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INTEGRATION OF FAECAL SLUDGE MANAGEMENT INTO THE KATHMANDU VALLEY WASTEWATER MASTER PLAN

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ABSTRACT

Over the next 30 years, more than $1 billion is expected to be spent on new sewers and STP upgrades. Because the Kathmandu valley has spread unevenly, over 400,000 people will continue to rely on on-site sanitation systems even after the sewerage plan is completed in 2050.To accomplish citywide inclusive sanitation, a feces sludge management (FSM) program should be implemented in conjunction with sewerage systems. The containment tanks' untreated liquid effluent as well as feces illegally dumped in sewer systems end up in the environment. The principle objective of this study was to find the potential synergies between FSM and sewerage, including i). Co-treatment of FS with municipal sewerage ii). Promotion of sewer connections to reduce the need for on-site systems iii). Use of one-billing system for both services and iv). One centralized entity can manage the FSM program as a component of the sewerage master plan. The methodology used to generate recommendations for the FSM Master Plan were Rapid Technical Assessment (RTA), stakeholder workshops, In-depth interviews, focus group discussion and preparation of shit flow diagram. Based on the gathered information a scenario has been developed to fully managed FSM program with enforced municipal sanitation ordinances, and evidence based promotion campaigns to increase building owners' rate of participation in desludging and willingness to pay user fees. The study also shows the immediate need of the development of the institutional and regulatory framework for FSM in Kathmandu Valley.

INTRODUCTION

Sewer renovations and new construction are estimated to cost more than $1 billion over the following 30 years (CIAMP 2, 2019). Even after the sewerage plan is finished in 2050, more than 400,000 people would still rely on on-site sanitation facilities due to the Kathmandu valley's uneven growth. This shows that it is clear to develop a parallel service of on-site sanitation along with sewer sanitation system in order to include everyone with safe sanitation network. In order to have safe sanitation system all stages of sanitation management should be proper like; periodic desludging of the containment tanks, proper treatment of collected faecal sludge (also called septage). In order to meet the sanitation needs of the most in remote areas with low population density, FSM services will be required, even if sewers and wastewater treatment plants are developed and improved.

To operate properly, containment tanks require periodic desludging and collected faecal sludge must be adequately treated to kill harmful pathogens and reduce environmental pollution. The untreated liquid effluent from the tank in the absence of treatment facilities eventually disposed into the Bagmati River. Therefore an effort to upgrade the on-site sanitation system in conjunction with a faecal sludge management program should be developed in combination with sanitation systems to help achieve citywide inclusive sanitation. The sewerage systems are being funded through ADB loan isolating FSM program out of the plan. Given the critical need for FSM, financial resources should quickly be sought from national and local governments, and development partners. At the same time the institutional and regulatory framework for FSM in the Kathmandu Valley should be developed. This includes establishing a clear home for FSM, a local ordinance on FSM and sanitation that can be adopted by municipalities, and an enforcement through teams of sanitary inspectors. To facilitate development of a Kathmandu Valley FSM program, Kathmandu Valley Water Supply Management board along with the City-Wide

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Inclusive Sanitation Technical Assistance Hub in South Asia engaged a study team composed of national and international consultants to develop FSM recommendations and investment cost estimates for the next 30 years. A key aspect of the study was to find synergies with the CIAMP 2 being prepared by the KVWSMB for water and sewerage infrastructure, with financing from the ADB. The study team found several potential synergies between FSM and sewerage, including: i) co-treatment of faecal sludge with municipal sewerage; ii) promotion of sewer connections to reduce the need for on-site systems; iii) use of one billing system for both services; and iv) one centralized entity can manage the FSM program as a component of the sewerage master plan. Faecal sludge collection services are offered in the Kathmandu Valley, although they are frequently hazardous and unclean. Faecal sludge that has been unlawfully placed in sewer systems without being treated ends up right in the Bagmati River in the absence of treatment. When feces are dumped into the environment, harmful microorganisms and organic contaminants are distributed, which has an effect on human health. Currently offered services are unregulated, frequently unreliable, and come at relatively high fees to building owners. This study presents an evidence-based plan for an organized Kathmandu Valley-wide FSM program along with implementation guidance. The rewards of successfully implementing FSM are many, including improved health of citizens, environmental improvements, and business and employment opportunities all along the sanitation service chain. This will ultimately act as a motivating factor for the regulatory officials to embrace the valley wide sanitation. The master plan incorporates:
(i) Development of the OSS upgradation plan (ii) Start from the on-demand desludging to focused and ultimately the scheduled desludging (iii) All of the Faecal Sludge Treatment Plants (FSTPs) in KV should have integrated automated FS receiving stations (iv) Stand- alone FSTPs at non-sewered municipalities (v) Development of the enabling environment such as institutional and regulatory framework, model ordinance, private sector formalization plan, capacity building plan for both the government and private sector, key performance indicators. However, the study for this paper focused on FSM recommendation and investment cost estimates for the next 30 years.

