Topic

Waste-water Management Systems for Small and Medium Towns: Issues and Options

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Abstract

India is transforming from a developing nation to a developed nation. As common to the other transition phase countries India is also facing two major problems of lack of infrastructure and huge population growth.

Water and sanitation are the major issues in India. According to 2011 cencus about 12.6 per cent population still defecate in open. About 32.8 per cent toilets are connected with the piped sewers. Installed treatment capacity is just 31 per cent and only 21 per cent treatment plants are operated by ULB's. The condition in small towns is worst.

In Gujarat out of 166 ULB's only 67 ULB's are having sewerage network. The ULB's having treatment plants are just 12. The maintenance cost of sewerage system is quite high and ULB's are not having enough resources to manage it. Revenue recovery rate in some of the ULB's are as low as 30 per cent. Government of Gujarat wants to connect all the municipalities and R-URBAN villages with the sewerage network. The waste water is directly discharged in to natural drains without any treatment – which is being used for irrigation by the farmers downstream – causing health and environmental hazards.

This paper is an effort to see the condition of the existing sewerage networks, to see their issues and to give the options to the municipalities.

Introduction

India, being an economy in transition from a developing to a developed nation, faces two problems. On the one hand there is a lack of infrastructure and on the other, an ever-increasing urban population. Public services have not been able to keep pace with rapid urbanization. Water supply, sanitation measures, and management of sewage and solid wastes cover only a fraction of the total urban population. It is estimated that by 2050, more than 50 per cent of the country's population will live in cities and towns and thus the demand for infrastructure facilities is expected to rise sharply, posing a challenge to urban planners and policymaker.

Huge urban growth has led to complex problems of inadequacy of basic urban services. About 21% of urban population is living in slums where access to the basic services is very poor or very substandard. About 80% of population leaving in urban areas though has access to safe drinking water but there are severe deficiencies in regard to equitable distribution of water. As per estimates about 46% of households have water borne toilets while only 36% are connected with public sewerage system. Inadequacy of minimum basic services in urban areas has resulted in deterioration of quality of life. The infrastructure development could not keep pace with rate of urbanization. The ULBs are unable to cope up with the increasing demand of providing quality urban services in towns and cities due to lack of resources. (MoUD, UIDSSMT Overview and Silent Features 2009)

It is estimated that about 38,254 million litres per day (MLD) of wastewater is generated in urban centres comprising Class I cities and Class II towns having population of more than 50,000 (accounting for more than 70 per cent of the total urban population). The municipal wastewater treatment capacity developed so far is about 11,787 MLD that is about 31 percent of wastewater generation in these two classes of urban centres. It is estimated that the projected wastewater from urban centres may cross 120,000 MLD by 2051. However, wastewater management plans do not address this increasing pace of wastewater generation.

Thus we can conclude that the management of waste water is worse in smaller towns. Many towns have no network or inadequate network in India. Also, most of these small and medium towns do not have any designed and operational waste water treatment facility. The sewage in majority cases directly dumped into rivers or lakes or in open fields. In majority of cases it is found that the local bodies either divert the generated waste water to agricultural fields or sell to farmers at very nominal rates so that it can be used for irrigation. All these creates enormous amount of local health and environmental issues. Also, there is a question regarding the quality of agricultural produce that is harvested by using this untreated waste water.

Aim and Objectives

The main aim of the study is to understand issues and gaps in current municipal waste water management practice focussed on small and medium towns and work out options related to waste water management system including recycling and reuse of waste water.

This paper is written to give answers of certain research questions. The research questions are as follows.

- What are the issues related to municipal waste water systems in small and medium towns?
- What can be the probable options for solving those issues?
- Are the municipalities follows the standards of waste water disposal?
- What could be the possible options for treatment and end usage of treated municipal waste water?
- How to develop a sustainable model of finance for small and medium towns?

Major Objectives of the study are as follows.

- To evaluate municipal waste water management systems and identify issues and gaps related to network planning as well as treatment plants (on health and environment).
- Find out the options for issues of waste-water management systems in small and medium towns.
- To check the treatment of waste water follows appropriate standards for disposal and to find appropriate options for reuse of treated waste water.
- To check the possibility of developing a financial model for Operation and Maintenance of sewerage systems.

