economy of scale.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly; sludge needs to be dug out and discharged properly (e.g. in composting or drying bed); needs to be vented.
Reliability	High resistance to shock loading and changing temperature, pH or chemical composition of the influent; requires no energy.
Main strengths	Strong resistance; built from local material; biogas can be recovered.
Main weakness	Long start-up phase.

Anaerobic up flow Filter

Working Principle	**Dissolved and non-settleable solids are removed by anaerobic digestion through close contact with bacteria attached to the filter media**
Capacity/Adequacy	Household and community level; as secondary treatment step after primary treatment in a septic tank or an anaerobic baffled reactor; effluents can be infiltrated into soil or reused for irrigation; not adapted if high ground-water table or in areas prone to flooding.
Performance	BOD: 50 to 90%; TSS: 50 to 80 %; Total Coliforms: 1 to 2 log units HRT: about 1 day
Costs	Generally low-cost; depending on availability of materials and frequency of back flushing and desludging.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Regularly backflush to prevent clogging (without washing out the biofilm); desludging of the primary settling chambers; needs to be vented if biogas not recovered.

Reliability	Reliable if construction is watertight and influent is primary settled; Generally good resistance to shock loading.
Main strength	Resistant to shock loading; High reduction of BOD and TSS.
Main weakness	Long start-up phase.

Constructed Wetlands

Working Principle	**Pre-treated grey- or blackwater is applied intermittently to a planted filter surface, percolates through the unsaturated filter substrate where physical, biological and chemical processes purify the water. The treated wastewater is collected in a drainage network (adapted from MOREL and DIENER 2006).**
Capacity/Adequacy	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water.
Performance	BOD = 75 to 90%; TSS = 65 to 85%; TN < 60%; TP < 35%; FC ≤ 2 to 3 log.
Costs	The capital cost of CWs are dependent on the costs of sand and gravel and also on the cost of land required for the CW. The O&M costs are very low (MOREL and DIENER 2006).
Self-help Compatibility	O&M by trained labourers, most of construction material locally available, except filter substrate could be a problem. Construction needs expert design. Electricity pumps may be necessary.
O&M	Emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/outlet systems.
Reliability	Clogging of the filter bed is the main risk of this system, but treatment performance is satisfactory.
Main strength	Efficient removal of suspended and dissolved organic matter, nutrients and pathogens; no wastewater above ground level and therefore no odour nuisance; plants have a landscaping and ornamental purpose.
Main weakness	Even distribution on a filter bed requires a well-functioning pressure distribution with pump or siphon. Uneven distribution causes clogging zones and plug flows with reduced treatment performance; high quality filter material is not always available and expensive; expertise required for design, construction and monitoring..

8.4 Small bore (solid free) sewers

A solid free sewer is a network of small-diameter pipes that transports pre-treated and solids-free wastewater (such as septic tanks or biogas settler effluents) to a treatment facility for further treatment or to a discharge point. As solids are removed, the diameter of the sewers can be much smaller than for conventional sewers. It can be installed at a shallow depth and does not require a minimum wastewater flow or slope to function. Thus, significant lower construction costs are required than for conventional sewers. Small bore sewer can be built for new areas or where soil infiltration of septic tanks effluents (e.g. via leach fields) is not appropriate anymore (i.e. densely populated areas, clogging of sub-surface). Although small bore sewer requires a constant supply of water, less water is needed compared to conventional sewers because self-cleansing velocities are not required. Figure 42 shows the schematic of a small bore sewer system.

