POLICY PAPER ON

Septage Management in India

CENTRE FOR SCIENCE AND ENVIRONMENT
New Delhi

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Abbreviations

COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CSTF	Common Septage Treatment Facility
CW	Constructed Wetlands
DFID	Department for International Development
DPS	Duckweed Pond System
DWASA	Dhaka Water and Sewerage Authority
DWWTS	Decentralised Wastewater Treatment Systems
GDP	Gross Domestic Product
HCWL	Horizontal flow constructed wetland
IWK	Indah Water Konsortium
LGU	Local Government Units
MBR	Membrane Bio- Reactors
MDG	Millennium Development Goals
MLD	Million Litres per Day
MoEF	Ministry of Environment and Forests
MWCI	Manila Water Company, Inc.
NUSP	National Urban Sanitation Policy
O & M	Operation and Maintenance
OSS	On-site Sanitation Systems
PDU	Pilot cum Demonstration Unit
RZT	Root Zone Treatment Systems
SAF	Submerged Aeration Fixed Film
SBT	Soil Biotechnology
SCOPE	Society for Community Organisation and Peoples Education
STP	Sewage Treatment Plant
TKN	Total Kjeldahl Nitrogen
TS	Total Solids
UASB	Up flow Anaerobic Sludge Blanket
UIDSSMT	Urban Infrastructure Development Scheme for Small and Medium Towns
ULBs	Urban Local Bodies
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
UV	Ultra violet
WHO	World Health Organisation
WSP	Waste Stabilization Ponds
WWTP	Wastewater Treatment Plant

Executive Summary

This document from the Centre for Science and Environment (CSE) is to assist the Ministry of Urban Development, Govt of India in the preparation of policy guidelines for Septage Management. CSE has been recognised by the Ministry of Urban Development (MoUD) as a Centre of Excellence in the area of sustainable Water management. This document on septage management is draft providing the strategies and guidelines for the preparation of National level septage management policy paper. This paper is presented in five chapters

With fast growing economy and urban population, the waste generation is steeply increasing in India. Due to paucity of resources, the local bodies, which are responsible for management of wastes, are not able to provide this service effectively. According to Centre Pollution Control Board (CPCB) study, out of 38254 MLD of sewage generated in India, the treatment facilities are available for 30% (11787MLD). The indiscriminate disposal of domestic wastewater is the main reason for degradation of water quality in urban areas, with negative impacts on health, the economy, and the environment. Major part of urban India is yet to be connected to the municipal sewer system and the people are mainly dependent on the conventional individual septic tanks. It is estimated that about 29% of the India's population uses septic tanks (USAID ,2010).

Access to improved sanitation in urban India has risen but the management of onsite sanitation systems such as septic tanks remains a neglected component of urban sanitation and wastewater management. Septage, which is a fluid mixture of untreated and partially treated sewage solids, liquids and sludge of human or domestic origin, flows out of septic tanks and enters waterways or is generally disposed into nearest water body or low lying areas. This leads to serious health and environmental implications. This necessitates a well-defined regulation, guidelines, and management strategy for septage in the country. The septage management approach, discussed in this report, is an effort for assuring that septage is managed in a responsible, safe, and consistent manner across the states.

Chapter 2 of this document presents treatment and disposal options for septage. One has to select the suitable option based on the local conditions, expected septage production per day, and its characteristics. While selecting the technological options, suitable background study to be done to ensure effective operation and maintenance of the treatment system adopted. Measures should be put in place to maximise the resource recovery e.g. reuse of treated wastewater, manure used for biogas generation. The treated wastewater can be reused for irrigation or other non-potable use. The sludge can be used as a bio fertilizer.

Septage management is a new concept in India. This guidance note for preparation of policy document for septage management in India draws its strengths from the existing case studies and methods, which are practised in other parts of the world in order to tackle septage. Chapter 3 showcases these case studies. These endeavours throw light on the technical as well as on the policy or regulations that are being implemented and followed by the agencies. In addition, these practices showcase the role of public and private service providers for managing septage in the region or the country which will enable us to understand the vital positions and responsibilities of both the players.

In India, there is no separate policy or regulation for septage management. However, there are several environmental laws, which prohibit discharge of sewage into a water body or on land without proper treatment beyond the prescribed standards. Consent is required for disposal of sewage or septage from State Pollution Control Boards under the law. There are penal provisions for violation of the law. The above environmental laws enforcement framework for industrial pollution control resulted in large change in the behaviour of the industries and was successful in reducing industrial pollution in the country.

However, similar success was not evident in case of domestic wastewater including septage. This can be attributed to inadequate technical ,managerial and financial capacities for management of domestic wastewater and septage within the concerned agencies such as PHEDs and ULBs. Thus, it is very important that these agencies are strengthened to manage the wastewater/septage in effective manner. A policy proposal including strengthening of these local bodies and involvement of private service providers, a system of revenue generation and effective collection, transport, treatment and disposal of wastewater, septage is included in chapter 4.

Finally several options for reuse of wastewater after proper treatment are proposed in chapter 5. A detailed review of the WHO guidelines for wastewater reuse is discussed and a comparison is made on standards from different countries to help the decision makers for adoption of appropriate standards for India. The major problem in wastewater reuse is related to health as the septage contains human pathogens. It is very important that the sewage is properly treated before reuse. The treatment options depend on the qualities required in the treated wastewater, which in turn depends on the type of reuse. Various treatment options and their efficiencies are presented which can help adopting a particular option for treatment depending on reuse.

1. Introduction

1.1 NEED FOR SEPTAGE MANAGEMENT

Providing environmentally safe sanitation to the people of world's second most populous nation is a challenging task. This task becomes more intricate in context to the country like India where introduction of new paradigms of plans, policies or projects can challenge people's tradition and belief. Around 600 million people i.e., 55% of country's population do not have access to safe sanitation or any kind of toilet/latrine (ADB, 2009). With around 102 million septic tanks and 60 million latrines (World Bank, 2006) and the projected improvement level to be achieved in sanitation sector of the country, it is intriguing to observe that India lacks national septage management guidelines/policies.

Inadequate sanitation has a great environmental economic and health impacts in India. In order to minimize these impacts, Government of India has under taken several measures including increased investment in sanitation, policy initiatives, regulations, and public campaigns to improve sanitary conditions in the country. This has resulted in raising the sanitation status during the last two decades but a marked improvement is yet to be achieved.

The report "Asia Water Watch 2015" projected that India will likely to achieve its Millennium Development Goals[1] (MDGs) sanitation target in both urban and rural areas if it continues to expand sanitation access at its 1990–2002 rates (ADB, 2006). It is expected that by 2015, the percentage of people in urban areas served by improved sanitation will reach 80% (up from 43% in 1990) and in rural areas, the projection is 48%, an incredible improvement over the coverage rate of just 1% in 1990 (ADB, 2006). In real numbers, that means more Indians will have improved sanitation. Despite the recent progress, access to improved sanitation remains far lower in India compared to many other countries with similar, or even lower, per capita gross domestic product.

In the absence of any consolidated septage management practices, all these improved sanitation facilities will continue to degrade surface water bodies and groundwater resources. Therefore, there is a need to invest in septage management as a complement to sewerage development.

This document is an attempt in this direction. It provides some significant policy guidelines and legal framework including technical options for septage handling, transport, treatment and disposal.

1.2 UNDERSTANDING SEPTAGE

"Septage[2]" is septic tank sludge that is a combination of raw primary sludge and anearobically produced raw sludge. It has an offensive odour, appearance and contains significant levels of grease, grit, hair, debris and pathogenic micro organisms (Solomon et al, 1998). There are broadly three categories of septage namely:

1. The Millennium Development Goals enjoin upon the signatory nations to extend access to improved sanitation to at least half the urban population by 2015, and 100% access by 2025.
2. Ecology dictionary

domestic septage, industrial septage and grease septage. This document focuses on management of domestic septage (household, non-commercial and non industrial sewage) in a responsible, safe and consistent manner.

Generally septage has three main components as follows:
Scum - floats on the top and is generally where the bacteria live that treat the waste
Effluent - the semi-treated liquid that comprises the majority of the material in the septic tank
Sludge- solids which collect at the bottom of the tank

The physical and chemical characteristics of these components and the whole septage can vary depending on the septage characters (like size, design, pumping frequency and climatic conditions of the place where it is located), the quality of water supplied and type of the waste from the household which is user specific (WEF, 1997).