Methodology

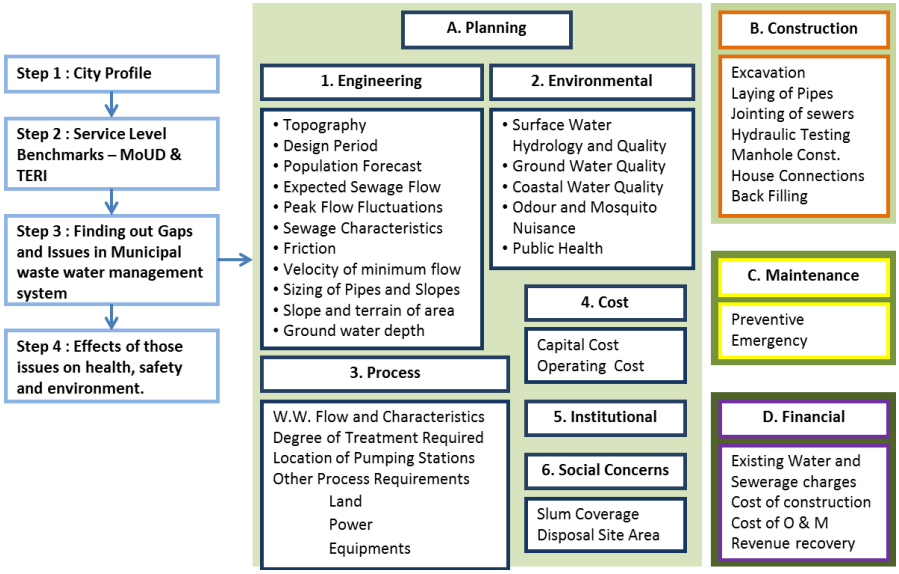


Figure 1: Process of Analysis

Literature review is based on number of national and international papers, laws and legislations, the existing policies for sanitation, Central Public Health and Environmental Engineering Organisation (CPHEEO) manual, Gujarat Urban Development Mission (GUDM) & Gujarat Urban Development Company (GUDC) guidelines. The case studies are selected by help of my previous research. Two major criteria considered are the availability of water-supply and the availability of treatment option in the town. Treatment facility available towns will have three different options that, they are fully functional, they are partially functional or they are not functional at all. Total four case studies are considered for the detail analysis. The towns where treatment facility is present but not working are Karamsad, Petlad and Vallabh Vidyanagar, the town where no treatment facility available is Sojitra. Figure 1 shows the process to analyse each town. The primary data collection is done by visiting municipalities and by meeting consultants – stake holder consultation method was adopted. Current issues of the system were found out by checking efficiency of the system which includes hydraulic efficiency and the operational efficiency. Existing network for each town is compared with Ministry of Urban Development (MoUD) and The Energy Research Institute (TERI) performance indicators for better understanding of the existing state. In treatment portion the existing issues with the treatment facility were found out by detail analysis and by stake holder consultation. For checking the quality of waste water, waste water samples were taken and the detail analysis of the samples is based upon the results of the samples tests. Indian standards for waste water irrigation are compared with the international standards for irrigation. Major emphasizes is on the treatment of the waste water, recycling and reuse of treated waste water. Ultimately sustainable model of finance for each town is developed by studying PIP model and cost & recovery based financial models.

Literature Review

India being an economy in transition faces two problems. On the one side there is a lack of infrastructure and on the other side a huge increment in urban population. (J.S.Kamyotra and R.M.Bhardwaj 2011) According to Census 2001, 27.8% of Indians, 286 million people live in urban areas which increased up to 31.8 % according to 2011 Census. Population projections indicate that the urban population would have grown to 368 million by 2012. According to 2011 Census 12.6 % urban households do not have access to latrines and defecate in the open. About 6 % Urban households use community latrines and shared latrines. About 38.2% households are connected to open drains and just 32.7 % people are connected to piped sewers. (Census 2011)