OBJECTIVES

The main objective of the paper was to develop FSM recommendations and investment cost estimates for the next 30 years i.e. 2050 AD.

METHODOLOGY

At first, the study team conducted a desk review, and data were collected using Rapid Technical Assessment (RTA) in 18 municipalities working along with the Capital Investment Asset Management (CIAMP) team and Key Informant Interviews (KII). The building owners were interviewed and on-site sanitation systems were inspected and the information into the FSM toolbox's assessment tool smartphone app. This was used to statistically define the amount of sludge to be collected and the type of collection vehicles required for site conditions such as narrow roads. The Shit Flow Diagrams (SFDs) which was prepared using Susana platform, is an advocacy tool used to illustrate how FS moves through the community and existing safe and unsafe practices. Also, City Service Delivery Assessment (CSDA) graphics for the 18 municipalities using the FSM toolbox and Susana Platform were developed. This was needed in order to determine the readiness for FSM programs. The graphics are an advocacy tool to illustrate where the investments in FSM are most needed. Transportation time and distance studies to treatment plants, decanting stations or transfer stations was estimated using geographic information system data and ArcGis modelling. The investment cost estimates for collection vehicles, treatment plants and supporting activities and a tariff structure were developed through Interactive Septage Management Toolkit which is a Microsoft Excel spreadsheet. The study team entered data such as population and number of septic tanks and other variables to develop outputs. The team discussed and collaborated with the stakeholders and the ADB and CIAMP 2 Technical teams and also hosted a stakeholder workshops shared the findings and gathered feedback, and incorporates into the study and recommended the types of treatment plants and the investment options, such as stand-alone FSTPs/ co-treatment at Kodku and Dhobighat WWTPs to meet the immediate needs.

RESULT AND DISCUSSIONS

RTA Result

The team with the help of enumerators surveyed 3,635 building owners in the 18 municipalities of the Kathmandu Valley. The table below shows the number and type of sanitation system estimates by municipalities of Kathmandu Valley. Of all of the buildings surveyed, 26% had an on-site containment tank (either a septic tank, holding tank or pit) and 72% had a sewer connection. 2% had waste flowing directly from the toilet to the drainage system. The total number of on-site systems in the Kathmandu Valley was estimated at 92,787. Therefore, roughly 26% of all buildings use on-site systems. The numbers also indicate that there could be 150 wells in the Kathmandu Valley located no more than 5 meters from an on-site sewage system. A system on-site is within 6 to 10 meters of another 100 wells. This is a significant issue for environmental health. As a direct channel between septic systems and the aquifer as well as for the families who might be using the possibly contaminated water for domestic uses.

Transportation Time and Distance Study

Routes were optimized using GIS from each municipality center to the nearest of the two locations where FSTPs will most likely be established first: Kodku and Dhobighat (STs).The routes are not fixed. Desludgers may have options for where their loads will be disposed of. Also, the authority will have the ability to divert trucks to different locations based on real-time STP capacity. Table 2 below shows the distances and travel time at different times of the day between each municipality.

Table 1: Transportation Time and Distance Study Results

Municipality closest to Dhobighat STP	Distance (KM)	Travel time (minutes)				Municipality closest to Kodku STP	Distance (KM)	Travel time (minute)			
		6AM	8AM	5PM	10PM			6AM	8AM	5PM	10PM
Chandragiri	10	20	30	60	20	Bhaktapur	10	16	23	47	16
Dakshinkali	13	27	40	80	27	Changunarayan	15	31	46	92	31
Kathmandu Metropolitan	7	15	22	44	15	Madhyapur Thimi	7	14	21	42	14
Kirtipur	3	6	10	19	6	Suryabinayak	13	26	39	78	26
Nagarjun	10	21	31	62	21	Budhanilkantha	15	31	46	92	31
Tarkeshwor	17	35	52	104	35	Gokarneshwor	26	52	77	155	52
Note: Travel speed at 6 AM and 10 PM: 30 km/hour 8 AM: 20 km/hour 5 PM: 10 km/hour						Kageshwori Manohara	17	34	51	102	34
						Shankharapur	28	55	83	166	55
						Tokha	16	33	49	98	33
						Godawari	13	27	40	80	27
						Lalitpur Metropolitan	4	9	13	26	9
						Mahalaxmi	8	16	23	47	16