Source of Septage

Septic tanks are the primary source of septage generation. A septic tank is a horizontal continuous flow type of a sedimentation tank (with a detention period of 12-36 hours), directly admitting raw sewage, and removing about 60-70% of the dissolved matter from it (Garg, 2001). Septic tanks receive black and/or grey water and separate the liquid from the solid components. A septic tank is generally followed by a soak-pit to dispose off the effluent into the ground. The sludge settled at the bottom and the scum at the top surface of the sewage is allowed to remain in the tank for several months during which they are decomposed by bacteria through anaerobic digestion. Septic tanks are generally provided in areas where sewerage system is not present and for catering to the sanitary disposal of sewage produced from isolated communities, schools, hospitals and other public institutions.

Why is septage a problem?

The indiscriminate disposal of domestic wastewater is the main reason for degradation of water quality in urban areas, with negative impacts on health, the economy and the environment. Discharging wastewater to the land or to surface waters is a menace to public health and is a violation of the fundamental right guaranteed by The Constitution of India (Right to Clean Environment). The unmanaged septage can pose direct and indirect socio economic impacts. According to the report prepared by ECO-Asia in collaboration with Department of Waste and Sanitation in Developing Countries, most countries neglect septage management, which results in significant damage of environmental, and public health. This finding is further supported by World Bank study which appraises that inadequate sanitation costs Rs 2.44 trillion (US $53.8 billion) per year to India (USAID, 2010).

Septic tanks require de-sludging at regular intervals in accordance with its design and capacity. Often only when a tank gets clogged and filled beyond its holding capacity that de-sludging is done. The overflow from the tank finds it way into any nearest waterways or land surface and pollutes it. The effluent and sludge from septic tanks are often rich in phosphates and nitrates. The effluents lead to saturation of surface soil and water bodies with nutrients posing a threat of eutrophication to the surface waters. People and animals in contact with these contaminated areas are susceptible to infections. It also pollutes the groundwater, when the sludge percolates. The leachate from the unmanaged septage virtually disposed on the subsurface can pollute the ground water. Communities coming in contact with these contaminated soil or water become susceptible to infections and water borne diseases.

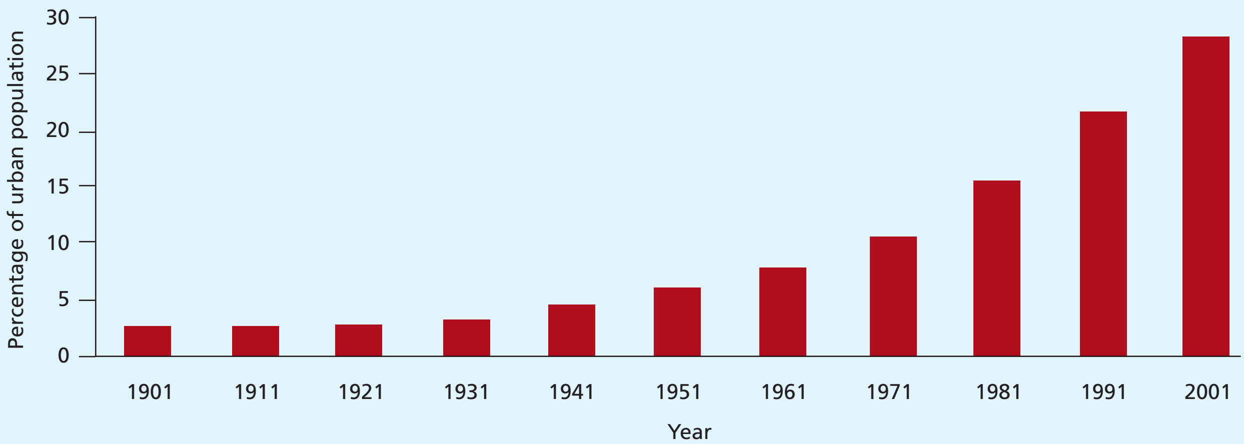
Is septage only a menace or can be a resource ?

Though septage is problem it can be harnessed into a useful resource. USEPA (1984) indicates 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 micro nutrients such as boron, copper, iron, manganese, molybdenum, and zinc (EPA, 2011). Septage can reduce reliance on chemical fertilizers and when combined with fertilizers can provide the required nutrients for crop production.

1.3 STATUS OF WATER SUPPLY, WASTEWATER GENERATION AND TREATMENT

As per 2001 census, India's population was 1027 million, out of which urban population was about 27.8% presented in Figure 1.1. It is observed that from a modest base of 25.8 million urban populations in 1901, the number of urban dwellers has raised to 285 million, signalling a phenomenal eleven fold increase in urban population over the period hundred years (Government of India Census (1901, 1911, 1921, 1931, 1941, 1951, 1961, 1971, 1981, and 2001). Rapid urbanization followed by increasing prosperity has led to steep increase in waste generation (both liquid and solid waste) in urban India. The uncontrolled growth in urban areas has made planning and expansion of water and sewage systems very difficult and expensive to carry out. As per estimates of UIDSSMT[3], about 46% of households have water borne toilets while only 36% are connected with public sewerage system. The local bodies, which are responsible for management of wastes, are not able to manage it.

FIGURE 1.1: **Urban population growth trends**



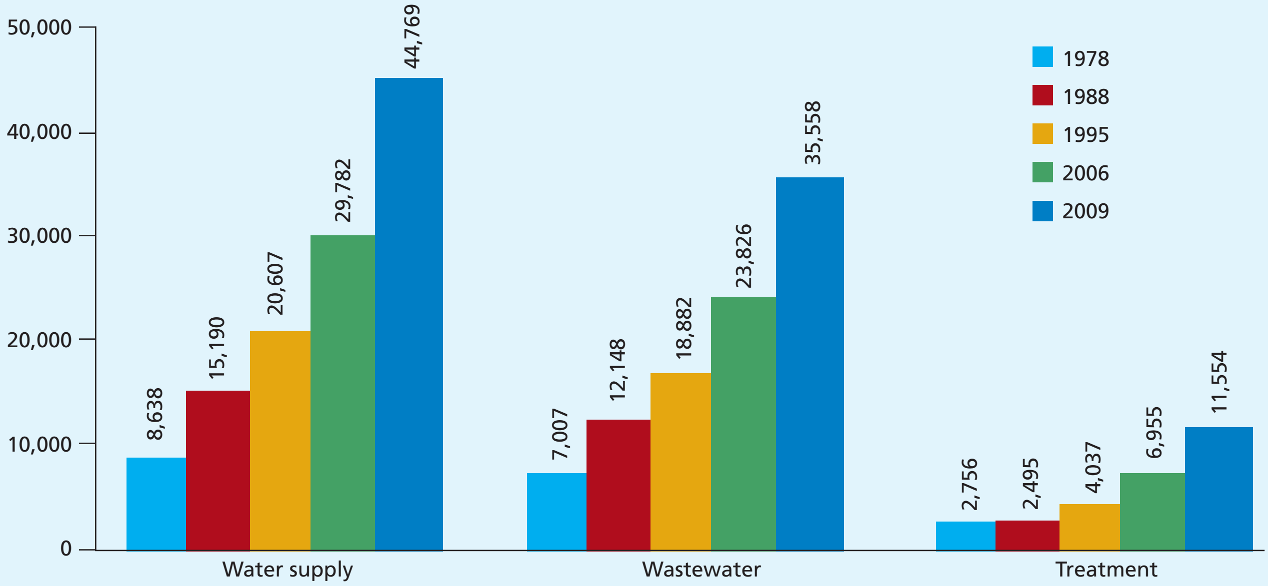
Source: Government of India Census (1901, 1911, 1921, 1931, 1941, 1951, 1961, 1971, 1981, 2001)

Central Pollution Control Board (CPCB) has been carrying out inventory of water supply, wastewater generation, its treatment and disposal in class-I cities and class-II towns in the country since 1977-78. It is observed that the sewage generation in class II cities is just 10 % of that of class I cities, the share of total sewage generated in smaller towns is considerably low. This can be attributed to low per capita water supply and their widespread dependence on septic tanks in the smaller towns. The water supply, waste water generation and treatment status for class I and class II cities over the last four decades is presented in Figure 1.2 and 1.3 respectively.

