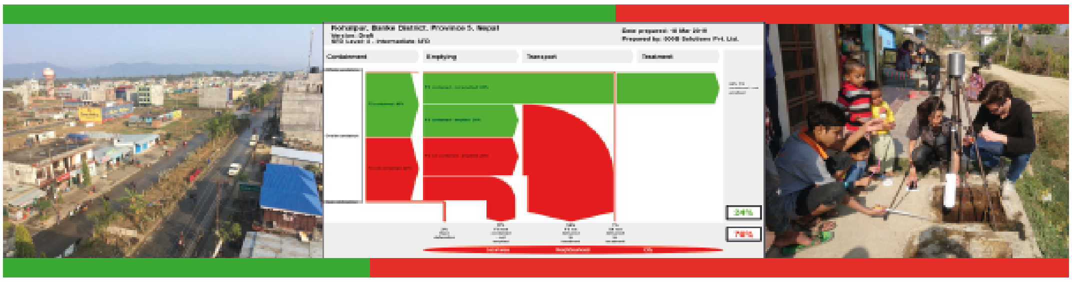
City Sanitation Plan
Kohalpur Municipality



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1. Background

In October 2019, Nepal was declared as an open defecation free (ODF) country. This implies that 100% of the population do not defecate in the open and have access to some form of sanitation facilities. ODF has been considered as a first step to achieving Total Sanitation. Among seven different indicators, proposed by the Nepal government under a total sanitation concept, the broader indicator on environmental sanitation lays emphasis on a system perspective and to consider safe management of both solid and liquid waste streams in towns and cities.

A citywide sanitation planning (CSP) process began in Kohalpur from November 2018 under a collaborative effort of Kohalpur Municipality and external partners mainly: 500B Solutions, Eawag-Sandec and the WASH Alliance International under the WASH SDG Program. The CSP process provide guidance in developing an integrated sanitation plan considering local needs and priorities. The Sanitation 21 Framework developed by the International Water Association together with Eawag-Sandec was taken as the guiding framework to develop the plan. The framework highlights 5 steps or stages to attain citywide sanitation planning mainly: i) building institutional commitment and partnership, ii) understanding the existing context and defining priorities, iii) developing systems for sanitation improvement, iv) developing models for service delivery and v) preparing for implementation.

This report outlines the details of the sanitation improvement plan for Kohalpur Municipality.

1.1 Scope, objective and limitations

Based on the priority set by the municipality, the sanitation improvement plan has focused mainly on the faecal sludge (FS) management component. The plan has been designed considering overall FS generation from the municipality based on a sample analysis. The plan does not dwell much into the other environmental sanitation components but tries to establish linkages within the plan.

1.2 Project Area

Kohalpur Municipality is located in Banke District in Province 5 of Nepal (Figure 1). The Municipality was established on May 8, 2014 with the merger of two Village Development Committees of Rajhena and Kohalpur. The Municipality spans across a total area coverage of 184.16 km2 and has a total population of 87,300. The climate is a sub-tropical type with the temperatures varying from a maximum of 46oC to a minimum of 7oC. The Municipality has a total of 15 wards where wards 14 and 15 was added in 2015 after the inclusion of adjoining Samsherganj VDC. The city of Kohalpur is growing due to rapid urbanization following the road expansion projects in the Mid-Western Region of the country. Most of the wards have urban settings with permanent built-up areas. Wards 3, 8 and 15 features peri-urban settings with semi-permanent and temporary housing structures.

Ward 13 has the largest forest coverage which is connected to the Bardiya National Park in Bardiya District. It is also the largest ward of Kohalpur Municipality with an area of 91.21 km^2 while ward 1 is the smallest with an area of 0.7 km^2. The population density ranges from a minimum of 71 persons/km^2 in ward 13 to a maximum of 3600 persons/km^2 in ward 11 while the average population density of the Municipality is 474 persons/km^2. The population growth rate is estimated to be at 3.53% p.a.

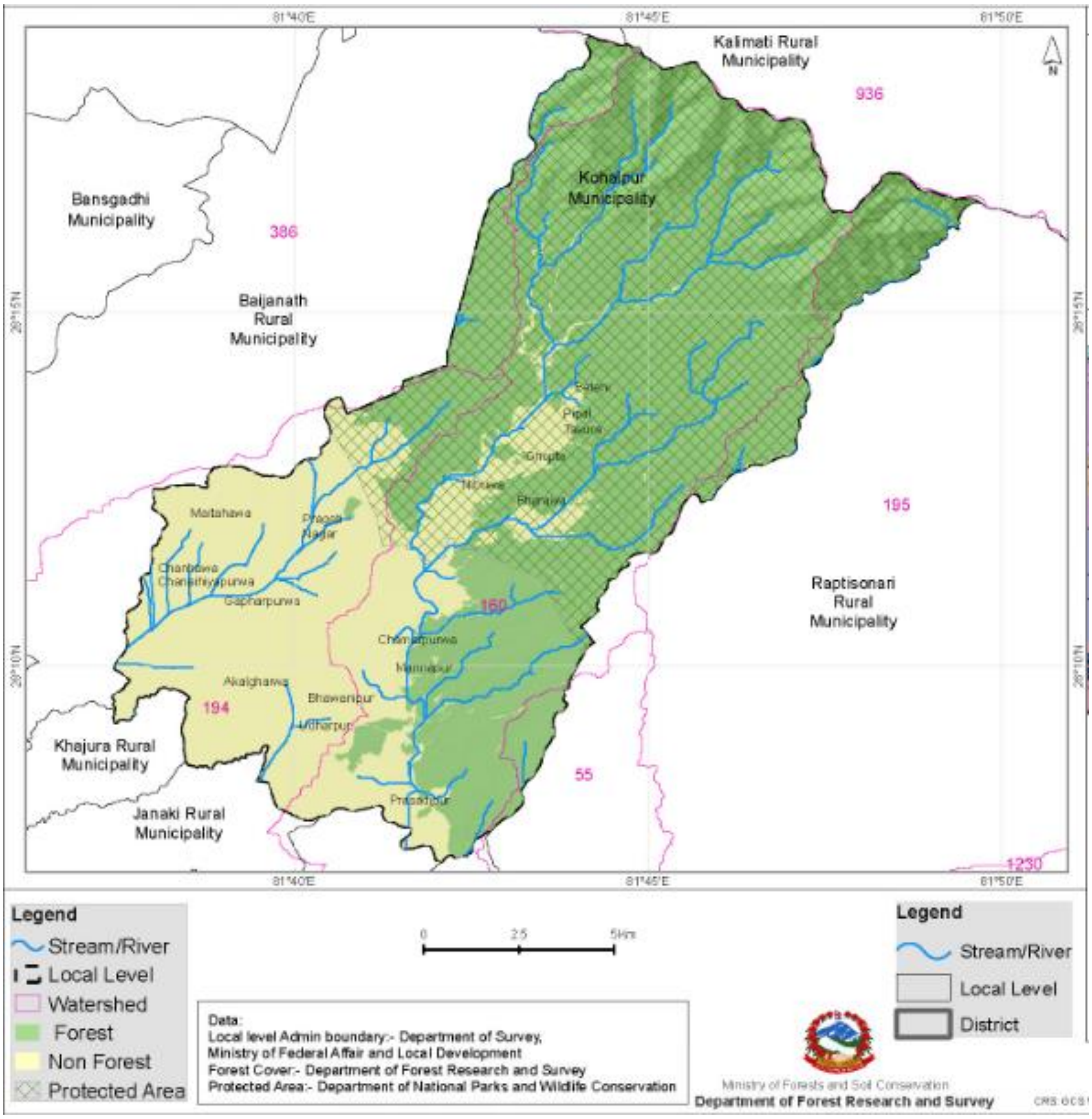

Figure 1: Map of Kohalpur Municipality

2. Methodology

2.1. Baseline situation assessment

Baseline data was collected in Kohalpur through a randomized sample household survey during December to January 2018. The main objective of the survey was to understand the environmental sanitation status of Kohalpur Municipality, particularly on access to toilet facilities, FS management, wastewater management status and solid waste management. The household survey comprised of a randomized sampling covering around 400 households in the Municipality. A mobile data collection using Kobo collect on smart phones was used for data collection.

2.2. Q&Q Analysis

Quantity and quality of FS was also measured and analyzed using two different tools developed by Eawag. The first tool used was the Volaser, which measured the size and volume of containment, to estimate the quantity of sludge accumulated in different types of containment. It allows for the quantity of FS to be measured in situ by the use of horizontal and vertical layers that allows the measure of area of containment and a telescopic rod to measure the depth of the containment.

The second tool used was a core sampler, also developed by Eawag. The sampler was used for collecting FS from containments for analyzing the quality of FS. Please refer to a separate report on the Q&Q methodology and experience from Kohalpur.

2.3. Need prioritization workshop

During the assessment period, several focus group discussions and interaction workshops was also conducted to collect issues and concerns of the users and identifying key needs and priorities with respect to environmental sanitation. In addition, a workshop with the Municipal WASH Coordination Committee (MWASHCC) was conducted to discuss on environmental sanitation status in Kohalpur and to identify the key needs.

2.1. Workshop on systems selection

Sanitation system were analyzed and discussed with the local stakeholders, mainly the MWASHCC and concerned stakeholders' groups, through a consultation workshop. Sanitation systems and service options recommended by experts were presented and discussed. The selected system options were further analyzed in detail and the best ones were recommended.

3. Situational Analysis

3.1 Drinking water

Almost every house in the Municipality had a tube well in their premises and the groundwater table could be reached in less than 45ft. Even though nine wards out of 15 were supplied drinking water by the Water Supply Sanitation and Sector Project (STWSSP), only about 25% of the houses had access to piped water supply and the rest relied on groundwater. People mentioned about high iron content in the water, water quality test results were however not available. Microbial contamination of water was another issue in the Municipality.

3.2 Grey Water

Grey water was either disposed in field or backyard (62%) or discharged into open drains (37%). Only 0.3% of HH had grey water draining together with wastes from toilet.

3.3 Solid Waste

The average per capita municipal solid waste generation in Kohalpur was around 177 g/day while the average per capita HH waste generation was around 117 g/day (Enrich Nepal, 2018). Around 68% of HH solid waste composition comprised of organic waste while the waste from commercial areas and institutions comprised of a mix of organic waste, plastic and paper and paper products (Figure 2).

