SMALL BORE SEWER SYSTEM

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1.0 INTRODUCTION:

Drinking water and sanitation are the key issues of urban areas. These perform complementary role for each other. It is impossible to consider these issues in isolation. The efforts to provide safe drinking water are being made at a more rapid pace than adequate sanitation. As a result, the fresh water resources increasingly in demand are also being increasingly polluted.

Collecting domestic wastewaters through elaborate sewerage system to a single point for treatment and disposal of treated effluent to surface water bodies are not affordable due to its high cost of construction, operation and maintenance. As such, very few cities are fully sewered and provided proper treatment to their wastewaters before disposal. This approach may pollute natural streams and water bodies, as those are the points of ultimate disposal.

Recognizing the interdependence of Protected Water Supply, Sanitation and Human Health & Well-being, it is now realized that without proper sanitation the envisaged development and progress cannot be achieved. Therefore, the Government of Gujarat has focused on sanitation aspect as much as the drinking water supply.

Due to high cost of construction, operation and maintenance of full-fledged sewerage system, an attempt is made here to highlight one of the low cost sewer systems, known as "Small Bore Sewer System (SBSS)"

2.0 Objectives of the project design should generally cover following criteria:

- Contamination of top soil should be prevented,
- Contamination of underground water should be avoided –it may find its way into springs, wells, etc.
- There should not be pollution of surface water sources,
- Method used should be cost effective, simple and easy to maintain,
- The method used should be odour free and devoid of unsightly conditions.

3.0 OPTIONS FOR WASTEWATER DISPOSAL:

Wastewater disposal methods are of two types: (i) offsite disposal and (ii) onsite disposal. Conventional sewerage system, small bore sewer system, shallow sewer system, open and covered surface drainage, etc. are the examples of off-site excreta and wastewater disposal systems. Septic tanks, pour flush water seal latrines, bucket/dry latrines, trench latrines, borehole latrines, dug well latrines, aqua privy, VIP latrines, ECOSAN system, etc are the examples of on-site excreta and wastewater disposal systems.

3.1 The conventional off-site excreta disposal method requires more water and sewage treatment and disposal plant. Thus it is an expensive option and not affordable by low-

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income and/or small communities like rural areas and small towns. Options like small-bore sewers and shallow sewers are comparatively cheaper than the conventional sewerage and treatment options.

4.0 SMALL BORE SEWER SYSTEM:

This system is designed to collect and transport the liquid portion of the domestic wastewater for off-site treatment and disposal. Solids from toilet waste are separated from the liquid in septic tanks or aqua privies installed upstream of every connection to the small bore sewers. Each house sewer is usually connected to an interceptor tank, which is designed as a septic tank. One or more houses may be connected to an interceptor tank through house connection. The effluent from the interceptor tank (IT) is discharged into the sewer system. Here flow occurs by gravity utilising the head resulting from the difference in elevation of its upstream and downstream ends. Effluent from the system can be treated through stabilization ponds, any other low cost treatment followed by fishponds or land treatment with the usual precautions. (fig 1 & 2)

4.1 Components of the system:

This SBS system consists of (a) house connections, (b) interceptor (septic) tanks, (c) the sewers and their appurtenances like cleanouts, manholes, vents etc. and (d) sewage treatment plants. Pumping may be provided to overcome elevation conditions or to convey collected wastewater from one zone to other zone.

4.2 House connection: The house connection is made at the inlet to the interceptor tank. All household wastes, except for garbage and trash, enter the system at this point. Alternatively, night soil line may be connected to the inlet to the interceptor tank and outlet of interceptor tank be connected to sewers. Bath and kitchen waste be connected to sewer through grit chamber. (fig 3)

4.3 Interceptor Tank: (fig 4)

Interceptor tank is a buried watertight tank with baffled inlet and outlet. It is designed to detain liquid flow for 12 to 24 hours and to remove both floating and settlable solids from the liquid stream. Ample volume is provided for storage of solids, which are periodically removed through an access port. Typically, a single-chamber septic tank is used as an interceptor tank. On narrow streets where space to accommodate interceptor tank is not available, a community interceptor tank can be provided at the nearest location where space is available and latrine waste of those houses should be taken in that interceptor tank. In such case size of interceptor tank should be as given in the table below

RECOMMENDED SIZES OF INTERCEPTOR TANK
UPTO 20 PERSONS

No. of users	Length(m)	Breadth (m)	liguie depth for cleaning interval of	
			2 Years	3 Years
5	1.5	0.75	1.00	1.05
10	2.0	0.90	1.00	1.40
15	2.0	0.90	1.30	2.00
20	2.3	1.10	1.30	1.80

Required number of interceptor tanks of size 1.8m x 0.9m x 1.5m in parallel can also be provided.