From these figures it is evident that there is a phenomenal growth in urban population, water supply and wastewater generation across the country. However the wastewater collection and treatment are lagging far

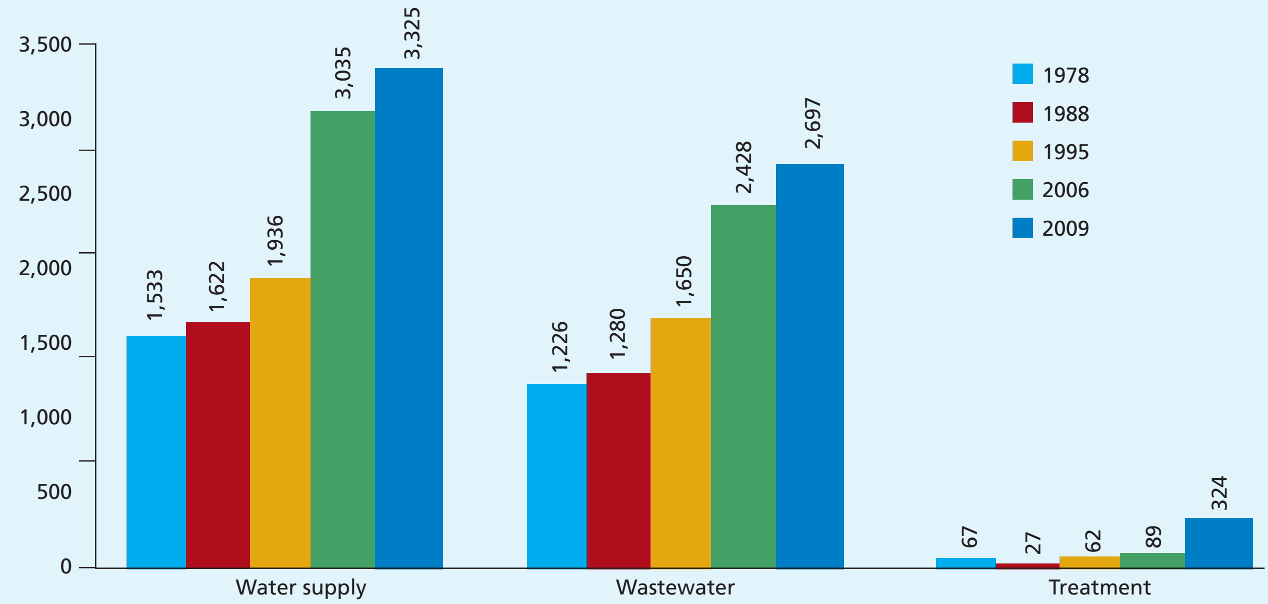
3. Urban Infrastructure Development Scheme for Small and Medium Towns

FIGURE 1.2: Water supply, wastewater generation, treatment in class I cities (MLD)



Source: CPCB reports (1978, 1988, 1995, 2006, and 2009)

FIGURE 1.3: Water supply, wastewater generation and treatment in Class II cities (MLD)

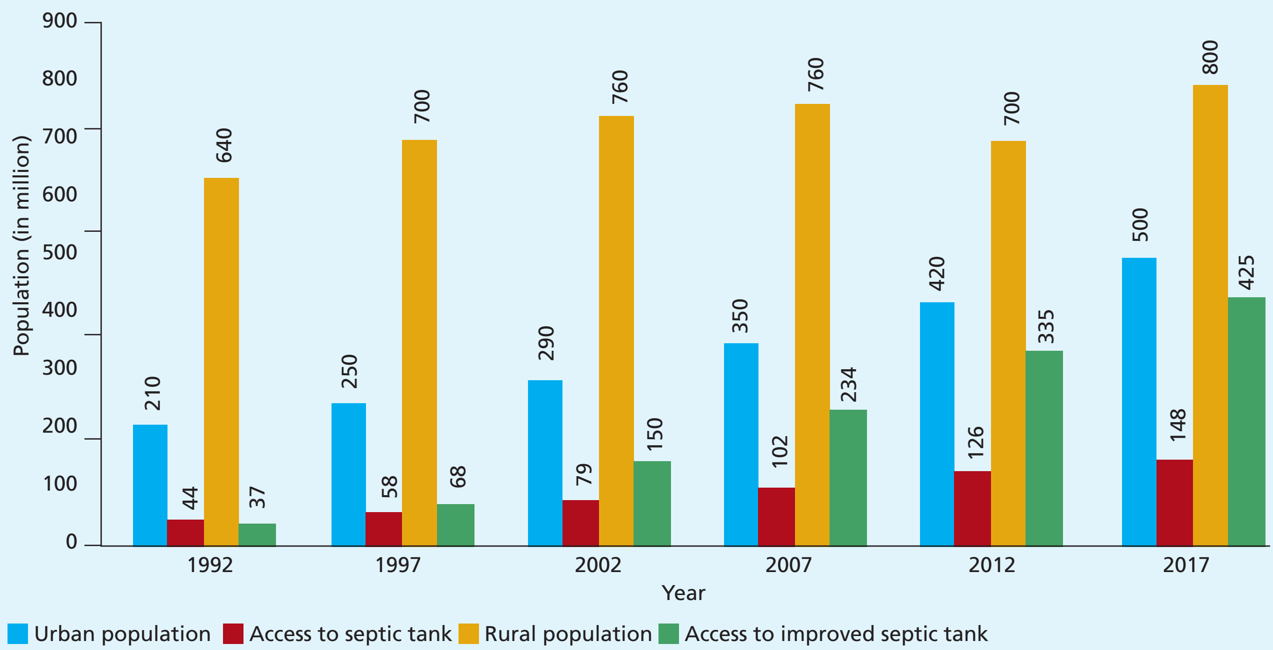


Source: CPCB reports (1978, 1988, 1995, 2006, and 2009) behind. CPCB (2009) indicated that about 38,254 MLD of sewerage generated from class I cities and class II cities out of which the treatment facility exists only about 11,787 MLD. This dismal position of sewage treatment is the main cause of pollution of rivers and lakes.

1.4 SEPTIC TANK DEPENDENCE IN INDIA

Septic tanks are one of the most common forms of urban sanitation facilities in India. Major part of urban India has not been connected to municipal sewer system which makes people dependent on the conventional individual septic tanks. Access to improved sanitation in urban India has risen but the management of on-site sanitation systems such as septic tanks remains a neglected component of urban sanitation and wastewater management. As per USAID(2010) projections, by 2017 about 148 million urban people would have septic tanks and about 425 million rural people would have access to improved sanitation (USAID, 2010) shown in Figure 1.4. Thus the number of septic tanks will grow steeply in the next few years.

FIGURE 1.4: **Growth in population and access to sanitation in India**



Source: USAID India, 2010

1.5 PRESENT STATUS OF SEPTAGE MANAGEMENT

According to World Bank (2006), approximately 50% of population in India lives in unhygienic situations. Among the 350 million urban residents in India, 206 million (58.8 %) urban households do not have access to a drainage network, only 102 million (29 % of the urban population) are connected to septic tanks, and 60 million (17%) use pit or vault latrines[4]. Even though there are over 160 million OSS in Indian cities, there are no septage management programs or treatment facilities in the country (NUSP, 2008).

4. *National Institute of Urban Affairs, estimated in 2005 that 26% of all urban households have a septic tank*

The adequate facilities and services for collection, transportation, treatment and disposal of urban domestic septage do not exist in Indian cities. Most on-site sanitation systems (OSS) are emptied manually in absence of suitable facilities. Ideally a septic tank system should be desludged every 2-5 years. But ignorance towards maintenance and operational conditions often results in accumulation of organic sludge, reduction in effective volume and hydraulic overloading which ultimately causes the system failure and release of partially treated or untreated septage from the septic tank. Private operators often do not transport and dispose of septage several kilometres away from human settlements and instead dump it in drains, waterways, open land, and agricultural fields.

Manual de-sludgers working in inaccessible low-income areas and squatter settlements, usually deposit the septage within the family's compound, nearby lanes, drains, open land or waterways without permits or any safety regulations. Indiscriminate discharge of untreated domestic/municipal wastewater has resulted in contamination of 75% of all surface water across India (NUSP, 2008). This has imposed significant public health and environmental costs to urban areas. According to a study by World Bank, the total economic impacts of inadequate sanitation in India is estimated to be Rs 2.44 trillion (US $53.8 billion) a year which is equivalent to 6.4 per cent of India's GDP in 2006 (USAID, 2010).

In India, septage management has not gathered much required attention, hence there is a strong need to invest in septage management to develop well defined guidelines, policy and regulation.

The next chapter elaborates the technological options for collection, handling, transport, treatment and disposal of septage.

2. Technological Options for Septage Management

2.1 BACKGROUND

The septage treatment required depends on the types and sources of domestic wastewater and faecal sludge (see Table 2.1).

The domestic wastewater and faecal sludge often contains high concentration of organic matter and pathogens. Hence it is important to provide environmentally suitable technological options for collection, transport, treatment and disposal/reuse of faecal sludge/ septage.