Projection of Daily Faecal Sludge Volume

Using the data toolkit the projection was made for the daily FS volume generation which is 243m^3/day for the year 2020. Currently 30% m^3/day is managed by the informal sector. Therefore the 2020 treatment demand is estimated at 170 m^3/day. By 2025, under a managed FSM program, the practice of informal desludging should be discontinued, while the population and number of on-site systems will increase. By this time, organized desludging should be introduced, and promotion campaigns launched to increase demand. Considering these factors, the 2025 flows requiring treatment expands to 323 m3 per day.

Faecal Sludge Management Recommendations

FSM currently uses the on-demand business model. On-demand desludging will likely be the business model of choice until about 2025, by which time capacity should be raised, municipal FSM regulations should be in place and enforced to a reasonable degree, promotion campaigns encouraging people to desludge should be implemented, and the practice of informal desludging should be gradually

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phased out. This generates a tipping point when it becomes economically advantageous to organize the desludging program. It may take up to 10 years to achieve full mandatory scheduled desludging in the Kathmandu Valley, as the business models morph from on-demand to focused to scheduled desludging. This should be the plan for long term FSM implementation in Kathmandu Valley.

Projected FSM Scenario from 2020-2050

Using the Interactive Septage Management Toolkit, the study team estimated desludging frequency increases over time as systems are upgraded, while at the same time, the cost for paying for the services decrease through economies of scale (Table 2). The team also used the toolkit to project the number of large and small vacuum trucks required, the tariff per household and per on-site system required to cover the costs of regular desludging.

Table 2. Projection of Key FSM Variables

	2020	2025	2030	2035	2040	2045	2050
Average Desludging Frequency(Years)	**3.2**	**3.2**	**3.8**	**4.1**	**4.3**	**4.3**	**4.3**
FS Volume (m3/day)	**243**	**323**	**414**	**360**	**324**	**275**	**222**
% of Buildings with On-site Systems	**26**	**26**	**22**	**19**	**17**	**15**	**12**
Participation Rate (%)	**35**	**45**	**69**	**72**	**75**	**82**	**90**
# of Trucks (6 m3 capacity)		**14**	**17**	**15**	**14**	**12**	**9**
# of Trucks (1.5 m3 capacity)		**14**	**17**	**15**	**14**	**12**	**9**
Tariff (per HH/month)		**$0.95**	**$0.75**	**$0.70**	**$0.65**	**$0.60**	**$0.55**
Tariff (per on-site system /month)		**$2.09**	**$1.66**	**$1.61**	**$1.56**	**$1.52**	**$1.48**

Faecal Sludge Treatment Installation Options and Recommendation

Option 1: Maximizing Co-Treatment

It maximizes co-treatment of faecal sludge with municipal sewerage. It starts with installation of stand-alone FSTPs at Kodku and Dhobighat, and then utilizes co-treatment at Guheshwori and for future phases at Kodku and Dhobighat. It assumes that by the end of the first 5-year planning period of 2020 to 2025, the waste-characterization study will be completed, and contractual roadblocks to co-treatment will be lifted. By utilizing co-treatment, this option maximizes non-cost advantages including the efficiencies at the STPs, such as utilization of skilled manpower, and the cost savings by eliminating the need for extra liquids treatment.

Option 2: Implementing Stand- Alone Treatment Plant

This option assumes there will be no co-treatment, and all the treatment will be conducted through mechanized FSTPs. Given the issues with contractual performance targets for the STPs, and the anticipated difficulty in securing large parcels of land for passive FSTPs, this may be the preferred option.

Option 3: Optimized Recommendation

It utilizes mechanized stand-alone FSTPs at Kodku and Dhobighat, and passive FSTP technology for the municipal systems. The municipal systems were estimated to have a 20-year depreciation and replacement cycle, while the mechanized plants have a 15-year depreciation and replacement cycle.