4.3.1 Waste from latrines will be drawn in the interceptor tank through 75 mm PVC pipe. Grit, grease and other troublesome solids which might cause obstructions in the sewers are separated from the waste flow in the interceptor tanks installed upstream of every connection to the sewers. The solids i.e. the sludge, which accumulate in the tank, will be removed periodically by vacuum tankers or portable pumps and dumped in compost pits where it will be digested and converted into odourless humus that can be used as very valuable natural manure.

4.3.2 The interceptor tanks need periodical cleaning every 1.5 to 2 years and disposal of digested solids. Special precaution should be taken to prevent illegal direct connections into sewers without interceptor tank and dumping of solid waste into interceptors, cleanouts and manholes.

4.4 Sewers:
Sewers are not supposed to carry solids and a large quantity of water is not needed for solid transport. With the troublesome solids removed, the sewers do not need to be designed to maintain a minimum flow velocity for self-cleansing. Therefore sewers can be laid with curvilinear alignment with a variable or inflective gradient; that is to say, the sewer may have dips so that sections of it remain full under static conditions. The sewer may be constructed with any profile as long as the hydraulic gradient remains below all interceptor tank outlet inverts. This reduces excavation cost, since the sewer can follow the natural topography more closely than conventional sewers.

4.4.1 Cleanouts: (fig 5)
Cleanouts and manholes provide access to the sewers for inspection and maintenance. Cleanouts are used in place of manholes, except at major junctions Cleanouts are provided at all upstream ends, intersections of sewer lines, major changes in direction, at high points and at intervals of 60-100 m in straight reaches of long flat sections. Cleanouts are preferred to manholes because they can be tightly sealed to eliminate major infiltration and entry of grit, which commonly enter through the lids and walls of manhole. They can easily be concealed to prevent tampering. They function as flushing

points during sewer cleaning operation. Manholes will become place of illegal direct connections and dumping of solid wastes into them.

4.4.2 **Vents:** The sewers must be ventilated to maintain free-flowing conditions. Vents within the household plumbing are sufficient, except where ineffective gradient sewers are installed. In such cases, the high points of the sewer should be ventilated either by locating the high points at connections or by installing a cleanout with a ventilated cap.

4.5 **Lift stations:** (fig 6) Lift stations are necessary where elevation difference do not permit gravity flow. Either residential or major lift stations may be used. Residential lift stations pumping wastes from the interceptor tank of home or of a small cluster of homes to the sewer, while major lift stations are located in the sewer line and service all connections within the larger drainage basin.

5.0 **Design Criteria:**

A design peak factor of 2.0 is normally adopted. At peak flow, sewer is to flow full. Where pumping is to be done the pump discharge rate, will be equal to the peak flow rate, unless pumping cycle is less than five minutes. Smallest pipe diameter of 100 mm is recommended. Maintenance of strict sewer gradients to ensure minimum self-cleansing velocity is not essential because the solids are retained in the interceptor tank. Minimum velocity should not be less than 0.3 m/s. Hydraulic gradient of street sewers should remain below all interceptor tank outlet inverts.

6.0 **Main advantages:**

- Sewers are not required to carry solids and a large quantity of water is not needed for solid transport. Hence it can be employed without possibility of blockages even when domestic water consumption in the community is low. Hence there is no need of augmenting present water supply on that count.

- With the troublesome solids removed, the sewers do not need to be designed to maintain a minimum flow velocity for self-cleansing. Therefore sewers can be laid with curvilinear alignment with a variable or inflective gradient. This reduces excavation cost, as the sewer can follow the natural topography more closely than conventional sewers.

- Peak flow required is lower because the interceptor tanks provide some surge storage, which attenuates peak flows. Therefore, sewers and any pumping equipment can be reduced in size (and pumps handling only liquids can be used).
- Expensive manholes can be replaced with much less costly cleanouts or flushing points. Mechanical cleaning equipment is not necessary to maintain the sewers in a free-flowing condition.

- Screening, grit removal and primary sedimentation or treatment in anaerobic ponds are not needed at the treatment works, since these unit processes are performed in the interceptor tanks.

- The sewer may be constructed with any profile as long as the hydraulic gradient remains below all interceptor tank outlet inverts.

- Less skill is required in the construction and its operation and maintenance are quite different to those of conventional systems and more labour-intensive. O & M cost is low in terms of low power consumption.
- As this system collects only settled wastewater, it can work at low per capita water supply rates and low velocities of flow. This in turn flattens gradients and reduces cost of excavation and materials due to smaller diameter of pipes required. Thus this system is considerably cheaper than conventional sewerage system.

6.1 Limitations:

- The interceptor tanks need periodical cleaning every 1.5 to 2 years and disposal of digested solids. This requires an organization and equipments for maintenance of these interceptors to ensure satisfactory performance of the system.
- Special precaution should be taken to prevent illegal direct connections into sewers without interceptor tank and dumping of solid waste into interceptors, cleanouts and manholes should be avoided.
- If solids are introduced in the system it could create serious operational problems as the system is not designed for solids.