2.2 CURRENT PRACTICES

In Indian towns/cities, municipalities/local government bodies are mainly responsible for ensuring the safe handling and disposal of septage generated within its boundaries. They also establish local ordinances or regulations to govern septage handling and to meet all requirements and standards for state permits. In most of the cities, only crude and unhygienic septage handling practices exist and there is no proper municipality infrastructure that performs the task of septage management. Most of the septic systems are not well maintained in the country and if they are maintained by individual home owners, many of them do not have the technical know-how for its operation and maintenance. For example, the household garbage disposals and pouring of grease into domestic drains can reduce the effectiveness of the septic tank in the long run. In terms of system operation, as many as 75 percent of all system failures have been attributed to hydraulic overloading. National Building Code of India (2005) have published guidelines for septic tank design, construction, installation, O&M but in practice the central, state and local governments fails to enforce these guidelines and requirements. In reality, the sizes and designs of septic tank vary from one place to another and are influenced largely by the local construction standards or the skill of masons.

TABLE 2.1: Types and sources of domestic wastewater and faecal sludge

Type	**Source**	
Faecal sludge	Pit latrines and leach pits	Decreasing concentration of pollutants and pathogens (top to bottom)
Septage	Septic tanks	
Blackwater	Water closets	
Domestic sewage	Sullage and black water mixed together	
Sullage (grey water)	Personal washing, laundary cooking and cleaning	

Source: WSP, 2008

Desludging of septic tanks is an over burden for many home owners that they postpone until the tanks have reached its capacity and they start overflowing. Untreated septage is often disposed in low lying areas or agriculture farms or even in a water body, which poses serious health and environmental problems.

2.3 STAGES OF SEPTAGE MANAGEMENT

The septage management basically consist of collection, treatment and proper disposal of septage. The basic stages of the septage management are represented in the Figure 2.1.

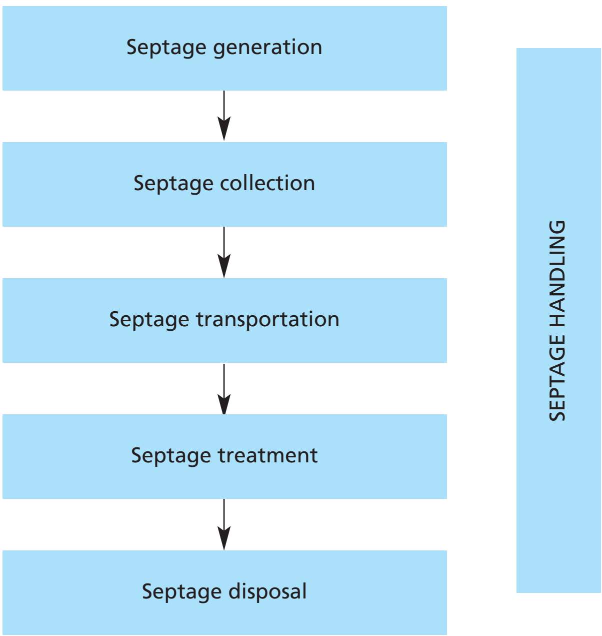
2.3.1 Septage Collection

An important feature of septage which has to be considered for septage collection is the septage generation rate and sludge withdrawal.

Septage generation rate

Septage generation rates vary widely from place to place depending on practices of septic tank use, number of users, water used for flushing, efficient functioning of the tank and level of contamination control. It can be considered that the volume of sludge evacuated from a septic tank corresponds more or less to the volume of the septic tank, plus some cleansing and rinsing water. The size of a septic tank in individual houses in India ranges from 1 to 4 m^3, the size of a septic tank in office or apartment buildings from 10 to 100 m^3.

FIGURE 2.1: Basic stages of the Septage management



The following estimations and assumptions can be used for the purpose of this guideline, which can be adjusted to the local requirements:

- One septic tank per 4 inhabitants
- Average volume of septage produced through emptying of a septic tank by vacuum tanker: 2.5 m^3.
- Emptying frequencies, which are in accordance with septic tank design (5-10 years intervals), will be observed
- Assuming there are 2500 houses in a town having individual septic tank.
- Number of houses served each year = 2500/5= 500
- Assuming septic tanks are emptied during 250 days (working days)/year or 500/250 = 2 tanks/d
- Total volume of septage in a day would be 2.5*2 = 5 m^3
- Biological Oxygen Demand (BOD) loading would be 2,800*5 = 14 kg/d
- Suspended Solids (SS) loading would be 15,000*5 = 75 kg/d

(*) stands for multiply

Desludging of Septic Tanks

In most of the cases the septic tanks are desludged manually. This is considered as unpleasant and repulsive job since the sludge (including fresh excreta) generally gets spilled around the tank during emptying, and poses a risk of transmission of diseases of faecal origin. Given the safety and health risks of manual desludging, it is critical for cities to take measures to stop this common practice. The most satisfactory method of sludge removal is by vacuum tankers (Tilley et al. 2008). The faecal sludge needs to be correctly disposed and further treated. For this, the faecal sludge should be separated from the liquid in drying beds or by settling. The separated effluents from these systems should be treated in Waste Stabilization Ponds (WSP) or constructed wetlands as described in next sections. Though desludging frequencies vary, it is generally recommended to desludge tanks once every three to five years, or when the tank becomes one third full (Boesch et al. 1985). Frequent desludging also helps reduce the pollution levels in the liquid effluent, which normally enters waterways untreated. However, small amount of sludge should be left in the tank to ensure that the necessary microorganisms responsible for anaerobic digestion remain in the system. Gas produced due to anearobic digestion might escape when tank is open for desludging. Hence it is highly advisable to avoid open fires in these cases. Regular desludging activities require well-organized community and public/private service providers. Because of the delicate nature of septic systems, care should also be taken not to discharge harsh chemicals such as soap; detergents etc into the septic tank (Tilley et al. 2008).

2.3.2 Septage Transportation

The septage transportation is one of the most important components of septage management. Recognizing a standard method of collection, handling and transportation of septage is an important requirement. Desludging trucks act as a “mobile sewer network” for onsite sanitation systems. They collect the septage at the building level and transport it to treatment or disposal sites, thereby complimenting the underground sewer network. These systems range in size and design, such as the small scale Vacutug (see Section 5.3), which can reach to areas inaccessible to large desludging vehicles.

2.3.3 Septage Treatment and Disposal

Septage can be treated in a variety of ways, and there is no single best option considering the widely varying conditions of urban areas in India. The selection of treatment depends upon characteristics of septage to be handled.

Septage characteristics

The quality and quantity of septage coming out of the tank depends largely on the type of treatment adopted, the frequency of desludging, climate, soil conditions, water usage and household chemicals going in the septic tank. The physical and biological characteristics of septage are highly variable. The anaerobic nature of septage results in the presence of odorous compounds such as hydrogen sulfide, mercaptans, and other organic sulfur compounds (USEPA, 1994). Septage contains constituents that may result in unpleasant odours, risk to public health and serious environmental hazards. Since septage is highly concentrated, if it is discharged into a water body it may cause immediate depletion of oxygen, increased nutrients leading to eutrophication and increased pathogens leading to a risk of health hazards. Knowledge of septage characteristics and variability is important in determining acceptable disposal methods. In the absence of adequate information on septage characteristics in India, typical characteristics of the septage in tropical countries are discussed in Table 2.2 based on the results of Faecal Sludge studies in Argentina, Accra/Ghana, Manila/Philippines and Bangkok/Thailand.

TABLE 2.2: Characteristics of Septage in tropical countries

Parameter	Type "A" high strength	Type "B" low strength
Example	Public toilet or bucket latrine sludge	Septage
Characterisation	Highly concentrated, mostly fresh FS; stored for days or weeks only	FS of low concentration; usually stored for several years; more stabilised than Type "A"
COD mg/l	20 - 50,000	< 15,000
COD/BOD	5: 1 to 10 : 1	5: 1 to 10 : 1
NH4-N mg/l	2 - 5,000	<1,000
TS mg/l	≥ 3.5 %	< 3 %
SS mg/l	≥ 30,000	7,000 (approx.)
Helm. eggs no./l	20 - 60,000	4,000 (approx.)

Source: Strauss ,1996

The management strategies for septage differ based on the differences in the chemical and physical characteristics of septage. The different septage treatment and disposal options are described in detail in the following section.

2.4 SEPTAGE TREATMENT OPTIONS

The treatment and disposal methods of septage can be conventional or non conventional. The conventional methods are the most widely used and they serve the purpose of treatment of sludge and effluent.

The non conventional methods are more improved and the methods are recommended for countries where septage management does not exist. This is because these methods help the septage management sector to leapfrog to improvement. The different methods of treatment of septage are summarized in Figure 2.2.