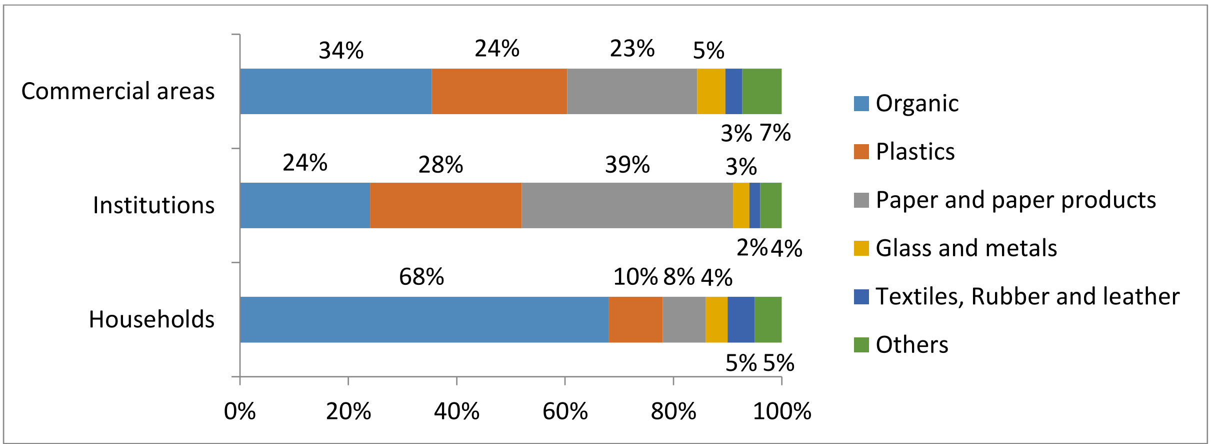

Figure 2: Waste generation and composition in Kohalpur Municipality

Source: adapted from Enrich Nepal (2018)

19% of the HHs (Wards 2, 10 and 11) had access to waste collection services who paid a monthly fee of NRs. 100-150. The collected wastes were dumped in a dumping site located inside the Saraswati Community Forest on the outskirts of the Municipality. Rest of the HHs managed the organic and inorganic waste in different ways (Figure 3 and 4).

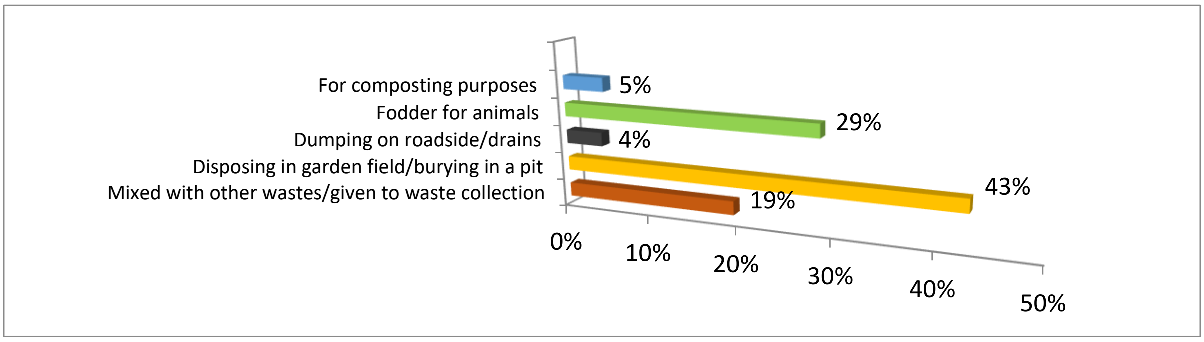

Figure 3: Organic waste disposal practices in HH

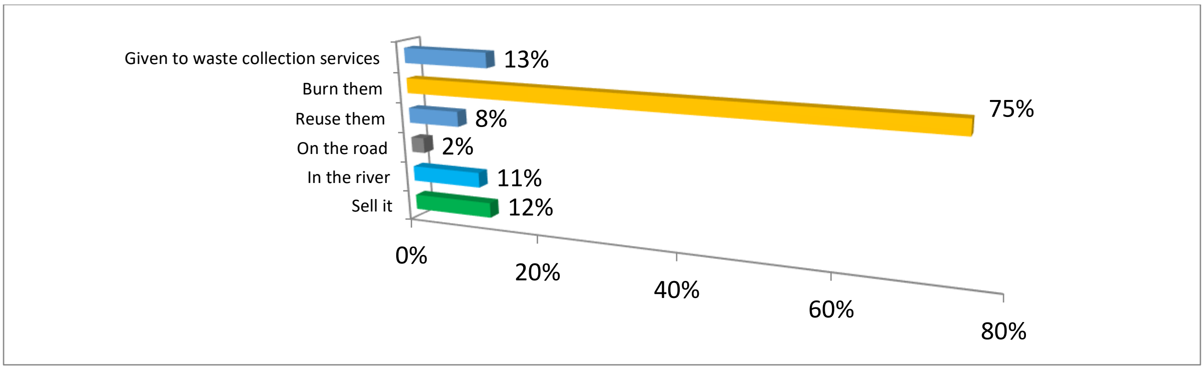

Figure 4: Inorganic waste disposal practices in HH

3.4 Sanitation

The following section provides an analysis of the sanitation situation across the sanitation value chain.

3.4.1 Toilets coverage

94% of the population in Kohalpur have access to a private toilet facility. 100% coverage was found in Wards 1, 5, 6 and 10 whereas the lowest coverage of 76% was found in Ward 15. Of the 6% without toilets, 64% shared a toilet with neighbours and 36% practiced open defecation.

3.4.2 User Interface

98.6% of the households had a squatting pour flush type of toilets and a small percent of pedestal pour flush and dry toilets.

3.4.3 Containment and Storage

Only about 2% containment were constructed in 2017-18 while a large percent (45%) was constructed between 2011 and 2016.

Among households with containments, around 40% of the containment consisted of Sealed Holding Tanks while 50% were Single Pits with rings and 9% had pits connected to a Bio-digester. Other containment was unsealed holding tanks and double pits. The average volume of sealed holding tanks was estimated to be around 14 m^3 while that of single pits was estimated to be around 1.2 m^3.

Permanent buildings predominantly constructed sealed holding tanks while a high percent of semi-permanent and temporary houses had single pits (Figure 5). It was interesting to note that over the year's household preference decreased for pits but increased for holding tanks with increase in the number of users (Figure 6).

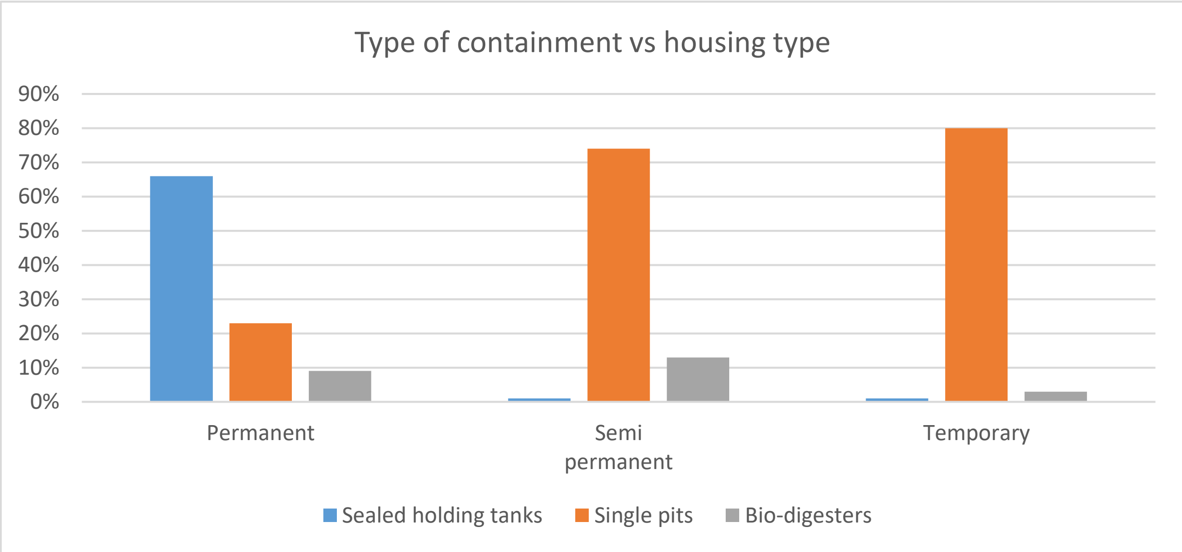

Figure 5: Containment types according to housing construction type

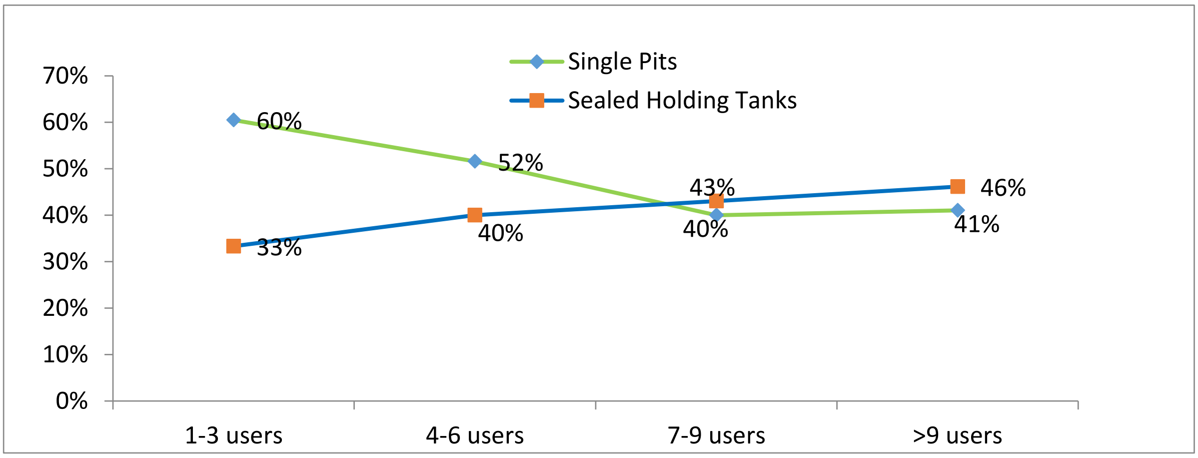

Figure 6: Variation of containment type with the number of toilet users

3.4.4 Emptying and Transportation

From the survey, it was shown that about 46% of the containments were not yet emptied as they were not filled and of those emptied, about 33% of the containments were emptied between 1-3 years.

The average emptying frequency for sealed holding tank was once every three years and for pits it was once every two years. 1% of the containment was connected to a sewer or open drain (Figure 7).

Among the households that emptied their containments, 36% of the households emptied manually by themselves while 42% hired manual emptier and the remaining 22% hired a mechanical emptier. 99% of the pits was emptied manually (58% self-emptying, 41%

hired) while 44% of holding tanks was emptied manually (40% hired) and 56% was emptied mechanically.

