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Simplified sewerage: An appropriate option for rapid coverage in peri-urban areas of India

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With increasing population pressure in the cities and towns across India, clearing the backlog, and improving and maintaining sanitation service levels has become increasingly challenging. Water borne human excreta disposal through conventional sewerage system is expensive and increasingly infeasible for congested, small plot habitations which experience low or declining service levels of water supply. Although this represents the higher order technology option, it is increasingly being questioned because of its water intensive feature. In areas where on-site sanitation is technically not feasible and where conventional sewerage is financially unaffordable, simplified sewerage as an intermediate technology solution offers an appropriate option. Successful experience of over 20 years in Latin American countries has positioned this technology as an important and only feasible option for peri-urban areas and low income settlements. A small municipality of Ramagundam (Andhra Pradesh, India) with a population of around 250,000 has successfully adopted this technology and has been able to provide full sanitation in 13 low- and middle-income communities covering over 6600 households. Lessons from this success story could be drawn for wider application and rapid coverage under the ongoing infrastructure strengthening programs. There is a need to evolve appropriate policy and technical guidelines such that the sanitary engineering community can confidently adopt this unconventional technology and extend the benefits of improved sanitary conditions and better public health to a larger population.

Introduction

There are over 4300 cities and towns in India wherein a thriving population of over 285 million resides. This section of the population is estimated to contribute over 60% of the Country's GDP. This urban population had recorded a growth of 31% during the 1991-2001 decade and is expected to be growing at an even higher rate in the present and the coming decades given the increasing impetus on industrialisation and urbanisation. In 1991 there were 24 'million plus' cities which rose to 35 by 2001.

As per the Census 2001, about 53% of the urban population had access to improved sanitation while the World Health Survey of 2002 estimated it to be around 62% (WHO/UNICEF, 2004). To address the wide gap, the Tenth Five Year Plan (2002-07) had kept the target of raising coverage in urban areas by 2006-07 to 75% which corresponds to reaching to an additional 31 million people and for which a budgetary estimate of Rs. 231.57 billion (~USD 4.8 billion, @ Rs. 48/USD in 2002)[1] was made (Planning Commission, 2002). In the Eleventh Five Year Plan (2007-2012) the coverage target has been raised to 100% which requires reaching to 198 million urban population by 2012, and out of which 138.8 million (70%) population is proposed to be served with sewerage connection. For the latter component the fund requirement in the Eleventh Plan is estimated to be Rs. 416.34 billion (~USD 9.7 billion, @ Rs. 43/USD in 2007) (MOUD, 2006). If India is to meet the Millennium Development Goal on sanitation then at least 92.5 million urban population has to be covered by year 2015, and in order to achieve the global goal of full sanitation coverage by 2025, then additional 240 million people have to be covered (Planning Commission, 2002).

While access to household toilets in urban areas could be increasing, sanitation beyond home toilets is a different story. The Census 2001 and the World Health Survey, 2002 estimated sewer connectivity as low as 15-17%. Out of 423 Class-I cities, only about 70 have partial sewerage network, while the rest of the Class-I, II and III cities and towns do not have this increasingly critical public health engineering infrastructure. Under such situation, typically septic tank is the preferred option but which in most cases is not followed by a soak-away/drainage trench, and as a result its overflow is let out either on the ground, into open storm water channels or drains. This, along with the practice of indiscriminate disposal of septage from filled septic tanks leads to release of pathogens into the open environment which poses a major risk to public health (municipal service for emptying of filled septic tanks is commonly not available; local bylaws for safe disposal of septage are not clearly laid out or implemented effectively and as a result, septage is disposed of into water bodies or on to agriculture fields). Often lack of space for construction of septic tanks and non-availability of sewer lines compels low income households to construct direct discharge latrines or to resort to the unhealthy practice of open defecation. In the case of relatively larger villages (population > 5,000) which are rapidly acquiring semi-urban characteristics, similar or still challenging situation prevails.

Further, as per the Central Pollution Control Board (CPCB) estimates for year 2003-04, over 26,054 million litres/day (mld) of sewage is generated in 921 Class-I & II cities and towns across the country and the aggregate available capacity for treatment is only 7,044 mld (MoUD, 2006). In view of this wide gap (effective operational capacity may be still less), 19,210 mld untreated sewage is discharged into water bodies and which in-turn leads to the associated adverse environmental and public health impacts.