2.4.1 Pretreatment of septage

Pretreatment/stabilization includes physical, chemical, or biological processes. Stabilization is a pretreatment method that decreases odours, the levels of pathogens and further decay of septage. Stabilization options include lime stabilization, aerobic digestion, anaerobic digestion, and composting .

Alkali (Lime) Stabilization

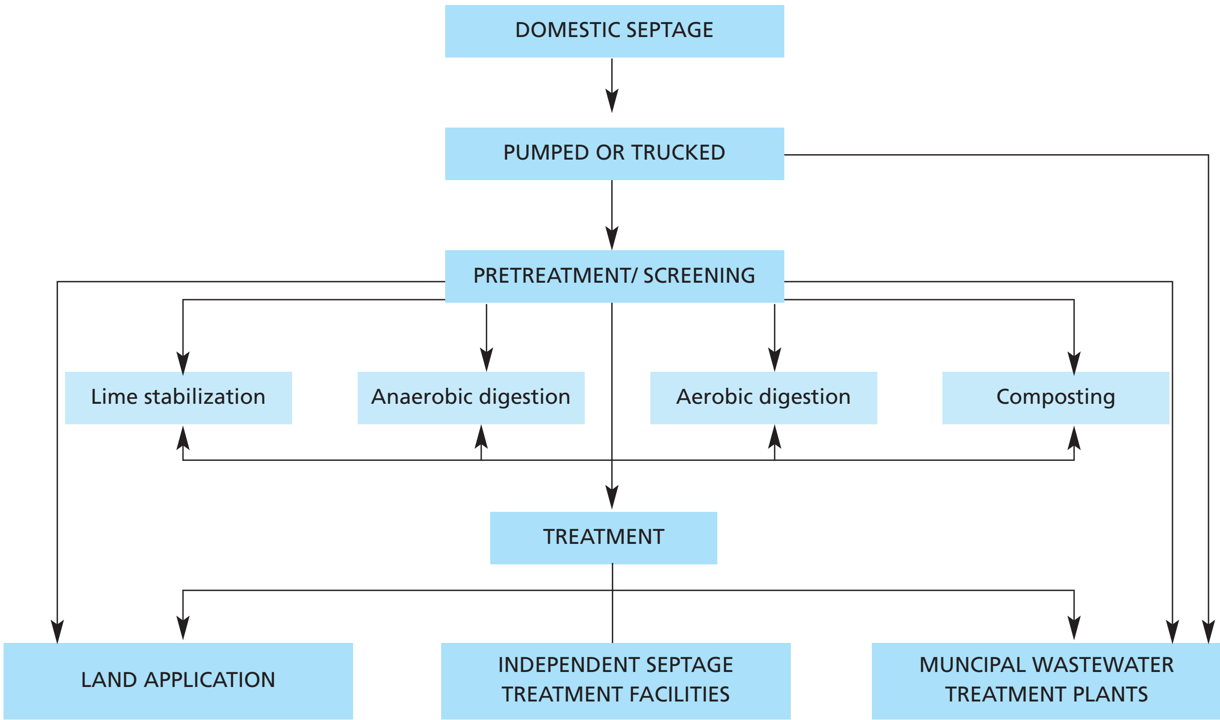
Lime or other alkaline material is added to liquid septage to raise the pH to 12.0 for a minimum of 30 minutes. Although there is a lot of variation in septage characteristics and lime requirements, mixing is not very difficult, and approximately 20 to 25 pounds of lime is used for every 1,000 gallons of septage. Lime addition could be done at any of these three points:

i) To the hauler truck before the septage is pumped,

ii) To the hauler truck while the septage is being pumped, or

iii) To a septage storage tank where septage is discharged from a pumper truck.

FIGURE 2.2 **Methods of Septage Treatment and Disposal**



Aerobic Digestion

In this method, septage is aerated for 15 to 20 days in an open tank to achieve biological reduction in organic solids and odour potential. The time requirements increase with lower temperatures. Normally, this is not a cost-effective option.

Anaerobic Digestion

Septage is retained for 15 to 30 days in an enclosed vessel under anaerobic conditions to achieve biological reduction of organic solids. Anaerobic digestion is generally not suggested except for co-treatment with sludge. However, one advantage is that anaerobic digestion produces methane gas, which can be used as fuel.

Composting

Liquid septage or septage solids are mixed with a bulking agent (e.g., wood chips, sawdust) and aerated mechanically or by turning. Biological activity generates temperatures that are high enough to destroy pathogens. The composting process converts septage into a stable, humus material that can be used as a soil amendment. However, there is a possibility of odours. After the septage is stabilized, it can then be sent for further treatment or disposal.

2.4.2 Land Application

Land application is the most commonly used method to manage the septage after stabilization. There are various application methods to dispose off septage on the land viz. Surface application, sub-surface application and burial (USEPA, 1984).

a. Surface application

It is relatively simple and cost effective, uses low energy, and recycles organic material and nutrients to the land. However, it has high odour potential during application and possibility of pathogen dispersal if not lime stabilized. Surface application includes spreading septage from septage hauler trucks, specially designed land application vehicles, or tank wagons onto sites, or using spray irrigation, ridge and furrow irrigation, and overland flow (USEPA 1984). Septage can also be applied to the land as a fertilizer and soil conditioner. Application rates depend on the slope, soil type, depth of application, drainage class and hydraulic loading. Septage must not be applied before or during rainfall or in the areas where water table is shallow. Thus, an interim storage facility is needed. The various surface application methods are as follows:

- *Spray irrigation*- Pre-treated septage is pumped at 80 to 100 psi through nozzles and sprayed directly onto the land. Spray irrigation can be used on steep or rough land and minimizes disturbances to the soil by trucks.
- *Ridge and furrow irrigation*- In this disposal method, pretreated septage is applied directly to furrows or to row crops that will not be directly consumed by humans. This is used for relatively level land, usually for slopes in the range of 0.5 to 1.5%.
- *Hauler truck spreading*- Septage is applied to the soil directly from a hauler truck that uses a splash plate to improve distribution. The same truck that pumps out the septic tank can be used for transporting and disposing the septage.
- *Farm tractor and wagon spreading* -Liquid septage or septage solids are transferred to farm equipment for spreading. This allows for application of liquid or solid septage. The septage must be incorporated into the soil within 6 hours, if lime stabilisation has not been done.

b. Subsurface incorporation

In this method, untreated septage is placed just below the soil surface, reducing odour and health risks while fertilizing and conditioning the soil. Subsurface incorporation allows better odor control than surface spreading and reduce the risk of pathogen dispersal. Septage can only be applied to slopes less than 8%, and the soil depth to seasonal high water table must be at least 20 inches (or as mandated by local regulations). A holding facility is required during periods of rainfall or wet ground. To prevent soil compaction and allow sufficient infiltration, equipment must not be driven over the site until 1 to 2 weeks after application. There are two ways for subsurface application:

- *Plough and Furrow Cover*— Liquid septage is discharged from a tank into a narrow furrow about 15 to 20 cm deep and is then covered by a second plough.
- *Subsurface Injection*— Liquid septage is injected in a narrow cavity created by a tillage tool with an opening of about 10 to 15 cm below the surface.

c. Burial

Major form of septage burial includes disposal in holding lagoons, trenches, and sanitary landfills. High odour potential during septage application is inherent until a final cover is placed on the top. Appropriate site selection is important not only to control odour, but also to minimize potential groundwater pollution.

- *Holding lagoons*- These lagoons are a maximum of 6 feet deep and do not allow any soil infiltration. The septage is placed in small incremental lifts of 15 to 30 cm and with multiple lagoons loaded in sequential order for optimum drying. To decrease odours, the lagoon inlet pipe can be placed below liquid level.
- *Trenches*- Septage is filled sequentially in multiple chambers in small lifts of 15 to 20 cm for optimum drying. Each trench is then covered with soil (2 feet) as a final covering and new trenches are opened. An alternate

option is to leave a filled trench uncovered to permit maximum solids to settle and liquids to evaporate and leach out. The solids, as well as some bottom and side wall material, are then removed and the trench can be reused.

- *Sanitary landfills-* Production of leachate, treatment, and odour are the primary problems to be considered when septage is added to sanitary landfills. As such, septage must not be added in landfills in areas that have over 90 cm of rainfall, landfills that do not have leachate prevention and control facilities, or those not having isolated underlying rock. A 15 cm of soil cover needs to be applied each day in the landfills where septage is added and 2 feet of final cover within 1 week after the placement of the final lift. In general, sanitary landfills are not cost-effective disposal options for septage.