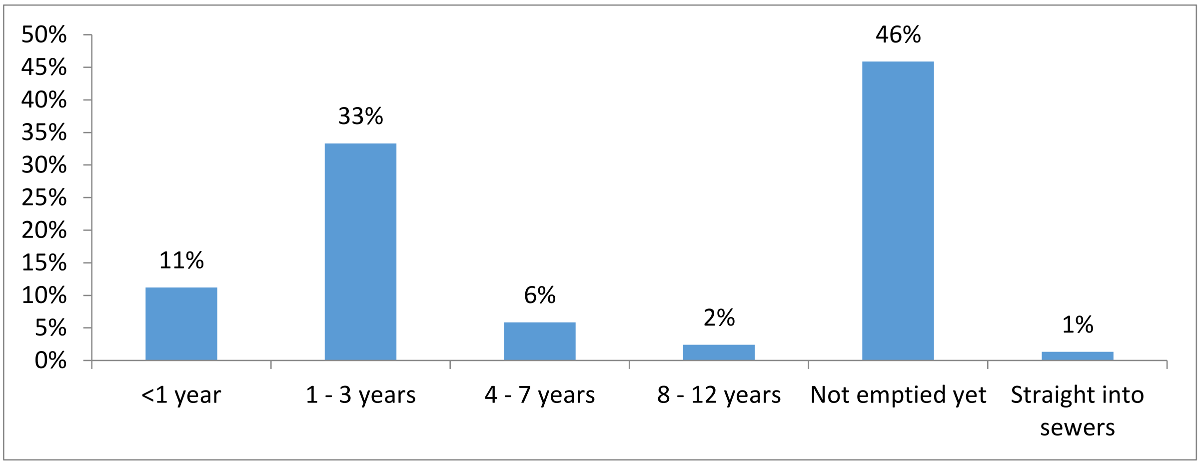

Figure 7: Emptying frequency of FS pit/tank for households in Kohalpur

3.4.5 Treatment and Disposal

There is neither a FS treatment facility nor a designated disposal area in Kohalpur. There are various disposal practices of which 62% constitutes of disposal in gardens or field, either burying in pit or disposal on ground. The mechanical emptier disposed the sludge in a temporary landfill site in the community forest of Ward 8.

3.4.6 FS Service Providers

There were three private mechanical emptier and the Municipality providing desludging service in the Municipality, each with 1 truck. Two of the three private service providers are new in the business while one has been in the business for a decade. Even the Municipality started providing service since a year back. All the private service providers had 6m^3 trucks while the Municipality had a 4m^3 truck with air compressor motors. The average cost for truck is about NPR 1.4 million and the monthly maintenance cost including fuel costs adds up to about NPR 18,000. The Municipality provided its services within the Municipality while the private operated in adjoining VDCs and Municipalities as well.

3.4.7 Shit Flow Diagram

The shit flow diagram (SFD) was developed for Kohalpur based on the information collected during the situational assessment study and using the SFD Generator tool (https://sfd.susana.org/data-to-graphic). The SFD for Kohalpur is a reliable estimation but it does not depict the exact situation in the Municipality. The SFD clearly showed that even with 98% toilet coverage, 76% of the faecal sludge and blackwater entered the environment untreated (Figure 8). Therefore, it is clear that having a toilet and a containment or a connection to sewer network alone does not ensure safe management of faecal matter. To achieve 100% ODF status, the containments should be of standard design such that it does not leach and pollute, the containments should be regularly emptied, and faecal sludge taken to a designated FSTP and the sewer network should be connected to sewerage treatment plant.

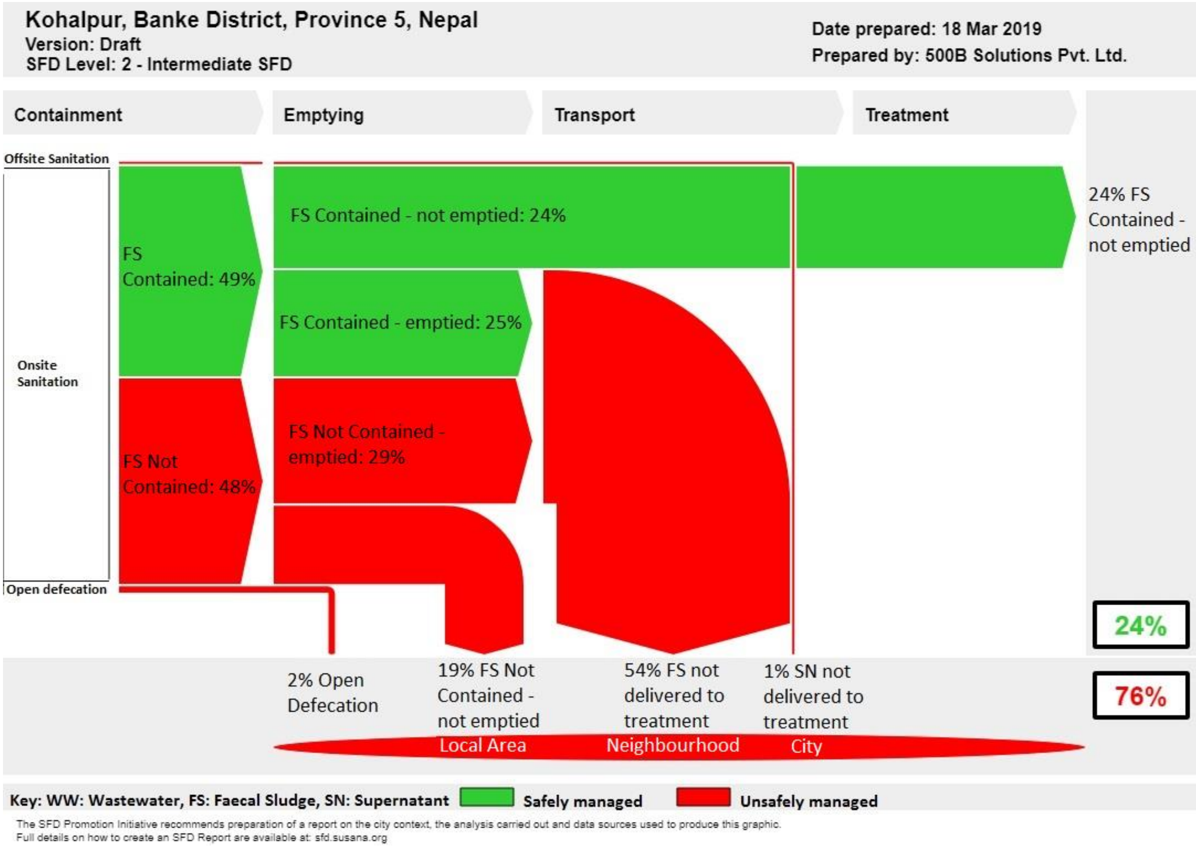

Figure 8 SFD Graphic of Kohalpur Municipality

3.5 FS quantity and characterization

3.5.1 Current FS generation

The following assumptions were made to estimate the FS quantity for Kohalpur:

- The households sample survey was considered to identify the distribution or categories of containments
- Volume of containments were determined through the Q&Q process where actual measurements were carried out
- The number of dwelling or buildings has been considered by taking the average number of families living in each building
- percent of mechanical emptying for each containment category was taken from the survey
- FS generated from households and institutions have been considered to estimate the sludge volume
- Estimation has been made based on the current mechanical emptying rate and manual emptying has not been taken into consideration.

Table 1 and 2 provide estimates of FS generated from household and institutions. These data were based on the household sample survey.

Table 1: FS estimation from households, Kohalpur

Type of Containment	Vol of FS in containment (m3)	Emp freq (yrs)	Tot coverage in Kohalpur	No. of HH having this system	No. of building units having this system	% mechanically emptied	Estimated FS generated (with present mechanical emptying) (m3/year)	Estimated FS de-sludged (with present mechanical emptying) (m3/day)
Sealed holding tanks	11.02	2.88	39.70%	7793	3117	30%	3578.15	9.80
Single pits	0.82	1.66	50.40%	9893	3957	1%	19.55	0.05
Double pits	0.69	0.5	0.50%	98	39	0%	0.00	0.00
Unsealed holding tanks	11.02	0	0.80%	157	63	0%		
								9.86

Table 2: FS estimation from institutions, Kohalpur

Institution	No. of trips per emptying	Emp freq (yrs)	No. of institutions	% Emptied from	No. of institutions emptied from	Estimated FS generated (with present emptying) (m3/year)	Estimated FS generated (with present emptying) (m3/day)
Army Barrack	9	0.5	1	100%	1	108	0.30
Area Police Headquarters	2	0.083	1	100%	1	144	0.39
Medical College	5	9	1	100%	1	3.3	0.01
Schools	2.38	0.55	80	100%	80	2077.1	5.69
Hotels	2.75	2.44	300	53%	160	1081.9	2.96
Ward Offices	3	0.75	15	50%	8	180.0	0.49
Public Toilets	2	0.05	5	40%	2	480.0	1.32
							11.16

Based on the calculation, the total estimated FS generated or collected in Kohalpur is around $21m^3$/day. Likewise, the estimated potential FS generation, considering both mechanical and manual emptying practices, is around $54m^3$/day. A detail calculation is provided in Annex 1.

3.5.2 FS Quality

Quality of FS was analyzed in 53 samples, 26 single pits and 27 sealed holding tanks, in Kohalpur. The parameters analysed were COD and TS. Analysis results showed a highly varied results for both the parameters in the sampled containment units. The mean values for COD and TS in a single pit was 33g/L and 68g/L respectively. Similarly, the mean values of COD and TS in sealed holding tanks was 11g/L and 10g/L respectively. Removing the outliers in the samples (N=50), the mean TS of both the containments was 37g/L. This can be taken as a basis for additional calculations in Kohalpur.

The mean supernatant fraction in pits was 22% while that in holding tanks was 75%. The lower concentration of COD and TS in holding tanks compared to pits could be due to the diluted sludge in larger containments. Sludge in pits were generally found to be thick with low moisture content.

No significant correlation was observed between COD and TS levels in the single pits (Figure 9). Comparatively, a better correlation was observed between COD and TS levels in the sealed holding tanks (Figure 10).