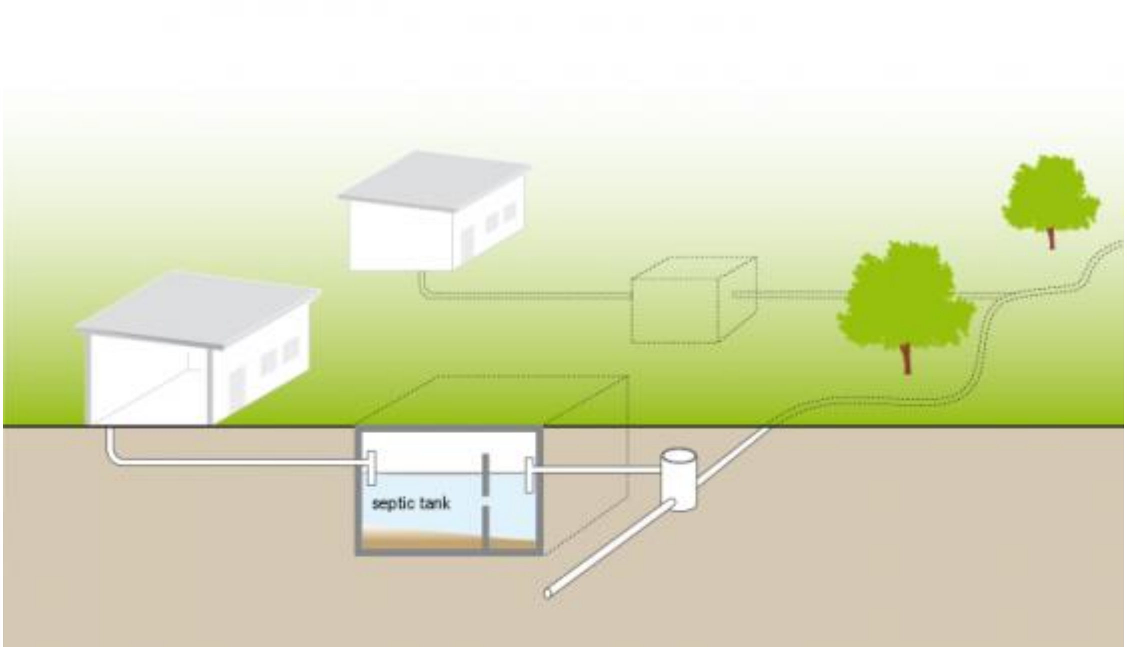

FIGURE 42: SCHEMATIC OF SMALL BORE SEWER SYSTEM INSTALLED IN A NEIGHBOURHOOD. (SOURCE: TILLEY ET AL. 2014)

8.5 Vacuum trucks

Vacuum trucks refer to a vehicle equipped with a motorized pump and a storage tank for emptying and transporting faecal sludge, septage. Humans are required to operate the pump and manoeuvre the hose, but sludge is not manually lifted or transported. Emptying and transport using a vacuum truck is fast and generally efficient. Moreover, it can generate local jobs. But large streets are required for the trucks to pass, thick or dried material cannot be pumped and garbage in pits may block the hose. Moreover, capital costs are high and spare parts may be not available locally.

Figure 43: Vacuum truck emptying a septic tank in Bharakpur near Kolkata and a Vacu tug used for emptying septic tanks in congested areas. (Source: EAWAG/SANDEC 2008 & Strauss et al. 2002)

In case of narrow lanes where the vacuum truck cannot reach, it is possible to empty the on site storage system using a vacu tug. Vacu tug is mini version of a vacuum truck which can be pulled manually or with help of a motorised vehicle. The capacity of vacu tug is usually 350 L.

8.6 Co treatment plant

A centralized co treatment plant is a treatment plant which has two systems, one for treating the septic tank effluent and grey water coming through small bore sewers and second septage from the septic tanks emptied using vacuum trucks.

The centralized wastewater treatment plant of capacity in MLD has to be mechanized and technologies such as Sequential Batch Reactor, Activated Sludge Process, Moving Bed Biological Reactor etc are suitable. All these technologies produce primary and secondary sludge which needs to be handled in the treatment plant itself. The sludge is first passed through thickening tank and then stabilised in a digestor before dewatering using a centrifuge or a belt press.

The incoming septage can be mixed with the primary and secondary sludge in the before the thickening tank. However, the design of the sludge management facility should consider the revised organic and hydraulic loading due to incoming sludge.

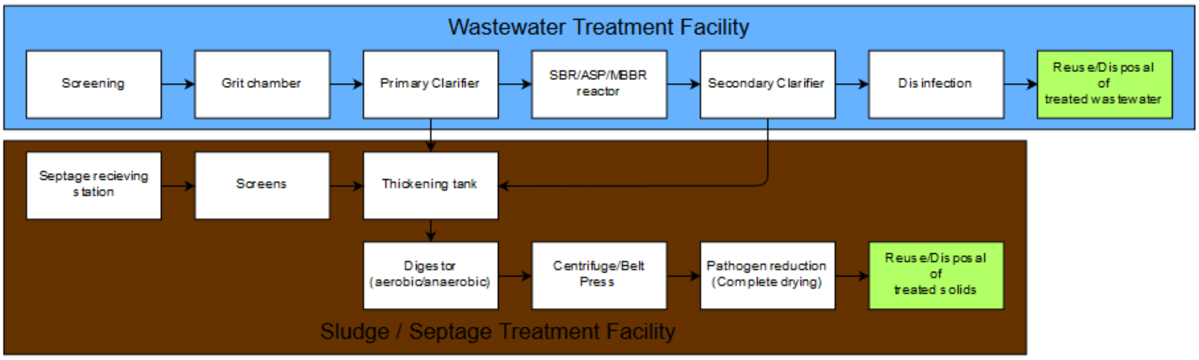

FIGURE 44: SCHEMATIC TREATMENT CHAIN AT A CO TREATMENT PLANT FOR WASTEWATER AND SEPTAGE