7.0 COMPONENT COMPARISON OF CONVENTIONAL AND SMALL-BORE SEWER SYSTEMS:

Component/ criteria	Conventional	Small-bore Sewer
Water requirement	Minimum 135 lpcd. For this augmentation of WS scheme necessary	No such limit. augmentation of WS scheme not necessary
Capacity at peak flow	0.80 full	Full
Minimum velocity	0.8 mps at design peak flow & 0.6 mps at present peak flow	0.3 mps
Peak factor	2.5 to 3.0 depending on size of community	2.0
Manholes /Cleanouts	MH- maximum distance 30 m	Maximum distance of cleanout 60 m
Minimum diameter	150 mm	100 mm
Alignment	Straight line with uniform grade	Can be constructed in any profile as long as hydraulic gradient remains below all interceptor tank outlet invert
Minimum cover on sewer	1.0 m	0.7 m

Pumping machinery	Very costly non-clog pumps required	Pumps used to pump water can be used
Treatment plant	Costly in capital cost & in O & M	No costly treatment plant are required. Wastewater can be disposed in natural drains.
O & M cost	High in terms of high power consumption & more and skilled staff requirement	Low in terms of low power consumption & low staff requirement
Self cleansing velocity	Required to maintain	Not required
Depth of sewer & MH	More depth due to requirement of maintaining grades	Less depth due to no requirement of maintaining grades
	High cost of MHs	Low cost of cleanouts

8.0 Disposal of effluent:

A sump of suitable diameter and depth which include 0.6 m depth below invert of inlet pipe and 0.3 m above ground level may be constructed at the end node of sewer network. An outlet pipe of the same diameter may be provided at invert level of inlet pipe in the sump. The purpose of providing 0.6 m depth below invert of pipe is that wastewater from this sump can be pumped for use for irrigation if planned and thus revenue can be generated by sale of the effluent.

As per CPHEEO manual the average per capita BOD contribution will be 45 gms per capita per day. Out of 85 lpcd wastewater 15 lpcd will flow into interceptor tank through latrines and 70 lpcd will flow to grit trap as kitchen waste. Hence initial BOD in interceptor tank will be 45000/15 = 3000 mg/l. As given in UNDP report one can conservatively assume BOD and fecal coliforms reduction of 60 % and 90 % respectively in interceptor tanks in warm climates. Assuming 60 % efficiency BOD of effluent of IT will be 3000 x 0.60 = 1800 mg/l. This will be added in 70 lpcd wastewater from kitchen. Thus BOD of effluent of SBS sewers will be 1800/70 = 25.7 mg/l, which is within permissible limit of 30 mg/l. Thus effluent of SBS system does not need any special treatment and can be disposed of into surface water. Even if BOD is more than the permissible limit the effluent will not cause nuisance when disposed off on land or discharged into receiving waters because the algal cells do not readily decompose or exert oxygen demand under natural conditions. In fact, algae increase the oxygen levels in the receiving water by continual photosynthesis.

If any waste land is available wastewater can be allowed to flow by gravity through outlet pipe to waste land or pumped from where it can be allowed to flow to natural drain through open channel. An embankment can be constructed at the point where this wasteland meets the natural drain. This embankment will be made from the soil excavated from the wasteland. Wastewater will be held in this pond. This effluent can be used for irrigation by pumping or by gravity if levels permit. Some wastewater from this pond will evaporate and some will percolate into the soil and recharge ground water. This advantage is to be taken as side product.

9.0 CONCLUSION

9.1 This system is designed to collect and transport the liquid portion of the domestic wastewater for off-site treatment and disposal. Hence the system has advantages of (a) reduced size of the sewers (b) reduced excavation cost (c) reduced material cost and (d) reduced treatment requirement due to interceptor tank where the treatment of sewage takes place. The system is practically free from complicated operation and maintenance procedures.

9.2 As this system collects only settled wastewater, it can work at low per capita water supply rates. Hence augmentation of existing water supply scheme is not necessary. Thus additional O & M cost of water supply scheme if would have augmented could be eliminated. Effluent of SBS system can be safely utilized for ground water recharge. Hence SBS is boon for water scare areas.

9.3 SBS can be implemented in quite a shortr period than conventional sewerage system as deep excavations are not required, construction of specialized sewage treatment plants, pumping stations and pumping machineries are not required.

9.4 Taking into consideration the high cost of construction, operation and maintenance of full-fledged sewerage system the SBS being cost effective is very suitable for small towns and also to pockets of areas of towns where due to adverse slopes pumping of sewage is necessary. The sewage collected in such lift stations can be pumped by pumps being used for pumping water.

9.5 In towns where natural ground slopes are available this system is very suitable.