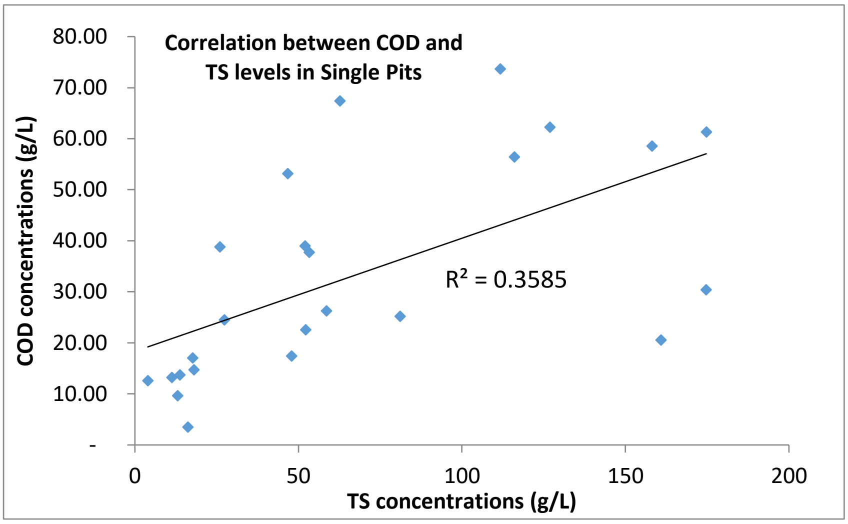

Figure 9: Correlation between COD and TS levels in Single Pits

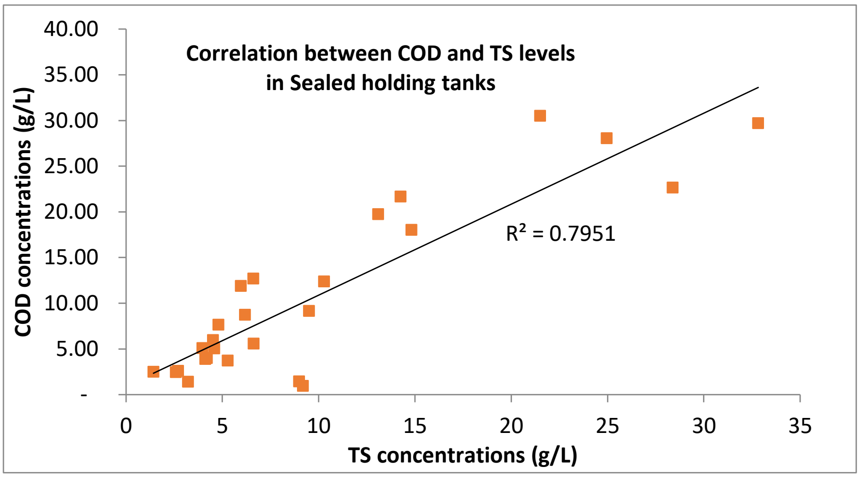

Figure 10: Correlation between COD and TS levels in Sealed Holding Tanks

3.6 Analysis of needs and priorities

In addition to the situational assessment survey, focus group discussions and key stakeholders' consultations were done to identify priority issues and potential actions to improve the environmental sanitation situation in the Municipality. Baseline survey showed a high demand for awareness raising on sanitation issues and establishment of a solid waste management system followed by sewer system to manage the human waste (Figure 11). There was lesser demand for faecal sludge management, mainly due to lack of awareness on the topic and due to the general understanding that sewer system was the solution to manage human waste.

During focus group discussions and the prioritization workshop held during May 2019 with the MWASHCC and key stakeholders, participants were informed about faecal sludge management and how it is different from a sewer system. Discussion was also held around the best options in the present situation in the Municipality. There was a general consensus that the need was for FSM and not for a sewered system in the Municipality. There was also a high demand for increasing access to toilets, particularly from Ward 15, where the toilet coverage is relatively lower in other wards.

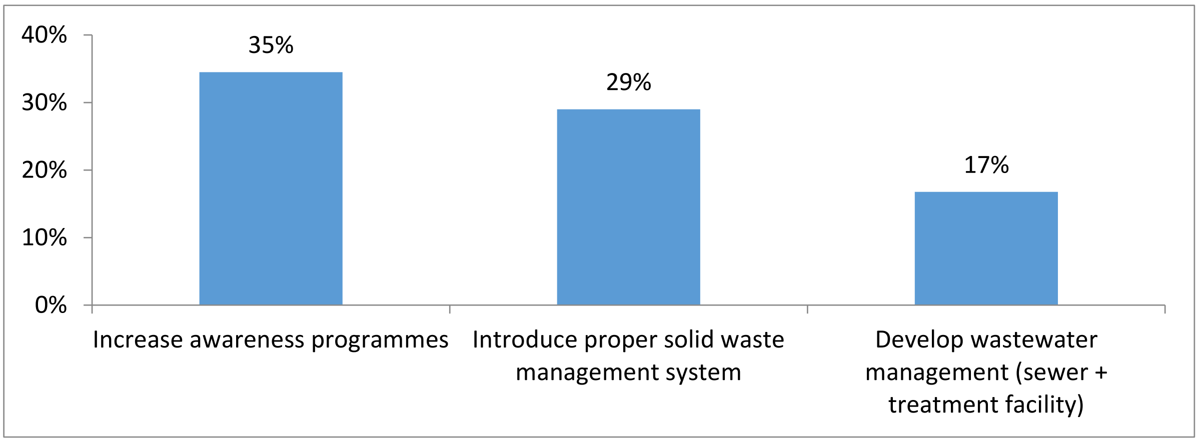

Figure 11: Top priority of households to improve sanitation situation in the locality

Regarding the willingness to pay for the chosen priority, 62.75% of the households were willing to pay up to NRs. 1000 as a one-time investment, while 13.75% indicated willingness to pay between NRs. 1001 - 5000 and only 0.75% willing to pay above NRs. 5000. As for the monthly fee they were willing to pay for the sustenance of their stated priority, 72.75% of the respondents were willing to pay up to NRs. 150, with 2.25% willing to pay within a range of NRs. 151 - 500 and only 0.25% willing to pay above NRs. 500 on a monthly basis.

4. Sanitation Improvement Plan

4.1 Sanitation including FS management

4.1.1 Onsite systems upgrading using septic tanks

As part of onsite system upgrading in Kohalpur, the plan recommends constructing standard septic tank systems at individual household and institutions. As per the national building code, it is mandatory to construct septic tanks buildings that do not have access to a sewerage network. In Kohalpur, the household survey showed that almost 40% of the on-site containment systems were holding tanks, while 50% were single pits.
The proposed strategy should be to ensure that the unsafe containments are upgraded over a defined period, of 5-7 years, to a standard septic tank. The upgradation plan should focus first on converting the Pits followed by Holding Tanks to standard septic tanks. Even though the sealed holding tanks do not pose a threat to public health, upgradation to septic tanks will be beneficial, particularly when an emptying service is based on scheduled desludging. The prevalent holding tanks are of varied sizes and volume which will create resistance from the households to scheduled desludging. The Municipality should develop a financial incentive plan for households to upgrade their containments.

The standard septic tank design guideline should be followed by the Municipality. It should make it mandatory for all new buildings to build a septic tank as per the ENPHO guideline. A schematic of a standard septic tank with corresponding dimensions based on the number of users is provided in Figure 12 and Table 3. The design temperature for the Terai Region is equal to or greater than 20^{o}C.

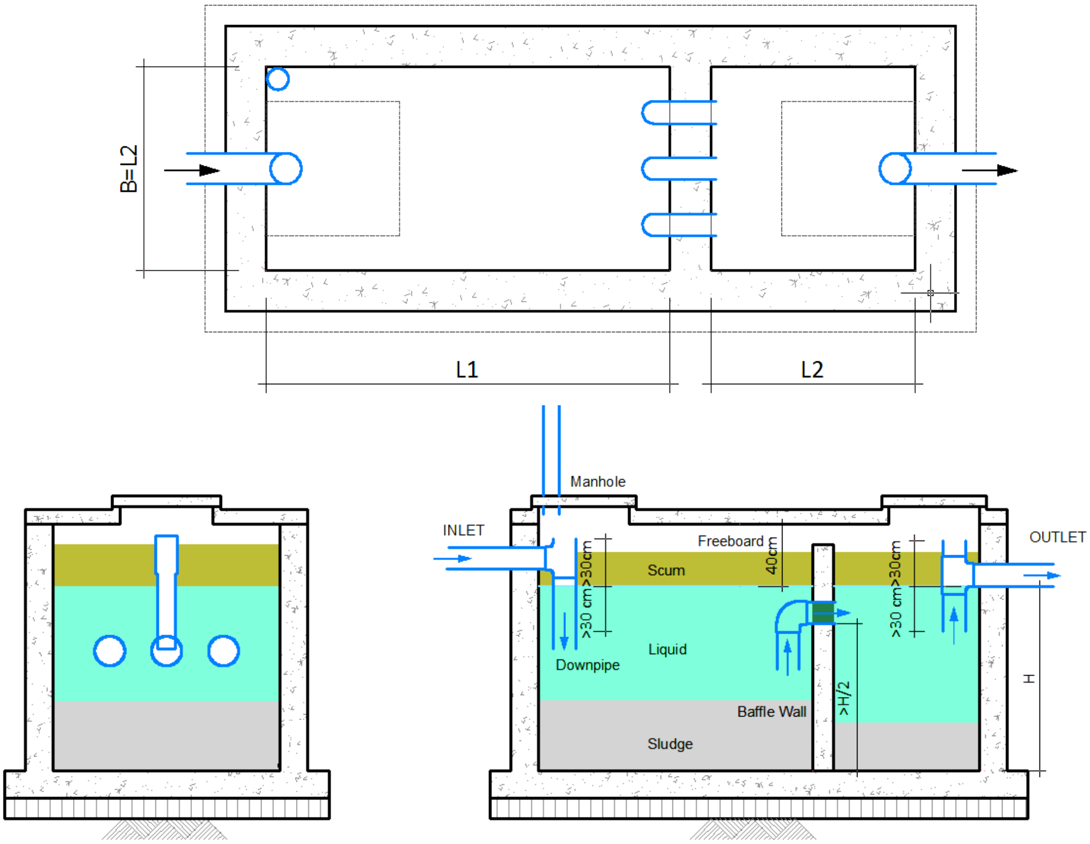

Figure 12 Schematics of septic tank design
Source: Septic tank design guideline, draft (ENPHO, 2020)

Table 3 Dimensions for a septic tank for the Terai Region

Users	5	10	15	20	25	50	75	100	150	200	250	300
Length	1.50	2.00	2.40	2.60	2.00	3.60	4.40	5.20	6.20	7.20	8.20	8.80
Breadth	0.70	1.00	1.20	1.30	1.50	1.80	2.20	2.60	3.10	3.60	4.10	4.40
Height	1.40	1.40	1.40	1.50	1.50	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Source: Septic tank design guideline, Draft (ENPHO, 2020)

4.1.2 On-site system upgrading using Biogas

As an alternative to septic tanks, household level biogas digesters, attached to toilets is also recommended for the peri-urban areas of Kohalpur. One of the pre-requisites is the availability of land and cattle rearing provisions at household level.

The, household sampling results (500B, 2019) of Kohalpur showed that, out of 6% households without toilets, half of them rear cattle. This is equivalent to 589 households that could potentially install biogas attached toilets as a safe sanitation option. In addition, there are 28% households with provision of pit latrines and cattle rearing option. This is equivalent to 5496 households which could potentially upgrade to a biogas attached toilet facility.

Currently, almost 9% of the households of Kohalpur use biogas in their homes. However, there is a decreasing demand to install biogas. A demand collected by BSP, a partner of WAI in 2019, showed that, on average only 0.8% of the households of Wards

7, 9, 12 and 13 of Kohalpur were interested to build a new biogas system. Despite, a government subsidy of around 40% on the total cost, one of the constrains is the high upfront cost required for installations and a decreasing trend to rear cattle at homes.

Thus, a well delivered marketing campaign, complemented by an innovative financing mechanism should be implemented to support installation of this option in peri-urban areas of Kohalpur.

4.1.3 On-site system upgrading using ready-made Septic Tanks

In addition to the concrete septic tanks, there are ready-to-install septic tanks on the market. Green Building Technologies Pvt. Ltd. together with its product development company Sintex Industries Limited is marketing such septic tanks in Nepal. These tanks come in different sizes for households and institutions (Figure 13). The average cost of a tank for a family size of 4-5 is about NPR120,000. However, performance of such product is yet to be proven in the context of Nepal.