By 2050, more than 50 per cent of the country's population will live in urban areas and so the demand for infrastructure facilities will also be expected to rise rapidly. That will cause a challenge to

urban planners and policymakers. Public services have not been able to match the pace with rapid urbanization. Water supply, sanitation measures, and management of sewage and solid wastes cover only a small fraction of the total urban population. There is clear inequity and disparity between the public services received by the inhabitants, depending on their economic strata. The slum dwellers have in majority of the cases received least attention of the civic authorities. Because of a huge migration of population, the rapid growth of urban population has taken place. Mostly from rural areas and small towns to big towns people are coming to the cities. The other major reason apart from natural growth of the population is the inclusion of newer rural areas in the nearest urban settings. The issue is quite big in small towns, as the municipalities are not capable to cater the huge increase of population due to inadequate resources. The majority of towns and cities have no sewerage systems and sewage treatment facilities. Many cities have grown and expanded beyond municipal limits, but the new urban agglomerations remain under rural administrations. The same issues takes place here also that the rural management do not have the capacity to handle the sewage. Management of sewage is worse in smaller towns. The sewage is either directly dumped into rivers or lakes or in open fields. (Bhardwaj 2005)

During literature review, it has been established that, there are 7 municipal corporations and 159 municipalities (From Class A to Class D) in Gujarat. In Gujarat, 67 cities have underground sewerage system but only 12 of these cities have sewage treatment plants. According to Performance Assessment Systems Projects (PAS Projects), only one-third of the ULBs in Gujarat have a sewerage network, and that too only a partial network. Access to toilets is high in the state; 81 % of households have either an individual toilet or access to a community toilet. However, only 33 % households have a sewerage connection. This means that many ULBs in the state do not have a sewerage network. The high access to toilets in the state is a result of targeted programmes. The Government of Gujarat has facilitated construction of 1,25,000 toilets under the Nirmal Gujarat programme, where state government subsidy is provided to families for toilet construction. Information on access to sewerage is difficult to obtain as most ULBs in Gujarat do not maintain records of sewerage connections, partly because there is no separate charge for sewerage. It is always lumped together with water charges. In Gujarat, under the Swarnim Jayanti Mukhya Mantri Sehri Vikas Yojna (SJMMSVY) launched in 2009, an underground sewerage system is planned in many ULBs. While this plan is being implemented, ULBs will have to focus on proper septage management. It is also worth an effort to develop an information system that links the Property Tax database with water connections, sewerage connections and types of disposal (septic tank, soak pit, etc).

In Gujarat, like water charges, charges for wastewater wherever levied are done as a part of Property Tax. The average cost recovery for wastewater is 51 per cent. It was observed that 63 ULBs do not levy any sewerage/drainage tax. With only half of the cost of wastewater services being recovered, ULBs in Gujarat will need to revisit the sewerage charges and taxes. In cities with sewerage networks, reduction of expenditure would require replacing pumps at sewage pumping stations, cleaning and maintaining the sewerage system on a regular basis and repairing leaks.

It is well known that farmers have been using wastewater as a source of irrigation for many years around the world. At least 20 million hectare (m ha) in 50 countries is irrigated with raw or partially treated wastewater. (Hussain I) This helps sustain the livelihoods of millions of poor farmers in Asia, Latin America, the Middle East and parts of Africa. It is estimated that one-tenth or more of the world's population consumes foods produced on land irrigated with wastewater. *(Smit J)*

The presence of nutrients and assured water supply is a major driving force behind wastewater use amongst famers. The United States Environmental Protection Agency suggests that domestic septage can be a resource rather than a waste when properly managed. Septage contains plant nutrients such as nitrogen, phosphorus, and in some cases varying amounts of micronutrients such as boron, copper, iron, manganese, molybdenum, and zinc.

Various countries including Mexico, Kuwait, Jordan, Peru, Chile, Argentina, USA, Tunisia, Moroco use wastewater (both treated and untreated water but more so treated water and mainly for vegetable cultivation) for a variety of crops including vegetables, cereals, cotton fodder, etc. *(Martin 2012)*

Major Issues with Waste Water Irrigation

Farming with wastewater for irrigation is known as 'sewage farming' among farmers. Although it results in lots of benefits, there are also growing concerns about health and environmental risks. The people at risk are the users (farmers), consumers of such produce and populace in the vicinity, which might suffer negative impacts owing to groundwater contamination and evolution of habitats for mosquitoes and other disease vectors. The breeding of mosquitoes and other disease vectors is more widespread in crops irrigated by wastewater as compared with breeding of the same in fresh water irrigated crops like paddy and sugarcane.