2.4.3 Treatment at sewage treatment plants

Co-treatment of septage along with domestic sewage at a sewage treatment plant (STP) is a feasible and acceptable alternative for septage treatment. Though septage is much concentrated in its strength than the domestic sewage, its constituents are similar to municipal wastewater. Sewage treatment plant should have an adequate capacity in order to accept the septage without hampering the normal functioning of other processes. Septage has the potential to cause negative impact on the performance of plant, if the facilities are not planned and designed to deal the septage. It may be necessary to increase treatment plant aeration capacity as a result of direct septage discharge. Therefore, additional organic loads due to inclusion of septage could lead to the requirement of facility expansion or up gradation of the plant to cater to the excess waste. The main approaches to treating septage at a sewage treatment plant are:

- *Septage addition to nearest sewer manhole-* Septage could be added to a sewer upstream of the sewage treatment plant, and substantial dilution of septage occurs prior to it reaching the sewage treatment plant, depending on the volume of sewage flowing in the sewer.
- *Septage addition to STP-* Septage could be added to sewage immediately upstream of the screening and grit removal processes. It is economical because of the very simple receiving station design and also allows the wastewater treatment plant staff to have control of the septage discharge
- *Septage addition to sludge digesters/sludge drying beds-* Septage could be processed with the sludge processing units of STP.

2.4.4 Treatment at independent septage treatment facilities

When the distance or the capacity of the plant becomes a limiting factor, it is not a feasible option to transport and treat the septage to the wastewater treatment facilities. In this case treatment plants specially meant for septage treatment becomes an attractive option. Independent septage treatment plants are designed specifically for septage treatment and usually have separate unit processes to handle both the liquid and solid portions of septage. These facilities range from stabilization lagoons to septage treatment plants such as constructed wetlands (see Section 2.4.5). The benefit of using these treatment plants is that they provide a regional solution to septage management.

Independent septage treatment facilities use processes like stabilization lagoons, chlorine oxidation, and aerobic and anaerobic digestion, biological and chemical treatment. Many septage treatment plants use lime to provide both conditioning and stabilization before the septage is de-watered. Solid residual can be sent to a landfill, composted, applied to the land, or incinerated. The remaining effluent can be released to another treatment works where it can undergo further treatment and then finally can be discharged.

Another feasible option is composting where bulking agents are easily available. The humus is produced after composting which can be used as a soil conditioner. It is advised to de-water septage before composting but since septage is resistant to de-watering, role of conditioning chemicals comes into play and usage varies according to different loads. Septage treatment plants also use other processes to de-water conditioned septage such as screw presses, plate and frame presses, belt presses, rotary vacuum filters, gravity and vacuum-assisted drying beds, and sand drying beds.

Choosing an appropriate septage management method relies not only on technical aspect but also on regulatory requirements. The management option selected should be in conformity with local, state, and central regulations. Some of the factors that determine the process of selection include: land availability and site conditions, buffer zone requirements, hauling distance, fuel costs, labour costs, costs of disposal and other legal and regulatory requirements. Brief guidelines for selecting the technological options are presented in table 2.3 below.

TABLE 2.3: Guidelines for selecting treatment and disposal options and financing norms for septage

Town category	Conditions	Recommended technologies	Capital Cost	O&M cost	Facility ownership	Financing norms
Unsewered Class-III, IV and V towns and rural communities	Remote land are avoidable with suitable site and soil condition	Land application of septage	Low	Low	Municipality or private	Fees to users
	Land available but close to neighbour	Land application a fter stabilization	Low to medium	Low to medium	Municipality or private	Fees to users
	Inadequate land area available with suitable site and soil condition, WWTP available within 30 km with adequate capacity	Disposal at WWTP	Low to medium	Low to medium	Municipality	Fees to users
Partially sewered Medium size (class-II towns)	Land area available with suitable site and soil condition but close to settlements	Land application after stabilization	Low to medium	Low to medium	Municipality or private	Fees to users
	Inadequate land area, but available WWTP capacity	Disposal ot WWTP	Medium	Medium	Municipality or private	Fees to users
	Inadequate land area; no available WWTP capacity	Disposal at independent treatment facility or CSTF*	High	High	Municipality or private	Fees to users
Class-I and Metro-cities	Available WWTP capacity	Disposal	Medium	Medium	Municipality or private	Fees to users
	No available WWTP capacity	Independent septage treatment facility or CSTF	High	High	Municipality or private	Fees to users

*Common septage treatment facility

Source: Complied by Centre for Science and Enviornmnent

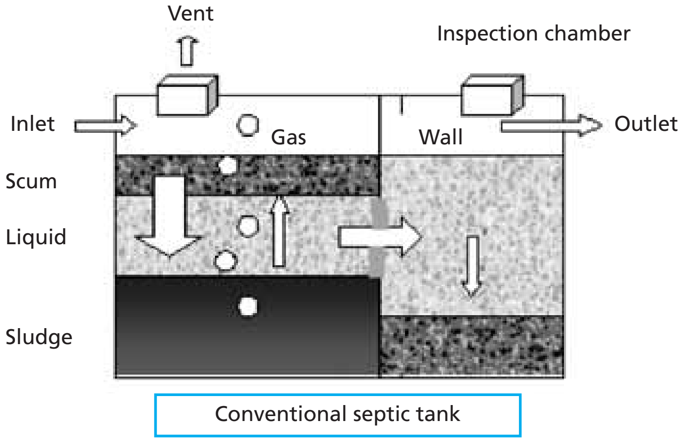
2.4.5 Non- conventional Management of septage

The conventional methods of septage management can be improved further for better management of septage. The improvement of septic tanks can help in improving the septage management by reducing the septage generation rate, while constructed wetlands as a method of septage management makes it more sustainable.

a. Improved septic tank/Anaerobic baffled reactor

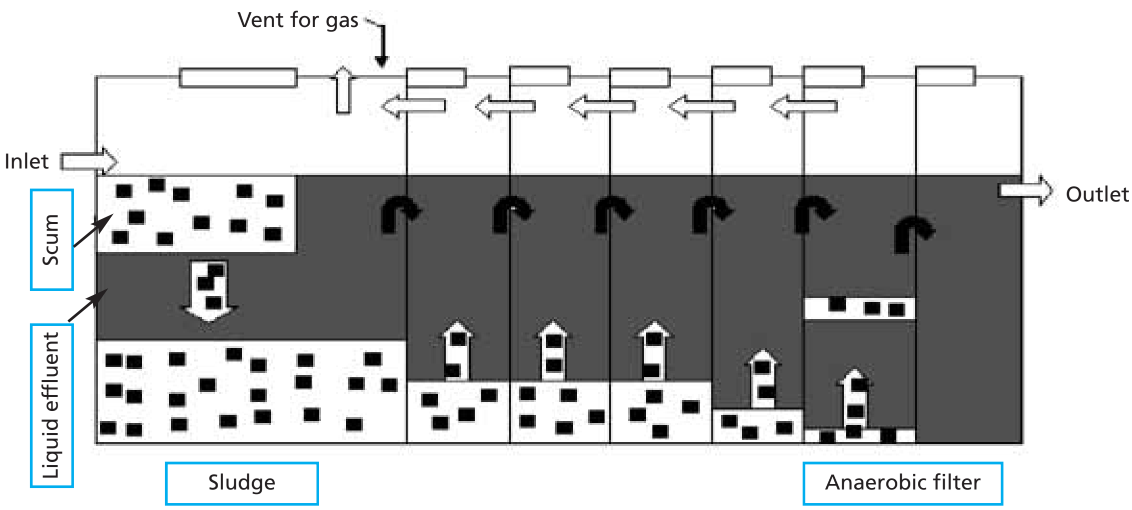
In conventional septic tank, most of the solids entering the septic tank settles down and form sludge layer at the bottom of the tank. Oils, greases and other light materials float to the surface and form a scum layer (Figure 2.3). The accumulation of the sludge at the bottom and scum at the top of the septic tank over the period reduces the wastewater volume storage and treatment capacity of the septic tank. This leads to reduced settling of solids and gradually causes clogging and premature system failure.

FIGURE 2.3: Conventional septic tank



To overcome the operational problems and to improve the performance of the conventional septic tank, baffle walls are introduced to have a multi chambered baffled septic tank. The incoming raw sewage settles in the first chamber and the overflow moves to the next chamber through pipes provided at the top of each chamber. This movement of wastewater inside the tank helps in creating the turbulent flow which causes enhanced mixing of the raw sewage with already existing activated sludge and accelerates the decomposition of the solids because of intensive contact between the activated sludge and fresh influent (Figure 2.4). This biological activity can be further enhanced by providing an up-flow filter. Anaerobic filters are provided in the penultimate chamber of the improved septic tank and provide an ideal breeding ground for the microbes and results in effective treatment of incoming wastewater. Hence by increasing the retention time of the incoming sewage, sludge accumulation problem can be significantly reduced and overall efficiency of septic tank can be greatly improved (Sasse, 1998).