CAPACITY AND USES OF ADVANCED SEPTIC TANK

Sintex Advanced Septic Tanks are manufactured in various sizes and shapes keeping in mind the usability aspect:

SINTEX ADVANCED SEPTIC TANK					
Septic Tank Capacity (Litres)	Residential/Bungalows/ Tenements/Villas/Farm House (150 LPCD*)	Office/Small Factories/Training Center (80 LPCD*)	Educational Institutions/Schools (80 LPCD*)	Only Toilet Water (50 LPCD*)	Canteen (20 LPCD*)
800	4	6	6	10	20
1200	6	8	8	16	30
1600	10	13	13	22	50
1800	12	15	15	24	60
2000	14	18	18	28	70
3000	16	23	23	46	80
4000	20	26	26	52	100
5000	24	33	33	66	120
6000	32	40	40	80	160

Figure 13 Specification of Sintex Septic Tanks

4.1.4 Strengthening demand and supply chain mechanism

A three-step approach should be followed to strengthen the demand and supply mechanism for on-site system upgrading mainly through: (i) demand creation, (ii) entrepreneurship development and (iii) financing mechanism (DEF). These approaches are briefly outlined below:

Demand creation for upgrading

As indicated in Section 4.1.1, households need to be sensitized on safe sanitation system concepts and options. The immediate target for upgrading is the households connected to pit latrines. However, as there is a reluctance from households to change from business as usual scenario, this should also be backed up by stricter regulations and enforcement mechanisms from the municipal authority.

Entrepreneurship development

There is very limited knowledge and skills on construction of Septic tanks. Local masons should be trained adequately. An entrepreneurial model could be followed, where by local private companies hire trained masons to provide standard septic tank construction services. Alternatively, private companies can also sell ready-made septic tanks as shown in Section 4.1.3. However, for business to flourish, there should be adequate demand for system installation.

To aid in demand creation, model septic tanks or ready-made septic tanks should be demonstrated on-site preferably, at a ward-wise level, involving local households. This will help to visualize and create further awareness.

Financing mechanism

Financing mechanism is integral part sanitation system upgradation. Hence, appropriate financing mechanism should be developed. One of the options is to mobilize revolving funds through local cooperatives. However, as the total cost for construction of septic tank is relatively high, based on experience from biogas promotion, only a revolving fund scheme will not scale up. Thus, a blended financing mechanism should be adopted whereby municipality provide additional financial incentives to households that construct septic tanks. For example, the municipality can introduce a tax rebatement mechanism for households that upgrades pits into a biogas digestor or septic tank within a specific time period.

4.1.5 Upgrading of the emptying and conveyance system

Based on the baseline assessment, there is a significant need to improve the sludge emptying practices in the municipality. The focus for upgrading or improvement should be in the following three areas:

Shift from manual to mechanical emptying

Among the pit type containments that were emptied so far, almost all were manually emptied either self-emptied or through a manual pit emptier. The practice of manual emptying should be completely abandoned. There should be shift from manual to mechanical emptying practices.

Upgrading mechanical emptying devices

The existing desludging devices used by the private FS operators in Kohalpur is primitive with a low suction efficiency. The overall suction vehicle consists of a suction pump connected to a diesel-powered generator. The sludge is pumped out and stored in locally manufactured metal tank and mounted on a tractor. Containments with high solid content, especially the pit latrines, are very difficult to empty. In most cases, only the liquid fraction is emptied while the solid remains. A lot of water needs to be poured into pits with high solids, stirred manually and finally pumped out. Among the 3 FS operators in the municipality, the truck owned by the municipal office is relatively better. It uses a vacuum pump, powered by the vehicle engine directly. The vehicle was imported from India and has a higher suction capacity.

It is observed that, in other parts of the country, there are FS emptying vehicles which are locally assembled and uses a vacuum technology to pump out the sludge. There are manufactures in areas like Butwal, who provide such services. Through a technical assistance, these local FS operators/entrepreneurs should be assisted to upgrade their technology and overall performance.

Training on occupational health and safety

As part of upgradation, the FS operators including their associated staff need to be fully trained on occupational health and safety protocols. During the planning phase (March 2019), one of the local operators lost two of its staff while desludging a containment. The workers were trying to manually de-sludge the solids from the bottom of the tank as it could not be emptied mechanically. However, due to toxic gases at the bottom, the two workers lost their life. There is a strong need to create awareness on safe operation and to ensure that the operators follow a standard protocol for operation (standard operation procedures (SOPs).

4.1.6 Establishing a Faecal Sludge Treatment Plant

After analysis of various treatment options, four possible treatment options are considered, mainly due to two factors, viz. operation and maintenance cost and ease of operation. These factors heavily influence the sustainability and longevity of the plant in the local context.

The amount of sludge to be emptied is calculated to be about 20 m^3/day. This volume is derived for the entire Municipality population and it is envisioned that sludge will not be collected from the entire Municipality area. Experience from the sub-region in India and Bangladesh shows that only about half the calculated volume of sludge is actually delivered to the treatment plant. Each system contains its own arrangement of treatment components with its unique features.

Conceptual Design Option 1

This system consists of Bar Screen, Thickening Tank, Filtration bed, Sludge Drying Bed, Settler, ABR & AF, Constructed Wetland and Polishing pond (Figure 14). It is a simple arrangement that dewaters the sludge and treats liquid and solid stream using simple components. For this reason, it has reduced operational procedures compared to conceptual design option 2. Some features of the system are:

- Low capital cost
- No use of mechanical system and use of external energy
- Technology is simple for construction and operation and maintenance
- BOD_5 of treated water is below 30 mg/l
- Dried sludge is reused/sold as compost.

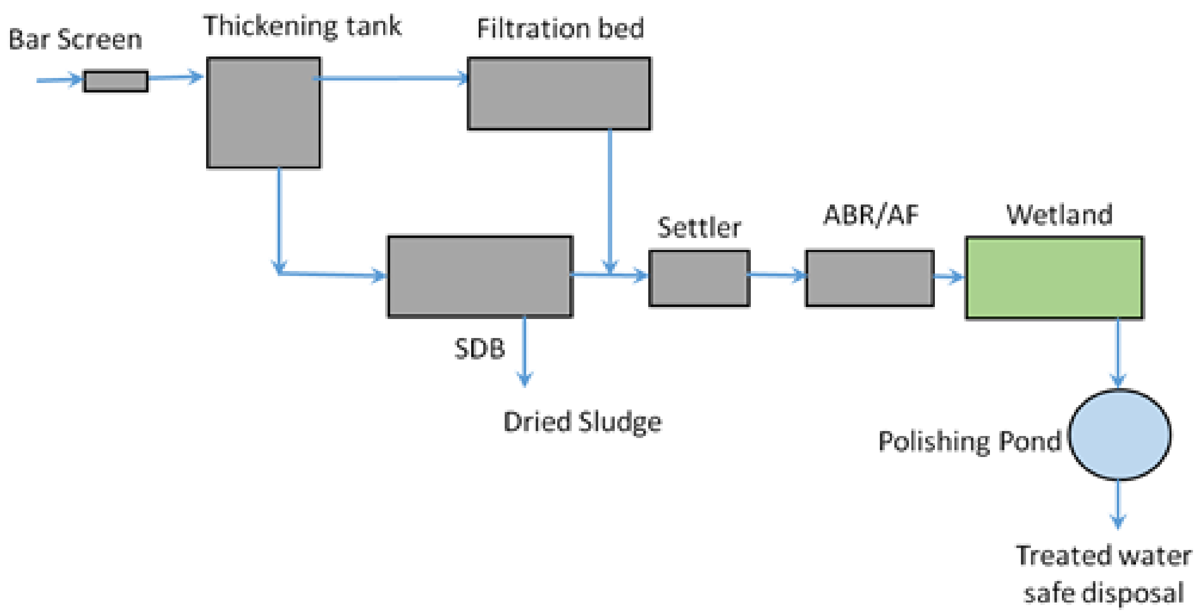

Figure 14 Schematic diagram of conceptual design option 1
Source: Eco Concern (2019)

Conceptual Design Option 2

This system has additional digesters (anaerobic) when principally compared to CTP option 1. It is used to reduce the Volatile Suspended Solids (VSS) that minimizes the occurrence of foul smell, if any. This system consists of Bar Screen, Thickening Tank, Digester, Sludge Drying Bed, ABR & AF, Constructed Wetland and Polishing Pond (Figure15). The features of this system are listed below:

- Low capital cost
- Comparatively larger area requirement due to addition of digesters
- No use of mechanical system and use of external energy
- Technology is simple for construction and Operation & maintenance. However, compared to other options, its operation is more complex due to the presence of digesters. The digesters need to be filled and emptied sequentially on a daily basis.
- BOD_5 of treated water is below 30 mg/l
- Dried sludge is reused/sold as compost
- Comparatively less odour

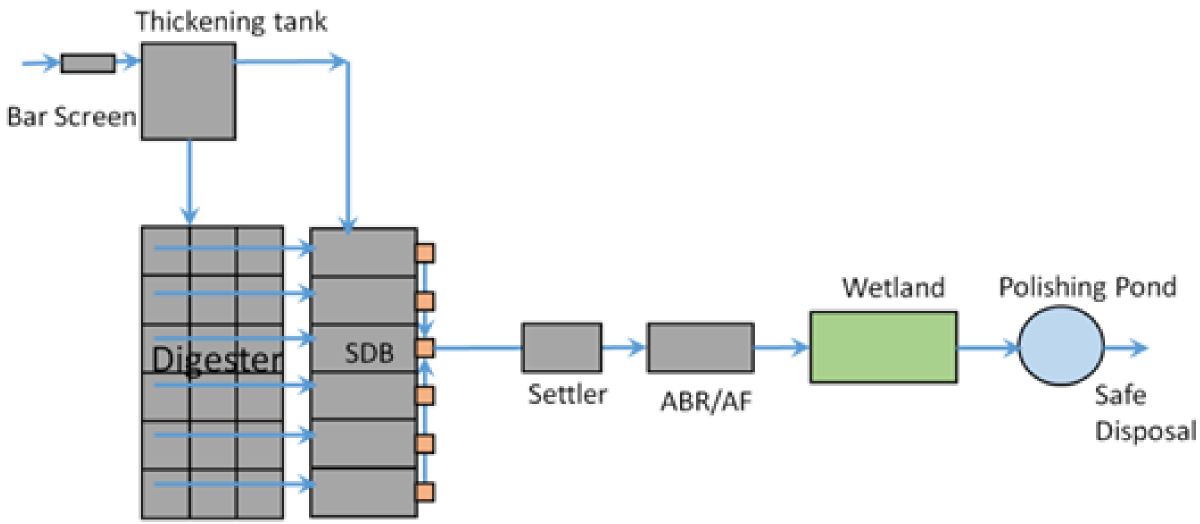

Figure 15 Schematic diagram of conceptual design option 2

Source: Eco Concern (2019)

Conceptual Design Option 3

This is another simple option, technically close to the Option 1. It consists of Bar Screen, Thickening Tank, Sludge Drying Bed, ABR & AF, Constructed Wetland and Polishing Pond (Figure 16).