Analysis

The basic analysis is done for the network concerns, maintenance concerns, treatment concerns and financial concerns. Detail hydraulic analyses of the existing system are done with the help of Sewer – 3.0 software and excel based software. The results for each town is discuses in the report. Vallabh Vidyanagar town is a well-planned and designed town. It does not have major issues in network. The major issues are with the treatment and reuse of waste water. The waste water is directly dumped in to Jol village pond causing serious impacts on the environment and health. Karamsad town does not have enough money to operate the pumping stations, thus the waste water directly goes to the natural drain bypassing the pumping stations. The issues of chocking up the main line due to shallow slope and less velocity are present in Karamsad town. No treatment is given to the waste water and waste water is directly used for irrigation purpose in the town. Sojitra town is a class D town. The major issues here are the coverage of the drainage. No treatment is given to the waste water. Revenue recovery here is the worst in comparison with the other towns. Petlad town is class B town. It has major issues of waste water treatment and network coverage. All the towns are having issues of revenue recovery and waste water treatment.

By comparing the networks and treatment facilities with the MoUD performance indicators, one gets the idea about the existing waste water management system of the town. (See Table – 1) Performance indicators confirm that the waste water treatment and reuse is very less in the towns comparing to state. 60 % Customer complaints are resolved within three days which is a good sign. Collection of sewerage related charges are quite low in the towns except Vallabh Vidyanagar where 84% of the charges are collected. The machineries at pumping stations of Vallabh Vidyanagar are of quite lower efficiency. The efficiency is as low as 40 % instead of minimum standard of 70 %. Municipalities are completely dependent upon the private contractors for operation and maintenance. Municipal staff is inadequate and does not have technical knowledge to solve the issues related to waste water management systems.

Waste water sample shows that the Waste water from Vallabh Vidyanagar and Karamsad are fulfilling the discharge standards given by CPCB. That waste water can be utilized for irrigation purpose without any treatment according to Indian norms. While the pathogenic analysis demonstrates that the waste water contains a high amount of pathogens and is unfit for the direct utilization even for irrigation purpose. The waste water can affect health of the farmer, community residing nearby and the consumers of the crop. (See Table – 2) When we compare the international irrigation standards and the Indian irrigation standards, we can see that the Indian standards do not have criteria of pathogens. One can use untreated waste water if the chemical standards are fulfilled. There is a need to rethink about the Indian standards for irrigation. It is also found that with the existing quantity of treated waste water from V.V.Nagar and Karamsad, we can irrigate the area of 690 hectares of land with existing cropping pattern after treatment of waste water. An attempt is made to formalise the waste water irrigation in such town. With the use the network of existing natural drains one can irrigate the area nearby Jol village.

Parameter	Benchmark	Gujarat	Vallabh Vidyanagar	Karamsad	Sojitra	Petlad
Coverage of sewage network services	100%	33%	95%	70%	46%	22%
Collection Efficiency of Sewage Network	100%	77%	86%	62%	23%	14%
Adequacy of Sewage treatment capacity (Cap of Treatment Plant)	100%	101%	72%	40%	0%	60%
Quality of sewage treatment (Treatment up to secondary stage)	100%	90%	0%	0%	0%	0%
Extent of reuse and recycling of sewage	20%	0.1%	0%	0%	0%	0%
Efficiency in redressal of customer complaints	80%	98%	98%	100%	100%	100%
Efficiency in collection of sewage charges	90%	55%	84%	32%	39%	63%

Table 1: Performance Indicators – MoUD

Microbial Type	Major diseases	Infectious Dose	Vidyanagar	Karamsad	Sojitra	Petlad
Viruses						
Enteroviruses		Low				
Poliovirus	Poliomylitis					
Enterovirus	Gastroenteritis, heart					LOW
Echovirus	Anomalies, meningitis		HIGH			
Hepatitis A virus	Hepatitis					
Adenovirus	Respiratory disease, conjuctivitis				MEDIUM	
Norwalk agent	Diarrheal, vomiting, fever					
Rotavirus	Gastroenteritis					
Astrovirus	Gastroenteritis					
Bacteria						
Vibrio cholerae	Cholera	High				
Salmonela typhi	Typhoid,	High				

Microbial Type	Major diseases	Infectious Dose	Vidyanagar	Karamsad	Sojitra	Petlad
	Salmonellosis					
Enteropathogenic E.coli	Gastroenteritis	High				
Shigella dysinterae	Dysentery	Low				
Yersinia enterocolitica	Yersiniosis	High				
Protozoa						
Giardia intestinalis	Giardiasis	Low				
Cryptosporidium	Diarrhea, fever	Low				
Entamoeba histolytica	Amoebic dysentery	Low				
Helminths						
Round worm	Ascariasis	Low				
Hook worm	Ancylostomiasis	Low				
Wrip worm	Trichuriasis	Low				

Table 2 – Pathogen analysis of Waste-water samples

Table 3 shows the summary of the concerns coming out by analyzing the qualitative and the quantitative data. In each of the segment there are certain issues must be solve to operate the system efficiently and effectively.