FIGURE 2.4: Improved septic tank



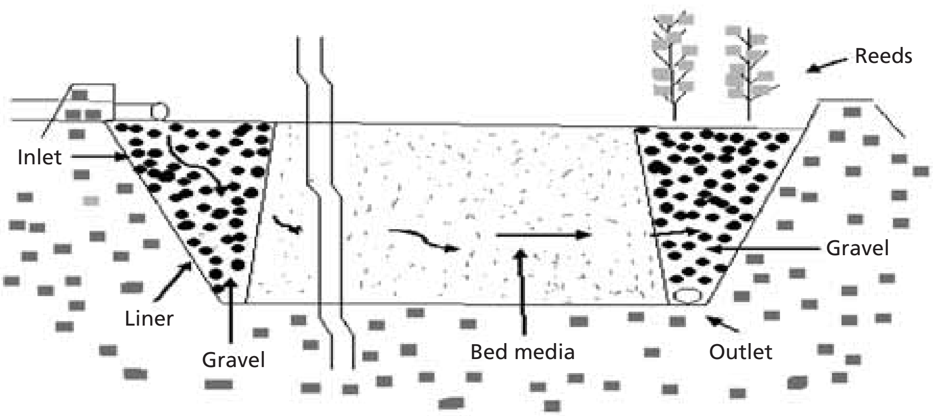
b. Constructed Wetlands (CW)

A septic tank provides only primary treatment and should always be followed by a soakage pit. In the areas where water table is shallow, the effluent from the septic tank/improved septic tank could be connected to constructed wetlands to prevent ground water contamination. Constructed Wetlands (CW) are a biological wastewater treatment technology designed to mimic processes found in natural wetland ecosystems. These systems use wetland plants, soils and their associated micro-organisms to remove contaminants from wastewater. They act as a filter removing sediments and pollutants such as nutrients and other heavy metals from waste water and septage. The bed is filled with porous media and vegetation is planted in the media. These systems require land but offer very effective biological treatment response in a passive manner so that mechanical equipment, energy and skilled operator attention are minimized. Vegetation in a wetland provides a substrate (roots, stems, and leaves) upon which micro-organisms can grow as they break down organic materials. Constructed wetlands are of two basic types: horizontal flow constructed wetlands and vertical flow constructed wetlands.

Horizontal flow constructed wetlands

Horizontal flow constructed wetland is suited for secondary treatment of wastewater or liquid component of the septage coming out of improved septic tank/anaerobic baffled reactor. The flow pattern is horizontal in the filter bed. A horizontal planted gravel filter acts through the combined effect of the filter material and plants growing on the filter media (see Figure 2.5). The effluent is odour free. As wastewater flows from one end to the other end through the planted gravel filter, it is resupplied with oxygen. A depth of 30-60cm is maintained in the bed with a slope of 1% (Srinivasan *et al*, 2008). The advantage of this system is that it can achieve high treatment efficiency at low-cost and since the flow is sub-surface, there is no odour problem.

FIGURE 2.5: Reed bed systems with horizontal filter

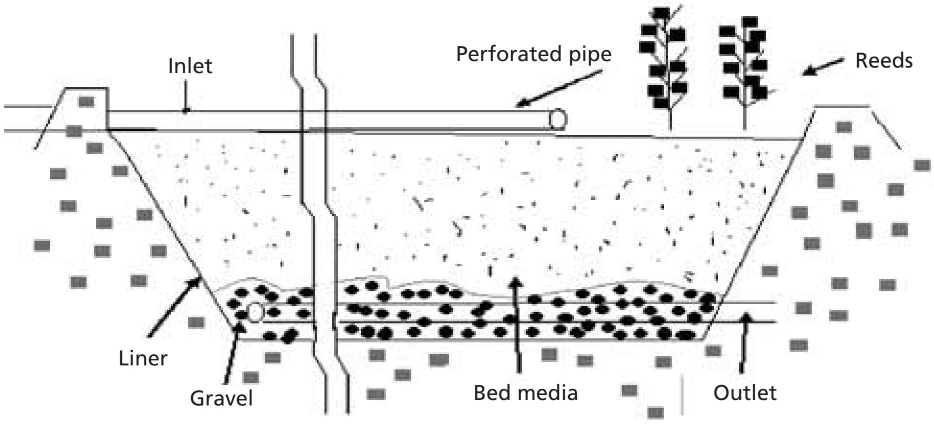


Vertical flow constructed wetlands

Vertical-flow operation is normally used to treat sludge or septage having high solid contents. To operate in a vertical-flow mode, the septage is uniformly distributed on the surface of the CW units (see Section 3.7). Vertical flow constructed wetland are usually preceded by some form of primary treatment, although some are built to receive raw sewage/septage. Each bed resembles a trickling filter, except that it has a layer of sand on top where aquatic plants are grown, usually the common reed (*Cana indica*). The septage is introduced to the surface of the bed and it percolates down through the sand and gravel media to the base. Intermittent dosing of the bed by a pump or flushing device improves distribution and improves the aeration (see Figure 2.6).

Based on the septage handling, the system could be designed for optimum solids loading rate of 250 kg TS/m^2.yr and 6-day percolate impoundments. At these operational conditions, the removal efficiencies of CW units treating septage at the range of 80 – 96% for COD, TS and TKN are achieved. The system could be designed to retain the de-watered sludge at the top of the bed for 5-10 years without any adverse effect on septage treatment and de-watering efficiency. The bio-solid contains viable helminth eggs below critical limit of sludge quality standards for agricultural use. The above mentioned operational criteria is subjected to local conditions and should be reassessed at the full-scale implementation (Koottatep *et al.*, 2004).

FIGURE 2.6: **Reed bed systems with vertical filter**



2.5 SLUDGE DISPOSAL/REUSE:

The sludge which is generated after the treatment of septage should be disposed appropriately. Even after the sludge is stabilised in the lagoons, additional stabilization or treatment measures may be required to generate final product of acceptable quality.

Sludge can be handled and disposed in various ways:
De-watering, stabilization and application to approved land application sites (bio solids only) de-watering and composting at an approved facility; incineration at an approved facility; disposal at an approved landfill, processing into a fertilizer at an approved facility. These are detailed in chapter 5 (section 5.5.3).

2.6 LIQUID EFFLUENT DISPOSAL/REUSE

Supernatant/liquid effluent from stabilization lagoons or any other treatment process can be disposed of through the following methods:

1. By approved subsurface disposal systems which are designed in accordance with the environmental regulations in India including Water (Prevention and Control of Pollution) Act,1974 and Environment (Protection) Act,1968.
2. By discharge to a surface water body/ watercourse provided the liquid effluent quality meets the requirements as specified in the CPCB/CPHEEO Standards and Guidelines Manual for the Collection, Treatment and Disposal of Sewage.
3. Treated effluent can be reused for horticulture/landscaping or irrigation purposes under the WHO guidelines for safe use of wastewater, excreta and grey water. Percolation or evaporation is not acceptable as methods of disposing of the supernatant from stabilization lagoons. Lagoons must be designed with liners that reduce percolation. More detailed options and guidelines on this subject are provided in Chapter 5.

The treatment methods discussed in the above sections are not common in India; however, they are being extensively used in other parts of the World. In order to implement these options in India, it is important to learn lessons from other countries. Some important case studies from Asian countries are presented in the next chapter to comprehend the concept of best practices in septage management, that could be followed in India.