In recent years the Government of India has initiated two very comprehensive urban infrastructure strengthening programmes, viz. Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) with a tentative outlay of Rs. 1000 billion (~USD 22.5 billion, @ Rs. 44.5/USD in 2006) which are co-terminating with the Eleventh Five Year Plan by 2012. Under these programmes, among others, construction of on- and off-site sanitation infrastructure is one of the key components (accounting for almost 40% of the outlay) and it is understood that several large, medium and small municipalities are planning or have already started construction of conventional sewerage system. It is also noted that for its perceived benefits, municipal councillors and officials increasingly prefer water borne excreta disposal system. While sewerage network represents a higher order technology option and which can enable significant improvement in sanitary conditions in a habitation, one of the preconditions for its satisfactory working is adequate water supply. However, with several urban areas being characterised by restricted water supply and declining service levels, it would be a challenge to ensure trouble free operation of a conventional sewerage system. It is also recognised that there are several challenges in its construction in congested areas, low income settlements, and even in new layouts in the suburbs because of high capital cost, space constraints, higher gradient requirements, subsidence, etc. Moreover, where topography is unfavourable, sewage pumping stations are unavoidable and it has been observed that municipalities find it difficult to sustain their operation because of high energy costs.

Simplified sewerage - an appropriate technology option

Rapid urbanisation and the accompanying pressure on the existing sanitation infrastructure require innovative and affordable solutions for meeting the needs of growing population. In this regard Brazil took the lead in early 1980s in developing an unconventional sewerage system which has come to be recognised as simplified sewerage, shallow sewerage or interceptor sewerage, etc. All of these systems are characterised by few basic features, i.e., provision of a solid interceptor tank at individual property connections and small diameter sewers laid at shallow depths. These features enable design of the sewer lines based on tractive force criteria rather than the minimum velocity criteria (as in the case of conventional sewerage). Secondly the sewer gradient is designed based on initial design flow and the diameter is designed based on the final design flow (Mara, et. al., 2001). These considerations enable use of smaller diameter pipes (minimum 100 mm) at mild slopes. With mild slopes, excavation is shallow, allowing cover of 400 mm or less, and minimising or altogether eliminating the need for lifting of sewage. As the sewer lines are installed below sidewalks/footpaths or inside private properties, heavy vehicle loads are not expected and as a result the need for providing a minimum depth of soil cover is also reduced. Further, with shallow pipes, the requirement of deep manholes is eliminated and instead shallow and less expensive cleanouts or access chambers are provided. All these modifications result in almost 50% reduction in capital cost compared to conventional sewerage. Further, experience in Brazil has shown that simplified sewerage is cheaper than on-site sanitation in areas with population density higher than 175 persons/ha.

Maintenance requirements of such a system comprise occasional flushing of sewer lines, removal of blockages through rodding machines or flushing equipment, repairs of sewer lines and connection chambers, as needed, manual inspection, and desludging of interceptor/septic tanks once every 5 years or so.

One of the essential and desirable aspects of developing a simplified sewerage project is the need for community participation in its planning, construction and O&M. For instance while interceptor tanks are essential, further cost reduction is possible on users' end by sharing of the interceptor tank by a group of houses before connecting to the network. The users also need to ensure that no large objects are disposed into the toilets and the tanks are emptied when full.

Simplified sewerage system has been found to be reliable, upgradeable and extendable. It is applicable in all situations but especially suitable for areas characterized by gently sloping topography, high and low-density population with reasonable water supply, small homesteads with lack of space, high water table, impervious soil and shallow bedrock. Variation occurs in rolling terrain where need for intermediate pumping may arise, however generally one or two lifts may be all that would be required. In Orangi slum settlement of Karachi, Pakistan, over the years the community with support from facilitating organisations is reported to have developed a wide network covering over 600,000 poor people and has been able to bring about significant sanitation improvements. In Brazil initially this system was provided in low income habitations, however, it is now successfully and appropriately used for low density middle- and high-income neighbourhoods as well.

Another advantage of this system is that it enables decentralised treatment of sewage in the form of either a low cost community septic tank followed by a wetland or somewhat higher order treatment option according to the applicable discharge standards. In this regard, it is to be recognised that on account of individual interceptor tanks, settled sewage also requires lesser degree of treatment.

Indian experience

The latest available edition of the Manual on Sewerage and Sewage Treatment of the Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Urban Development introduces 'small bore' and 'shallow sewerage' as appropriate technology options (CPHEEO, 1995) however as yet they have not been adopted by consulting organisations, municipal engineers and urban local bodies. Apparently lack of local references, design expertise and experience in O&M can be attributed to hitherto low acceptance of these options.