The features of this system are listed below:

- Simplest form of FSTP
- No use of mechanical system and use of external energy
- Technology is simple to construction and O & M
- BOD_5 of treated wastewater is below 30 mg/l
- Dried sludge is reused/sold as compost

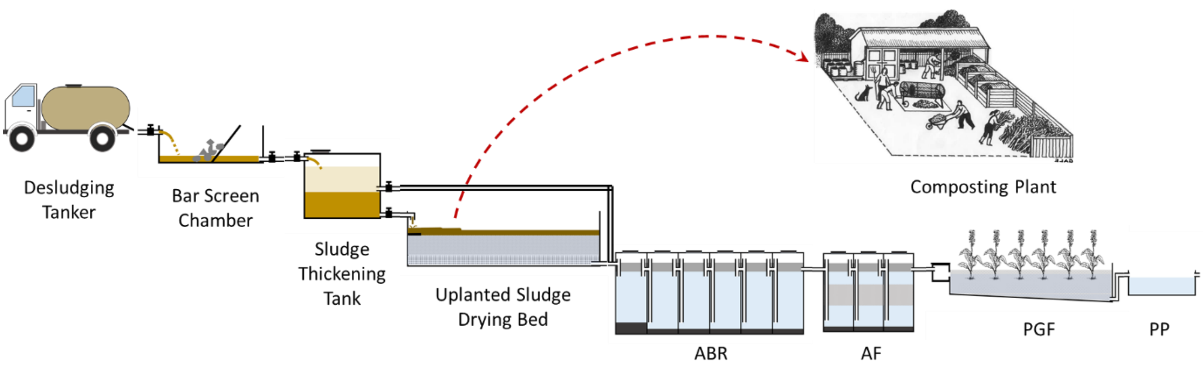

Figure 16 Schematic diagram of conceptual design option 3

Source: Eco Concern (2019)

Conceptual Design Option 4

This system consists of Bar Screen, Planted Sludge Drying Bed, Settler, ABR & AF, Constructed Wetland and Polishing Pond (Figure 17). It is a simple arrangement that dewaters the sludge and treats liquid and solid stream using simple components. Some features of the system are:

- Low capital cost

- No use of mechanical system and use of external energy
- Technology is simple for construction and operation and maintenance
- BOD_5 of treated water is below 30 mg/l
- Dried sludge is reused/sold as compost.

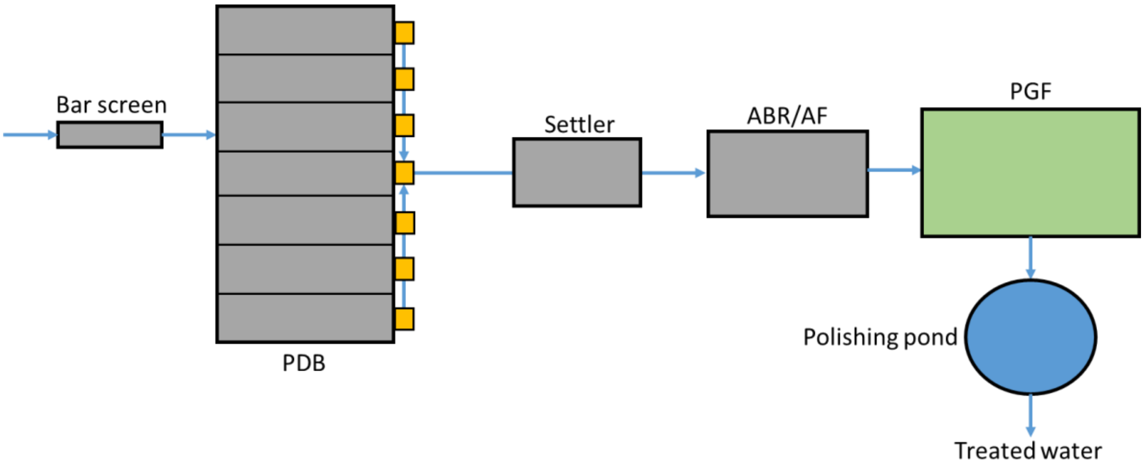

Figure 17 Schematic diagram of conceptual design option 4

For the conceptual design option 4, further detail analysis was carried out, and tentative cost estimates were made. The main components of the system, i.e. the sludge drying beds (Table 4), ABR &AF and the horizontal planted drying bed is calculated below.

A. Sludge Drying Beds

Table 4. Dimensioning of sludge beds

	Unit	Value
Population to be served	nos.	1,29,794
FS generated per (Vol per day)	m3/day	21
Total solids	mg/L	37,000
Total solids	Kg/m3	37
No. of working days per week	days	6
Total solids loading per year	Kg/year	2,42,424
Total solids loading rate	Kg/year/m2	180
Area required for PDB	m2	1346.8
Resting period (days)	Days	8
Operational beds	nos.	7
Area required per PDB	m2	192.4
Area provided per PDB	m2	260
Moisture content in sludge after 8 days of retention	%	70
Total weight of sludge remaining in drying bed	Kg	2590
Total volume of sludge remaining in drying bed	m3	2.59
Sludge height after retention time of 8 days	cm	1.00
Freeboard of PDB	m	1
Number of loads	nos.	100
Time required	months	26

The estimated population to be served in 2030 is targeted at 129’794 as per the population projection method . The total solids present in the FS generated here amounts to around 37Kg/m3 as obtained from the Q&Q analysis. Considering that the FSTP will be functional for 6 days a week, the total solids loading per year amounts to around 242,424 kg/year (242 tons/year). Assuming a total solid loading rate of 180kg/year/m2, the total area required for the drying of the sludge coming in to the FSTP is obtained as around 1’346 m2.

Here, we propose 7 identical operational beds (plus 1 reserve bed), thereby yielding an area of around 192 m2 per bed. Considering a resting time of 8 days per bed, the total volume of sludge remaining in each drying bed is estimated at around 2.59m3 at the end of 8th day, which is around 1 cm of height (assuming density of sludge = 1 kg/L). Giving a freeboard of 1m in each PDB, the no. of loads each bed can accommodate is estimated at 100 loads, which requires an estimated time of 26 months.

B. Anaerobic filter (AF) with integrated septic tank (ST)

From the sludge drying bed, the FS is then transferred to the percolate treatment unit comprising of AF and HPGF. The design has been based on conceptual designing of Consortium for Dewats Dissemination (CDD) Society of India. Here, it is assumed that around 85% of the total FS coming into the FSTP will be transferred for the percolate treatment. The dimensions for the same have been calculated accordingly. Dimensioning for the Anaerobic filter (AF) with integrated Septic Tank (ST) is provided in Annex 2.

The minimum annual temperature of Kohalpur is observed at around 9oC during two months of December and January (Climate Data 2019). The rest of the year the average minimum temperature is observed at around 15oC. This value is kept as the lowest digester temperature to avoid for underestimating the design parameters.

Hence this gives us a septic tank dimensioning having a first chamber of 1.4m length and a second chamber of 0.7m length, with the width being 2.5 m (Figure 18). Three filters of 1.8 m length and 3.4 m breadth each shall be provided which will have a retention time of around 31 hours (preferred 24 - 48 hours). The COD and BOD5 concentrations from this treatment unit is estimated to be around 292 mg/L and 140 mg/L respectively. From here, the effluent is then transferred to the horizontal planted gravel filter for further treatment.

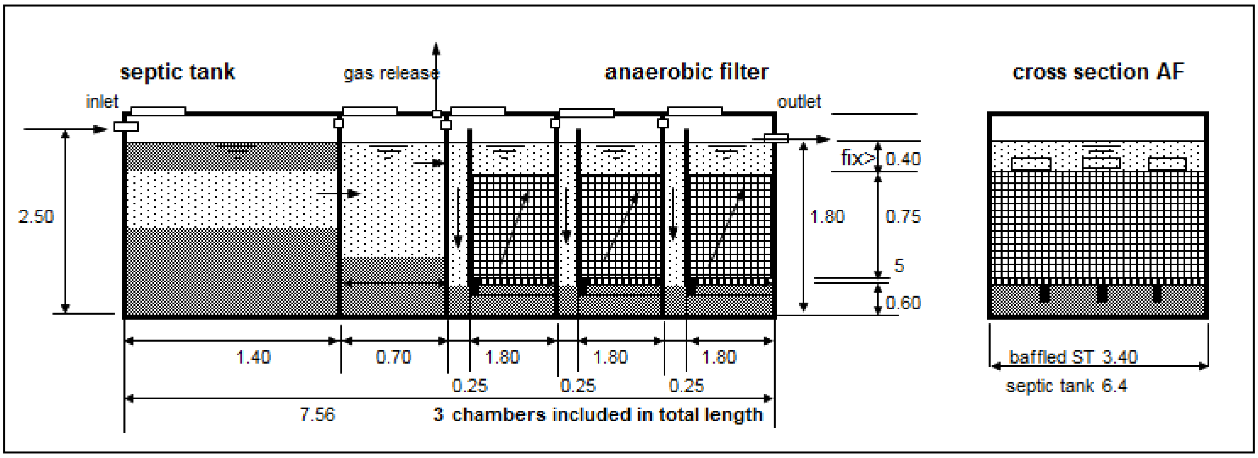

Figure 18. Cross section and plan of the proposed ABR and AF unit

C. Horizontal Planted Gravel Filter

To further reduce the COD and BOD5 levels to within permissible Government levels, from the Anaerobic filter and septic tank unit, the percolate is transferred to the Horizontal Planted Gravel Filter. Here too, the design has been based on conceptual designing of CDD society of India. The detailed calculations and dimensions of for the HPGF is provided in Annex 3.

To reduce the COD and BOD5 levels from 292 mg/L and 140 mg/L to permissible levels of <250 mg/L and 50 mg/L respectively (Ministry of Forests and Environment 2019, GoN), a Horizontal Planted Gravel Filter (HPGF) is proposed having a width of 19m and a length of 21m (Figure 19). Retention time of around 20 days has been estimated, before the effluent can be discharged into the environment.