	Vidyanagar	Karamsad	Sojitra	Petlad
Planning Concerns				
Design Period Is Over				
Gap Between Design Period And Construction				
Population Forecast				
Actual Water Consumption Is Not Considered				
Area Not Covered				
Deep Sewer lines				
Treatment Options				
Slope				
Spacing Of Manholes				
Sewage Characteristics				
Maintenance Concerns				
Manholes Clearing				
Poor Pumping Efficacy				
Inadequate Staff				
Treatment Plant Maintenance				
Poor Treatment / No Treatment				
Complaints Unsolved %				
Fiscal Concerns				
Revenue Not Recovered				
Sewerage Tax Is Low				
Social and Environmental Concerns				
Ground Water Pollution				
Surface Water Pollution				
Waste Water Is Used For Irrigation				
Disposal In Natural Drains				
Public Health				
Odour And Mosquito				

Table 3 – Summary of Concerns

Analysis of Alternatives

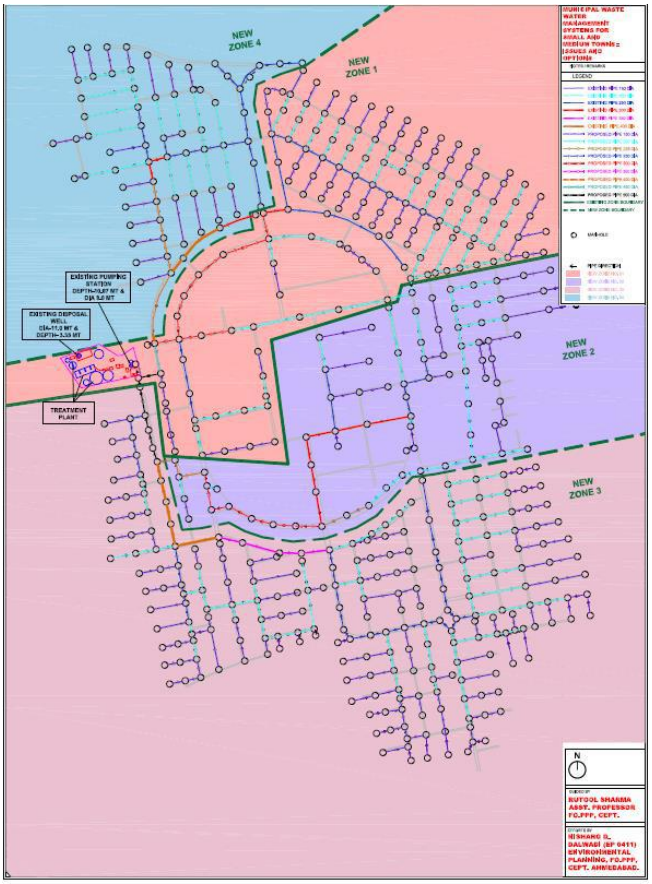
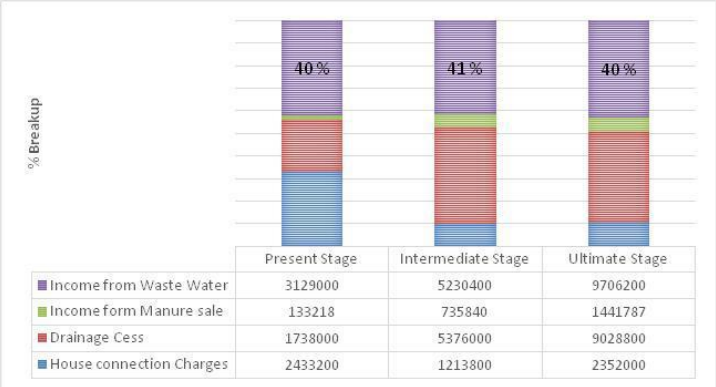