Recommended Option

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The study team recommends Option 3 because it addresses the initial need with stand-alone systems at both Kodku and Dhobighat, which is likely more realistic than assuming co-treatment will quickly be approved. The team believes the waste characterization study will show that there will be enough capacity at the STPs to conduct co-treatment, and that any contractual issues regarding the contractors and their performance guarantees can be eventually worked out.

The FSM program is estimated to require $52 to $62 million over the 30-year planning period, with most of the funds required in the first 10 to 15 years. The study team reviewed three treatment plant configurations and designated a preferred option that first utilizes stand-alone and eventually co-treatment systems. Co-treatment maximizes both cost and operational advantages, such as the availability of skilled personnel and liquid treatment facilities at the STPs. The study team recommended alternative options if the contractual issues with co-treatment cannot be worked out. The first two recommended FSTPs that are to be co-located at Kodku and Dhobighat STPs should be designed in two phases, each with the expandable to 150 m3 with their first installed capacity as soon as possible to address current demand. Table 3 summarizes the investment options for the KV’s FSM.

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Table 3: Investment Estimates of Option 1, 2 and 3

Data	**Option 1(Maximizing Co-treatment)**							**Option 2 (Mechanized Stand-alone FSTP)**							**Option 3 (Recommended Option)**						
M3/day	2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050
Kodku phase 1	75							75							75						
Dhobighat phase 1	75							75							75						
Guheswori		75														75					
Kodku Phase 2									75												
Dhobighat phase 2		75							75							75					
Municipal systems 1	30							30							30						
Municipal systems 2	30							30							30						
Municipal systems 3			30							30							30				
Municipal systems 4			30							30							30				
CumulativeTreatment capacity m3/day	210	360	420	420	345	270	270	210	360	420	420	345	270	270	210	360	420	420	345	270	270

Investment in $US	Option 1	Option 2	Option 3
	2020-2050	2020-2050	2020-2050
phase 1(Kodku & Dhobighat)	3,800,000	4,800,000	4,800,000
Project Development Cost Phase 1	5,70,000	7,20,000	7,20,000
Phase 2 (Kodku & Dhobighat)	1,100,000	4,200,000	1,100,000
Project Development Cost Phase 2	5,70,000	7,20,000	7,20,000

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Guheshwori and Co-treatment and land	1,900,000		1,100,000
Municipal systems 1&2	2,200,000	2,200,000	2,200,000
Municipal systems 3&4	2,200,000	2,200,000	2,200,000
Land cost	6,038,862	6,038,862	6,038,862
Development cost of municipal systems	6,60,000	6,60,000	6,60,000
Equipment replacement & repair cost	27,850,000	32,587,500	23,312,500
Operating and office complex	3,035,000	3,035,000	3,035,000
Supporting activities/logistics & software	4,321,000	4,321,000	4,321,000
Bio solid treatment (CAPEX)	1,500,000	1,500,000	1,500,000
Grand Total	**58,889,834**	**62,982,362**	**55,982,362**

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CONCLUSIONS

There is a critical need to address FSM and planning should start now. Currently the limiting factor is treatment capacity. The quickest path is to start planning for a stand-alone FSTP at Kodku and another at Dhobighat. One of these should be installed as soon as possible and put into use by the existing desludging fleet. That should provide up to 75 m3 per day of treatment capacity, which is about half of the transport ready FS that is currently being collected every day, but it is a good start. Planning should also begin for the Guheshwori co-treatment system that will have a reception facility located off-site (at a decanting station) due to space constraints at the STP site. Once septage begins to flow, the waste characterization study should begin (for faecal sludge as well as municipal sewage) so that actual data can be used for co-treatment modeling. It is likely that most, if not all, the FS could be co-treated effectively.

While this is happening, the institutional home of FSM should become firmly established. A sanitation cell should be established to manage and oversee the FSM program. Monitoring and evaluation protocols should be put into place, along with municipal ordinances and promotion campaigns. Capacity building and training should begin as soon as possible. The municipalities that are currently interested in developing stand-alone FSTPs should be encouraged to begin planning and land banking. They should develop an ordinance, hire sanitary inspectors and begin enforcing the ordinance, and adopt the upgrading strategy. Funds should be sourced from ADB, government agencies and donors. The study team considered many variables to estimate investment costs, including the use of co-treatment, mechanized versus passive technology, and stand-alone versus co-locating FSTPs at the existing STPs.

REFERENCES

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