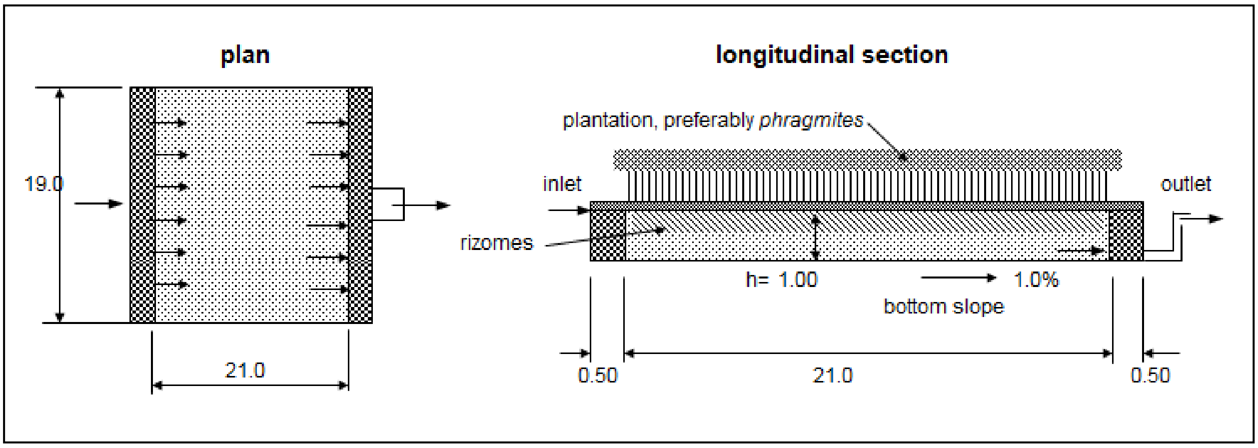

Figure 19. Longitudinal section and plan of proposed Horizontal Planted Gravel Filter

The tentative cost estimate for the above system is around Rs.2,80,00,000 (USD 248,000). The cost was calculated based on reference from similar systems designed and developed in other parts of the county. A detail calculation estimation is provided in Annex 4.

4.2 Service Models for FSM in Kohalpur

Various service models are envisioned in the case of Kohalpur Municipality to deliver FSM services. Some of the most potential service models are briefly outlined below.

A. *Demand-based subsidized model*

Under this model, the demand for services is only viable if a municipal subsidy is included. Containments are emptied based on demand from household i.e. normally when the pits are full. Under this model, only the mechanically emptied sludge is brought to the treatment plant, whereas pits are not emptied mechanically due to high solids content. Hence, as per current calculation only around 21 m^3 of sludge is brought to the treatment plant. The potential of generating revenue from sale of treated biosolids is lower under this model. Hence, to sustain this type of service model, there is a need for an external subsidy to meet the operational cost. For example, the municipality could cover the human resource cost of the treatment plant operators.

B. *Scheduled desludging model*

Under this model, all containment within Kohalpur are periodical desludged at a fixed interval, e.g. between 3-5 years. Households do not pay the FS service providers directly for emptying. The municipality can outsource the FSM services from emptying to treatment to a private entity through a service level agreement. Likewise, revenue is collected by the municipality either through property taxes or by integrating in the drinking water bill. A collaboration mechanism is established with the existing water and sanitation user committees mainly the Kohalpur Small Town Water and Sanitation User Committee. The target will be to initiate a schedule desludging mechanism starting from households connected to the water supply network. One of the advantages of this service model is that there is a constant source of revenue to cover operational costs. Likewise, at the treatment plant, larger volume of sludge is received since the number of containments to be desludged increases due to scheduled emptying.

C. *Integration of solid waste and FSM services*

Kohalpur municipality is looking at options to integrate FSM and SWM at the treatment level such that a single location is allocated for treatment of both waste streams. While doing so, there are also potential opportunities to integrate the service model for both waste streams. Under this service model, a single entity provides both SWM and FSM services in the municipality under an integrated tariff. The tariff can be collected by the municipality by combining it under a municipal property tax system. The municipality invests a major portion of the capital cost (Capex) to establish the system. Depending on the business viability, the private sector can also co-invest to cover Capex. The operational component is performed under a public, private partnership (PPP) model whereby the private entity is responsible for delivering the SWM and FSM services under a service level agreement.

All the above three service models need to be analyzed in greater depth including the financial analysis and additional stakeholder consultations.

4.3 Management of other waste streams

4.3.1 Solid waste management

Even though substantial amount of organic waste is being managed at the household level, inorganic waste is posing a problem in Kohalpur Municipality. Burning and haphazard disposal of inorganic waste creates nuisance and poses both environmental and public health hazard. Some of the interventions to improve the solid waste management are as follows:

- Organise massive awareness campaigns to sensitize the public on health hazard of improper handling of solid waste and on proper segregation of solid waste to follow the 3R principle of reduce, reuse and recycle.
- In coordination with the Municipality, develop and implement a source separation and management mechanism. The collection, transportation and management service can be provided by the local authority through public private partnership modality.
- Conduct training on household level composting through use of better equipment like compost bins; introduction of new forms of composting like vermi-composting.
- Co-composting with FS can also be an option to manage both organic waste and FS. However, further market survey is required to implement this option.
- Likewise, integration of solid waste and faecal sludge management service delivery and treatment options should be explored

4.3.2 Greywater and storm water management

Currently, greywater management is not a priority issue in Kohalpur Municipality. Nevertheless, a long-term plan for greywater management should be in place. One of the options can be a combined drainage system to manage both greywater and storm water. However, a detailed survey is necessary to estimate and design a stormwater drainage system. Collaboration with Department of Water Supply and Sewerage Management Provincial Office and the Municipality is necessary to both develop and execute the plan.

4.4 Capacity building

During the consultative meeting, one of the major issues raised was lack of awareness on environmental sanitation in Kohalpur Municipality. The major key intervention in the implementation phase should be sensitization and awareness raising initiatives on total sanitation and hygiene behavioral change to support the ongoing national campaign and to facilitate the sanitation intervention in Kohalpur Municipality as planned through the project.

Some of the key capacity building activities to improve the current environmental sanitation situation in Kohalpur Municipality are listed below:

- Awareness campaigns on the need for safe sanitation practices

- Awareness on proper management of inorganic waste which is currently being burnt or allowed to litter
- Door to door awareness campaign for sanitation behavioural change through use of female community health volunteers (FCHVs), schools, Mother's group, youth clubs, etc.
- Training on household level composting by using better equipment or by improving the present pit composting to improve the composting practise and the quality of compost.
- Trainings on safe emptying and disposal of sludge from pits/septic tanks both to households and potential entrepreneur

Annex 1: Estimation of FS generation

For Households

Type of Containment	Mean Vol of cont. (m3)	Vol of FS in containment (m3)	Emp freq (yrs)	Tot coverage in Kohalpur	No. of HH having this system	No. of building units having this system	% Emptied from	%Emptied from mechanically	No. of buildings emptied from	No. of building emptied from mechanically	Estimated FS generated (with present emptying) (m3/year)	Estimated FS desludged (with present emptying) (m3/day)	Estimated FS generated (with present mechanical emptying) (m3/year)	Estimated FS desludged (with present mechanical emptying) (m3/day)	Potential FS generation (m3/year)	Potential FS generation (m3/day)
Sealed holding tanks	12.38	11.02	2.88	39.70%	7793	3117	53%	30%	1652	935	6321.41	17.32	3578.15	9.80	11927.18	32.68
Single pits	0.85	0.82	1.66	50.40%	9893	3957	60%	1%	2374	40	1172.86	3.21	19.55	0.05	1954.76	5.36
Double pits	0.72	0.69	0.5	0.50%	98	39	50%	0%	19.629	0	27.09	0.07	0.00	0.00	54.18	0.15
Unsealed holding tanks	12.38	11.02	0	0.80%	157	63	0%	0%	0	0	0.00	0				0
										0		20.61		9.86		38.18

For Institutional Housings and Public Toilets

Institution	No. of trips per emptying	Emp freq	Emp freq (yrs)	No. of institutions in Kohalpur	% Emptied from	No. of institutions emptied from	No. of trips per year (with present emptying)	Estimated FS generated (with present emptying) (L/year)	Estimated FS generated (with present emptying) (m3/year)	Estimated FS generated (with present emptying) (m3/day)	Potential no. of trips per year	Potential FS generation (L/year)	Potential FS generation (m3/year)	Potential FS generation (m3/day)
Army Barrack	9	6 months	0.5	1	100%	1	18	108000	108	0.30	18	108000	108	0.30
Area Police Headquarters	2	1 month	0.083	1	100%	1	24	144000	144	0.39	24	144000	144	0.39
Medical College	5	9 years	9	1	100%	1	0.56	3333.33	3.33	0.01	0.56	3333.33	3.33	0.01
Schools	2.38	6 months	0.55	80	100%	80	346.18	2077090.91	2077.09	5.69	346.18	2077090.91	2077.09	5.69
Hotels	2.75	2.44 years	2.44	300	53.33%	160	180.32	1081899.59	1081.90	2.96	338.11	2028688.52	2028.69	5.56
Ward Offices	3	9 months	0.75	15	50%	8	30	180000	180	0.49	60	360000	360	0.99
Public Toilets	2	18.5 days	0.05	5	40%	2	80	480000	480	1.32	200	1200000	1200	3.29
										11.16				16.22

Total FS generation in Kohalpur	Estimated FS generated by mechanical emptying (m3/day)
From Households	9.86
From Institutional Housings	11.16
	21.02

Potential FS generation in Kohalpur	Estimated FS generation (m3/day)
From Households	38.18
From Institutional Housings	16.22
	54.40
Estimated Total HH in Kohalpur (2019) based on 3.53% annual pop growth is 18960	19629

Annex 2: Dimensioning for the Anaerobic filter (AF) with integrated Septic Tank (ST)

General spread sheet for anaerobic filter (AF) with integrated septic tank (ST)											
general data						**septic tank (settler)**					
daily waste water flow	time of most waste water flow	COD inflow	BOD_5 inflow	$SS_{settl.}$ / COD ratio	lowest digester temper.	HRT in septic tank	de-sludging interval	inner width of septic tank	minimum water depth at inlet point	length of first chamber	length of second chamber
given	given	given	given	given	given	**chosen**	**chosen**	**chosen**	**chosen**	**chosen**	**chosen**
m³/day	h	mg/l	mg/l	mg/l / mg/l	°C	h	months	m	m	m	m
17.85	**4**	**500**	**250**	**0.30**	**15**	**0**	**36**	**6.40**	**2.50**	**1.40**	**0.70**
		COD/BOD_5		*normal*		*normal*	*preferred*			*calc. min*	*calc. min*
		2.00		*0,35-0,45 (domestic)*		*1,5-2h*	*12*			*0.00*	*0.00*
anaerobic filter											
specific surface of filter medium	voids in filter mass	depth of filter tanks	length of each tank	number of filter tanks	width of filter tanks	HRT inside AF reactor	max. velocity in filter voids	COD removal septic tank	BOD_5 removal septic tank	BOD_5 inflow into AF	COD inflow in AF
given	given	**chosen**	**chosen**	**chosen**	**chosen**	calcul.	**check !!**	calcul.	calcul.	calcul.	calcul.
m²/m³	%	m	m	No.	m	h	m/h	%	%	mg/l	mg/l
100	**40%**	**1.80**	**1.80**	**3**	**4.70**	46.1	1.32	0%	0%	250	500
range	*range*		*cal.max*			*normal*	*max.*				
80 -120	*30-45*		*1.80*			*24 - 48 h*	*2.00*				

treatment efficiency									biogas production		
factors to calculate COD removal rate of anaerobic filter						COD removal rate (AF only)	COD outflow of AF	BOD_5 outflow of AF	out of septic tank	out of anaerob. filter	total
calculated according to graphs						calcul.	calcul.	calcul.	assump: 70%CH_4; 50% dissolved		
f-temp	f-load	f-strenght	f-surface	f-HRT	f-chamb.	%	mg/l	mg/l	m³/d	m³/d	m³/d
0.57	1.00	0.91	1.00	0.72	1.12	42%	**292**	**140**	0.00	0.93	0.93
			intermediate calculations								
COD rem rate of total system	BOD/COD rem. Factor AF	BOD_5 rem rate of total system	max. peak flow per hour	sludge accum.	Volume septic tank incl. sludge	actual volume of septic tank	inner length of first ST-chamber	length of second ST-chamber	org.load on AF COD	filter height	net volume of filter tanks
calcul.	calc.	calcul.	calcul.	calc.	requir.	calcul.	calcul.	calcul.	calcul.	calcul.	calcul.
%	ratio	%	m³/h	l/kg BOD	m³	m³	m	m	kg/m³*d	m	m³
42%	1.06	44%	4.46	0.0025	0.00	33.60	0.00	0.00	0.26	0.75	34.26