Figure 2: Rezoning – V.V.Nagar

It is found that each individual town has a different issue. Those issues are tried to solve by alternative ways. The network issues in Vallabh Vidyanagar are quite less. A rezoning will solve the issues of the network. The network will be able to take the load of next 30 years with the existing diameters of the pipe. It will save about 40 cr. INR required to reconstruct the whole network. (See figure – 2) In Karamsad also proper considerations of topography and a small change in zoning pattern will solve the network related issue. In smaller towns like Sojitra small bore sewer system can be adopted and can save a huge amount of capital investment. For maintenance purpose public private partnership can be done in the towns. Maintenance should be sub contracted to the private contractors to lessen the burdens of the municipalities. The efficiency of the equipments is a huge issue in all the towns and so the energy audit is a necessity for every town.

The maintenance in the municipal waste water management system is a major issue. The pumping stations are working with poor efficiency of the pumps. For maintenance purpose energy audit of the mechanical equipment should be done at every six months gap. Life of such equipment should be based upon the efficiency of the equipment and not in years. If efficiency comes around 60 % and if it can't be increased by repairing it, it should be changed. That will save a large amount of electricity and ultimately it will be economical.



	Present Stage	Intermediate Stage	Ultimate Stage
Income from Waste Water	3129000	5230400	9706200
Income form Manure sale	133218	735840	1441787
Drainage Cess	1738000	5376000	9028800
House connection Charges	2433200	1213800	2352000

Figure 3: Revenue Recovery – V.V.Nagar

Maintenance can also be sub-contracted to private contractors. For example in Patan municipality the maintenance is given to the private contractors. There are 3 contractors who are looking at the whole system. If there is any problem in the network people call the contractors office. The issues are solved within 24 hours in majority cases. Selection of contractors was based upon the Local competitive bidding. The contractors are paid up to 7 lac rupees per year for the cleaning of the manholes and chock up. The private contractors also need to maintain the pumps in the pumping station. They need to do the maintenance at every 3 months for each pump. The electricity bills are paid by the municipality. Patan is one of the four medium towns in Gujarat where the waste water is reaching the treatment pond, even though the treatment is not given to the waste water.

The waste water can be utilized for irrigation after appropriate treatment. This will be a huge income source for the municipality. From the analysis it is seen that about 40 % of waste water management systems operation and maintenance cost can be recovered by selling the waste water for irrigation. (See Figure – 3).

Indian standards of waste water irrigation are not compatible with the international standards. There is a need to rethink about the Indian Irrigation standards to reduce the environmental stress and human health stress. The standards should be based on the type of the crop. There are number of treatment options available in the market. With proper guidelines suitable option for that locality should be adopted. In class D and class E towns the decentralized approach should be adopted.

There are certain methods by which one can do the formalization of waste water selling for irrigation can be done. First is the Public Private Partnership mode. The Municipality can invite the parties by Notice in newspaper. Interested parties will bid for the waste water on lump sum bases. The party who is bidding maximum will be given a yearly contract for selling waste water. This practice is carried out in Unja Nagarpalika in Gujarat. The municipality has given the yearly contract to the private contractor. The private contractor lump sum pays 2.30 lac per annum to the municipality. The municipality gets the income from the waste water annually. The private contractor sells it to the farmers nearby. The waste water is sold without any treatment. The farmers pay around 60 Rupees for 10,000 liter. The income of the contractor is about 4 lac rupees which is annually profit of 1.70 lac to the contractor.

The other method of the waste water selling is municipality can directly sell the waste water. Municipality can give the permits to the farmers for utilizing the waste water. Each season the farmers need to take the permit. According to crop and the size of the farm rates should be fixed. Higher water demand crops like Patterveli will have to pay a lump sum amount to the municipality for a season and tobacco farmers with the same land needs to pay less. The rates should be lower than the rates of irrigation. (J.S.Kamyotra and R.M.Bhardwaj 2011) This method is quite complicated. The method is not yet practically implemented anywhere in Gujarat.

The lump sum method is majorly adopted by the municipalities in north Gujarat. The model is successfully implemented by many municipalities. Thus, this method can be adopted by the municipalities in Anand district.

There is a need for institutional strengthening. The Institutional Strategy should be designed to foster effective and efficient use of existing human resources. The proposed framework aims at helping the ULBs achieve a capable and motivated workforce, responsible and accountable elected representatives and stronger financial management. The strategies are proposed aiming at dealing with the above two issues and to tackle the work load of existing staff due to staff crunch.