However, a small beginning has been made during last 5 years under the Department for International Development, UK (DFID) supported project 'Andhra Pradesh Urban Services for the Poor' at Ramagundam (Census-2001 population 247,751) in Karimnagar district of Andhra Pradesh[2]. To start with, the municipality identified a resettlement colony of 300 lower-middle income families for a pilot project wherein each family agreed to construct an individual household latrine at its own cost and contribute towards 40% cost of sewer network. Each house connection includes a raised chamber at the front of a property. The sewers are of 150 mm diameter and are laid rather shallow, with invert between 150-200 mm below ground (Photographs 1&2). The combined sewage from 300 houses is discharged into a common large septic tank which subsequently overflows into a storm water drain. Although there are no individual interception tanks on any of the properties, the pipes are not laid perfectly and the treatment is not complete, the system can be characterized as 'shallow sewerage' or a variant of 'simplified' sewer system. It has resulted in significant behaviour change with preference towards fixed point defecation among the beneficiaries and improvement in environmental sanitation within the community. In 2003-04 the project cost was Rs. 0.75 million (~USD 15,790, @ Rs. 47.5/USD in 2003) wherein each family contributed Rs. 1000/- (~USD 21) towards community contribution and the balance was paid by the municipality. Drawing from this successful initiative, in subsequent years Ramagundam Municipality has by now provided total sanitation coverage in 13 middle and low income colonies benefiting around 6600 families with incrementally improved design and construction specifications and the average cost of construction is found to be Rs. 1100/- per person (~USD 23.2). This is found to be one third of the going estimate of Rs. 3000/- per person (~63.2 USD) for the conventional sewerage system. An interesting aspect under the whole programme has been provision of cement concrete pavements along with the simplified sewerage systems which together have led to significant improvement in the quality of life of the beneficiary communities.

These simplified sewerage networks are found to be working well and the community is satisfied with the level of service. The municipality is responsible for repairs and maintenance aspects while the community extends necessary support in terms of timely reporting of any blockages and sharing of minor costs. In due course the municipality plans to collect overflows from community septic tanks, which are currently discharged into open drains, and divert them to one of the two existing sewage treatment plants (which are based on waste stabilisation pond technology) which were constructed under a separate centrally sponsored programme. However it has yet to overcome several challenges, mainly resource constraints, before the overflows could be fully intercepted and the treatment plants could be commissioned satisfactorily.

Photograph 1. Simplified sewerage in a resettlement colony in Ramagundam

Photograph 2. A shallow chamber for house connection

Conclusion

Based on the experience from Brazil and several other Latin American countries, simplified sewerage has been recognised as an important, appropriate and affordable off-site sanitation technology option in peri-urban areas, high density slums, squatter settlements and comparatively larger rural areas of developing countries. It is recognised as the only technically feasible solution in areas characterised by high population density, small plots, relatively reasonable water supply levels, adverse groundwater and soil conditions, and has been successfully implemented even in affluent areas as well. However, this sanitation technology has not received due recognition and acceptance within Indian sanitary engineering community. Limited experience from Ramagundam in Andhra Pradesh shows that this is a feasible and acceptable solution in the Indian context as well which enables significant improvements in sanitation conditions with substantial reduction in costs and time of construction. The current impetus on urban infrastructure strengthening under the JNNURM and UIDSSMT programs of the Ministry of Urban Development and on sanitation in rural areas (with reference to villages with population > 5000) under the Total Sanitation Campaign of the Ministry of Rural Development offers an opportunity to adopt this technology for wider and rapid coverage of un-served and under-served population. There is a need to evolve appropriate policy and technical guidelines so that the sanitary engineering community, the consultant fraternity, the urban local bodies and the state public health engineering departments can develop confidence on this option and start offering as a 'standard solution' for not only low income areas but high income areas alike. A few more success stories within the country will lay the ground for its wide scale adoption and thereby bring the country closure to meeting the Millennium Development Goals and the global goal of full sanitation.

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End notes

[1] Exchange rates for various years have been taken from www.exchangerate.com.

[2] The author has been involved in preparation of strategic sanitation and solid waste management plans for Ramagundam and four other small municipalities in Andhra Pradesh and Maharashtra on behalf of the Water and Sanitation Program – South Asia of the World Bank during 2006-08. The information presented here is based on first hand data and personal visits to the sites.