Annex 3: Dimensioning for the Horizontal Planted Gravel Filter (HPGF)

General spread sheet for planted gravel filter, input and treatment data											
average flow	COD in	BOD_5 in	COD/BOD ratio	outfl. BOD_5	min. annual Temp.	hydraulic conduct. Ks	bottom slope	depth of filter at inlet	BOD_5 rem. rate	COD rem.	COD out
given	given	given	calcul.	wanted	given	given	chosen	chosen	calcul.	calcul.	calcul.
m³/d	mg/l	mg/l	mg/l / mg/l	mg/l	C°	m/d	%	m	%	%	mg/l
17.85	**292**	**140**	2.09	**50**	**15**	**372**	**1.0%**	**1.00**	64%	59%	121
					Ks in m/s=>	4.31E-03			*BOD rem.factor via graph->*	1.097	
dimensions										**results**	
HRT factor acc. to *k20=0,3*	HRT	HRT in 35% pore space	cross section area	width of filter basin	chosen width	surface area required	length of filter basin	length chosen	actual surface area chosen	hydr. load on chosen surface	org. load on chosen surface
calcul.	calcul.	calcul.	calcul.	calcul.	chosen	calcul.	calcul.	chosen	**check !**	calcul.	calcul.
via graph	days	days	m²	m	m	m²	m	m	m²	m/d	g/m² BOD_5
0.43	19.55	6.84	16.63	16.6	**22.0**	349	15.9	**38.0**	836	0.021	3.0
		max BOD_5 on cross sectional area-->	*150*							*max. loads-->*	*10*

Annex 4: Cost Estimation for FSTP

In order to prepare the Municipality of Kohalpur to the upcoming costs for the described FSTP a rough estimation of the conceptual design was calculated. The calculation is based on two main inputs, the capital expenditures (Capex) and operational expenditures (Opex) for each treatment component. The Capex estimation is primarily based on the cost estimation presented in the DPR of Mahuban Municipality. The comparison of latter with the cost calculation of Gulariya and Charali Municipality pointed out its adequacy as reference, due to following reasons:

- The cost estimation of NRs. 580’000 appeared to be accurate as the construction cost were around NRs. 500’000.
- The FSTP of Madhuban was build in 2019 and thus represents the most current reference as the data from Charali and Gulariya municipality are from 2016.
- The Municipality of Madhuban is located in the same area as Kohalpur Municipality.
- The costs for the FSTP of Madhuban are mainly on the higher side (safe side), compared to the FSTP of Charali and Gulariya.

The collection of Opex data in Nepal presents itself as difficult. Due to this reason the estimated Opex for Charali are used as reference. The FSTP of Charali was designed for a simillar capacity (100’000 capita), thus this decision seems reasonable.

Following general inputs were used to calculate the cost of each treatment component.

Input			
Item	*Unit*	*Value*	*Source*
Discount rate	%	0.5	Assumption
Inflation rate	%	0.787	Gulariya IWM Financial project (Inflation rate median from 2014 to 2018)
Project horizon	Years	25	Assumption
Exchange rate		0.0088	09.10.2019
Inaccuracy of Capex	%	10	Assumption
Inaccuracy Opex	%	10	Assumption

Cost estimation of component

The Capex calculation requires two component specific inputs: original investment costs and lifespan. In this way, first the number of replacements during the project horizon can be calculated and subsequently the NPV and Annuities.

Equation 1 calculates the number of replacement needed during the project horizon (capital maintenance expenditures). If the lifespan is a multiple of the project horizon the last replacement is neglected as it is the end of the planed horizon and no replacement is needed anymore.

Equation 1

*=IF (ROUNDDOWN (A/B; 0)*B = A; ROUNDDOWN (A/B; 0)-1; ROUNDDOWN (A/B; 0))*

With: A = Project horizon; B = Component life span

Equation 2 calculates the NPV of capital expenditures (including capital maintenance costs). For this purpose, the original costs are multiplied by the inflation rate and discounted subsequently respective to their time of replacement (using an index n with steps equal to the lifespan).

Equation 2

```
Function NPVCapex(cost As Double, lifespan As Double, inflationrate As Double, discountrate As Double, replacements As Integer) As Double
    NPVCapex = 0
    For n = 0 To lifespan * replacements Step lifespan
        NPVCapex = cost * (1 + inflationrate) ^ n * (1 + discountrate) ^ -n + NPVCapex
    Next n

End Function
```

Eventually the annuities are calculated by using the NPV as shown in Equation 3.

Equation 3

```
Function AnnuityCapex(NPV As Double, horizon As Double, discountrate As Double) As Double
    AnnuityCapex = NPV * (discountrate / (1 - (1 + discountrate) ^ -horizon))
End Function
```

For the calculation of Opex, the operational costs replace the original investment costs and the occurrence frequency the lifespan.

The number of times the operational costs arise during the project horizon is also calculated using Equation 1. However, for specific Opex the last payment are considered if the frequency is a multiple of the project horizon (ex.: salaries, water and electricity bills).

Equation 4

```
Function NPVOpex(cost As Double, arise As Double, inflationrate As Double, discountrate As Double, noarise As Integer) As Double

    NPVOpex = 0

    For n = arise To arise * noarise Step arise
        NPVOpex = cost * ((1 + inflationrate) ^ n) * ((1 + discountrate) ^ -n) + NPVOpex
    Next n

End Function
```

Equation 4 is used to calculate the NPV for Opex. Eventually the annuities of Opex are obtained by applying the Equation 3.

- **Drying beds**

Input				
Index	*Item*	*Unit*	*Value*	*Source*
A	**Amount of drying bed units**	Nos.	8	FSTP Design
B	**Size of one drying bed unit**	m2	215	FSTP Design
C	**Cost of drying bed**	NRs. / m2	13’376.09	Dangol et al. (DPR Madhuban)
D	**Total cost of drying beds**	NRs. (USD)	23’006’874.80 (202’460.50)	= A*B*C
E	**Lifespan of drying bed**	Years	25	Assumption
F	**Cleaning of filter material**	NRs.(USD)/m2 drying bed	76.31	Cost estimate FSM Charali
G	**Frequency of cleaning**	Years	2	FSTP Design

	Overview								
	Annuity			NPV			Investment		
	min	USD	max	min	USD	max	min	USD	max
Capex	12928.56	14365.07	15801.58	182214.45	202460.50	222706.55	182214.45	202460.50	222706.55
Opex	1278.59	1420.66	1562.72	18020.42	20022.69	22024.96			

- **ABR-AF**

Input				
Index	*Item*	*Unit*	*Value*	*Source*
A	**Size of Settler**	m3	24.19	FSTP Design
B	**Amount of chambers**	Nos.	3	FSTP Design
C	**Size of one chamber**	m3	11.02	FSTP Design
D	**Anaerobic filter included***		Yes	FSTP Design
E	**Amount of ABR**	Nos.	1	FSTP Design
F	**Cost of ABR**	NRs. / m3	25'704.32	Dangol et al. (DPR Madhuban)
G	**Total cost of ABR**	NRs. (USD)	1'692'308.17 (12'949.84)	= (A+B*C)*E*F * 1.15
H	**Lifespan of ABR**	Years	25	Assumption

* Adding 15% of ABR cost

	Overview										
	Annuity				NPV				Investment		
	min	USD	max		min	USD	max		min	USD	max
Capex	826.94	918.82	1010.70		11654.85	12949.84	14244.82		11654.85	12949.84	14244.82
Opex	0.00	0.00	0.00		0.00	0.00	0.00				

- **HCFW (Gravel filter)**

Input				
Index	*Item*	*Unit*	*Value*	*Source*
A	**Amount of Wetlands**	Nos.	1	FSTP Design
B	**Size of one Wetland**	m2	158	FSTP Design
C	**Cost of Wetland**	NRs. / m3	21'925	Dangol et al. (DPR Madhuban)
D	**Total cost of wetlands**	NRs. (USD)	3'464'206.88 (30'485.02)	= A*B*C
E	**Lifespan of wetlands**	Years	25	Assumption

	Overview										
	Annuity				NPV				Investment		
	min	USD	max		min	USD	max		min	USD	max
Capex	1946.69	2162.99	2379.29		27436.52	30485.02	33533.52		27436.52	30485.02	33533.52
Opex	0.00	0.00	0.00		0.00	0.00	0.00				

- **Overall Operational costs**

Input			
Item	*Unit*	*Value*	*Source*
Salary of caretaker	NRs. (USD)/day	1'000	Assumption
Amount of caretaker	Nos.	2	Assumption
Total cartaker salary	NRs. (USD) / year	672'000.00 (5'913.60)	Assumption
Accidental and health insurance	NRs. (USD) / year/caretaker	8'969.03 (78.93)	Opex estimation Charali
Pipes, Valves and refilling Sand	NRs. (USD) / year	23'917.40 (210.47)	Opex estimation Charali
Electricity, Water and other	NRs. (USD) / year	239'173.99 (2104.73)	Opex estimation Charali

	Overview										
	Annuity				NPV				Investment		
	min	USD	max		min	USD	max		min	USD	max

Capex	0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00
Opex	19345.30	21494.78	23644.25		272651.56	302946.17	333240.79				

Cost estimation of the FSTP

To estimate the total cost for the FSTP, the used components were allocated with a capacity they were designed for. By dividing the population served by it, the amount of each component is calculated. In this case only one of each components is used as they were all created respecting the design for the whole population. In order to obtain the total cost for the FSTP the costs of each component are summed.

System 1					
Population Served (%)	100%	129784			
			USD		
Designed for (capita)	Responsible	Component	Annuities	NPV	Investment
129784	Municipality	Unplanted drying beds	15786	222483	202460
129784	Municipality	Anaerobic baffled reactor	919	12950	12950
129784	Municipality	HFC Wetland	2163	30485	30485
129784	Municipality	Overall FSTP Cost	21495	302946	0

Total (USD)			
Household	0	0	0
Private	0	0	0
Municipality	40362	568864	245895
Sum	40’362	568’864	245’895
Total (NRs.)			
Household	0	0	0
Private	0	0	0
Municipality	45,86,627	64,64,3661	2,79,42,654
Sum	0	0	0