Intervention at ULBs is needed to fill up the cadre related posts such as Sanitary Inspector, Jr. Water Supply Engineer, Internal auditor, Administrative officer, etc which are currently vacant. This will help in reduction of workload on existing staff and ensure smooth functioning of each department. It will also help in strengthening the monitoring of work of the department.

Outsourcing of sanitation services on contract basis: Since the current staffing pattern cannot be changed or new recruitments (besides sanctioned posts) cannot be made, increasing the staff at ULB level is not possible. Which means that as and when the staff in this category retires, the post will not be filled, leading to further staff crunch. Hence outsourcing of sanitation services on contract basis should be further explored. Option of engaging private party and also existing CBOs/SHGs and certain other groups like informal rag pickers should be explored. But these services should be operated on user fee basis so as to cover the O & M costs and payments to the contractor, etc.

In this case there is a need to strengthen the public health department of the ULB which looks in to sanitation aspects for effective monitoring of implementation and O&M. The role of the ULB will be more facilitator and provider of infrastructure and monitoring. The monitoring of the contract work and also that of the existing sanitary workers can be achieved by filling up the post of Sanitary Inspector.

Lack of awareness and importance placed on sanitation and hygiene is an emerging issue- be it be use of toilets, knowledge about safe disposal of waste water or disposal of HH waste, its treatment and reuse. IEC can play an important role in bringing about attitudinal and hence behavioural change. Awareness generation using communication as a means plays an important role in achieving 100 percent access to sanitation. Complete sanitation can be ensured by bringing about change in existing mind-sets through an integrative process of behavioural change. This goal can be met by implementation of comprehensive IEC plan, targeting stakeholders at various levels in the town and introducing them to the purpose and rationale of the plan in detail.

Recommendations

Based upon the study "Municipal Waste Water Management Systems for selected small and medium towns: Issues and Options" some recommendations which will be helpful for the municipality as well as the community are as follows.

Planning and Network:

- CPHEEO manual should be followed as far as possible, during designing the system.
- The design of sewer lines should be based upon the actual consumption of water and not upon 135 LPCD or 100 LPCD assumptions.
- Delays in implementation in the construction and implementation of the projects should be avoided.
- Before construction of the whole sewer network, pilot project should be carried out and tested over and above testing the mathematical models. Critical section having more depth and less velocity should be selected and testing of such should be done.
- Artificial flushing system should be introduced in critical areas of the towns to avoid chock ups in the system.

Maintenance Recommendations:

- For maintenance purpose energy audit of the mechanical equipment should be done at every six months gap. Life of mechanical equipment should be based upon the efficiency of the equipment. If efficiency comes around 60 % and if it can't be increased by repairing it, it should be changed. That will save a large amount of electricity and ultimately it will be economical.
- Administrative staff requirement should be established during implementing drainage projects. Both technical and non-technical staff should be available for proper maintenance of the system.
- Skill improvement should be done at every stage – From management to cleaners.
- For maintenance Public Private Partnerships should be done if the man power is not available with the municipalities.

Waste Water Treatment Recommendations:

- Alternative technologies for safe disposal and treatment as well as for reuse of water should be encouraged by the government.
- Waste water treatment standards must be followed and without treatment, reuse of waste water must be avoided.
- Waste water irrigation standards in India should be analysed for its appropriateness with the international standards. The inclusion of pathogenic criteria should be done.

Finance Recommendations:

- The planner should design the system such that it is self-sustainable.
- Revenue recovery part is very poor in case of majority of the municipality in study. Revenue recovery rate should be reach at least 90 %.
- Drainage meter system can be introduced and the tax should be proportionate to waste generation.
- Municipality can generate the revenue from selling the treated waste water for agriculture purposes and the sludge cakes (Manure) form treatment plant. There is a very high potential hidden in the revenue generated from selling the treated waste water.

Government of Gujarat shall study carefully examined above aspects before investing huge amounts in developing underground drainage systems in 405 Towns and R-Urban Villages. They need to first enhance capacity of municipalities and then introduce underground drainage systems which are quite costly in maintenance. Municipality should target at least

95% revenue recovery. Higher revenue recovery can address maintenance problems and will increase the efficiency of underground drainage system. There is a need to look at the standards form international perspective to avoid environmental and human health stresses.

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