3. Case Studies

3.1 BACKGROUND

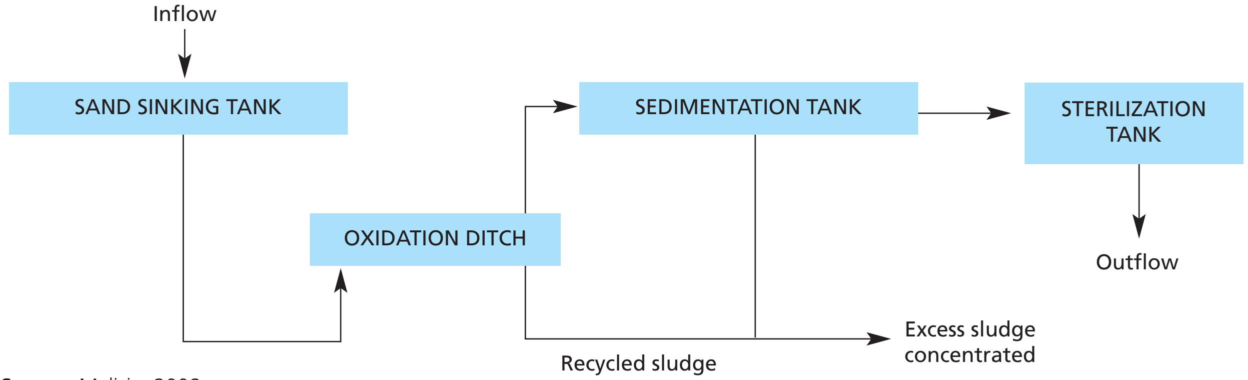
Septage presents a big challenge in our country and demands earnest consideration. India still lacks expertise in various aspects of planning and promotion of septage management services. As this is a new subject in India, it is important to understand the methodology and policies adopted in other countries to handle septage. Few case studies showcasing good practices on septage management in Asian countries are described in this chapter. These case studies from Indonesia, Malaysia, Philippines, Thailand, Bangladesh and a recently started pilot project in India displays the concept of septage management from technical and regulatory perspective. Also, these practices display the efforts done by public and private players collaboratively to handle septage.

3.2 CASE STUDY 1: SEPTAGE TREATMENT FACILITIES IN SURABAYA, INDONESIA[5]

Indonesia with a growing population is one of the emerging economies of South-east Asia. The country struggles to manage its septage as only 67 percent of the urban population is dependent on the OSS (WHO, 2008) and only 11 cities have Waste Water Treatment Plants (WWTP). This situation has acted as an impetus for introduction of septage management in the country. Government established 150 septage treatment plants in large and medium sized cities across the country (USAID 2010). One such model treatment plant is in the Surabaya which is a second largest city in Indonesia with a population of 3 million. 87% houses in the city have access to improved sanitation facilities including OSS (USAID, 2010).

Surabaya's septage treatment plant is regarded as one of the successful initiatives for septage management. The facility is operated by the local agencies (*Dinas Kebersihan*) and activities like sludge collection and transportation is provided by private companies using hauler truck service. The outline of the process for septage treatment is shown in Figure 3.1

FIGURE 3.1 Surabaya septage treatment facility



Source: Malisie, 2008.

5. (For details, visit weblink http://issuu.com/lindashi/docs/indonesia-country-assessment_0/1 Accessed on March 15, 2011)

The septage treatment facility has a capacity of 400 cubic meters per day and is based on modified activated sludge process. The plant consists of a sludge receiving facility, oxidation ditches, and sedimentation tanks, sludge collecting tanks and sludge drying beds (Malisie, 2008). Dried sludge from the drying beds is then used as manure. The results achieved in this facility are showed in Table 3.1

TABLE 3.1: **Analytical results from sludge treatment plant in Surabaya**

Parameter	Inlet (mg/l)	Outlet (mg/l)	Efficiency (%)
pH	-	6-8	
BOD (Biochemical Oxygen Demand)	8,250	80	99
COD (Chemical Oxygen Demand)	17,250	200	98
TSS (Total Suspended Solid)	2000	100	95

Source: Malisie, 2008

Over the past decade private companies have been active in septage management sector. These companies obtain a business license, nuisance permit and a disposal permit from the local government. This ensures the compliance with the national standards and regulations. Surabaya city level government has comprehensive ordinances and regulations like nuisance permits, tipping fees at treatment facilities, water quality management and water pollution control to manage the septage efficiently. Surabaya's sanitation agency collects tipping fees each month at a rate of $0.30 per cubic meter (USAID, 2010). In this way the decentralised approach of planning, development, implementation and management of wastewater and septage in Indonesia equipped the local governments with responsibilities to monitor the cycle of septage management effectively.

3.3 CASE STUDY 2: SEPTAGE MANAGEMENT IN MALAYSIA[6]

Malaysia is deemed as a pioneer in sewerage and septage management services in Asia. It has achieved 100 percent septage treatment under Indah Water Konsortium (IWK) service area (USAID, 2010). In Malaysia, 95 % of the urban population has access to improved sanitation (USAID, 2010). 73 % of the urban households are well connected to sewerage and rest of 27 % relies on septic tank systems (Malaysia Water Association, 2005; USAID, 2010). Malaysia generates approximately 6 million cubic meters of raw sewage and septage every year (USAID, 2010). IWK (formerly a private company) provides sewerage and septage management services in most of the parts of the country. The 100 percent status achieved under the auspices of IWK is attributed to the holistic approach through legislative reforms and successful implementation of the treatment facilities. IWK's operational scheme is based on the three tier approach. First, to conduct a comprehensive study to locate and restore the old treatment plants, subsequently developing its septage handling capacity. Secondly, to use oxidation ponds for septage disposal while identifying and constructing trenching sites. Thirdly, is to construct centralised septage management facilities for densely populated area.

IWK develops sewerage systems, takes care of O&M and de-sludging activities. IWK works in close association with the regulatory bodies to establish limpid and concise policy guidelines along with the operating procedures for the developers and operators of the treatment plants. Individual septic tank users participate in de-sludging

6. (For details, follow weblink http://issuu.com/lindashi/docs/malaysia-country-assessment_0/1 Accessed on March 15, 2011)

programs and pays semi annual wastewater bills at the rate of $1.70 a month as compared to $2.20 for those connected to sewerage. For special de-sludging requests, IWK charges $14 to $50 per tank depending on the size of the tank (Indah Water Konsortium , 2008). This demonstrates the collaborative efforts of Government and private sectors to achieve a unified goal. During this process, expertise in various aspects of planning and promotion of the septage management services has also been achieved. Malaysia has also established consolidated legal framework along with the institutional responsibilities to ensure provision of sewerage and septage services at the national level. Regulations like Sewerage Services Act (SSA) (from 1993 to 2008) and Water Services Industry Act (from 2008) act as a tool to provide efficiently monitored water and sewerage services in the country.

In this manner, Malaysia's government has improved sewerage and septage management practices exponentially in past two decades. These experiences can help other countries which are in the process of developing the guidelines and services in wastewater/septage management field.

3.4 CASE STUDY 3: SEPTAGE MANAGEMENT IN MANILA, PHILIPPINES[7]

Approximately 40 % of all Filipino households are based on septic tanks (ADB, 2007). In Manila, 85 % of households are OSS systems based and only 5 % of the septage generated in the city is being treated. In the east zone, Manila Water Company, Inc. (MWCI) initiated septage management pilot projects in the city to provide regular de-sludging services to 5.6 million people (USAID, 2010). MWCI has encouraged decentralized treatment of septage by establishing localized treatment plants. MWCI maintains a fleet of over 90 vacuum trucks for de-sludging of septic tanks in its service area on a rotating, five-to-seven-year cycle. MWCI operates three septage treatment facilities with a total treatment capacity of over 1,540 cubic meters per day (USAID, 2010). In the west zone another company, Maynilad Water Services, Inc. (MWSI) operates a dedicated septage treatment plant with a capacity of 450 cubic meters per day and perform de-sludging activities. These agencies charge an "environmental fee" by adding 10 percent to the water bill as de-sludging activity charges . The Philippines is one of the few countries in Asia that has a national policy and has issued inclusive set of laws on septage management. The Clean Water Act of 2004 (CWA) necessitate Local Government Units (LGUs) and water districts to build septage management programs in those areas which are deficient of sewerage systems. As a result, two cities have adopted decree on septage management and constructed septage treatment facilities. Private service providers in Metro city Manila have also participated in the collection and treatment of septage. These initiatives serve as an example for other cities and countries in the region.

The Department of Health manual states detailed guidance and local regulation notes on septage collection, handling, transport, treatment, and disposal (USAID, 2010).

3.5 CASE STUDY 4: FAECAL SLUDGE COLLECTION SERVICE IN DHAKA, BANGLADESH[8]

Recognising the potential demand for faecal sludge removal in all urban entities in Dhaka, WaterAid (non profit organisation in Bangladesh) addressed the need by introducing a pilot project in December 2000. WaterAid imported a Vacutug system for collection and transportation of faecal sludge in Dhaka. The O&M responsibility was delegated to a regional partner DSK. DSK was also responsible for establishing partnership with Dhaka Water and Sewerage Authority (DWASA) for the discharge of the collected faecal sludge into main sewer line. Vacutug system was inspired and adopted from the technology developed in Kenya. But due to the technical

7. (For details, follow web link http://issuu.com/lindashi/docs/philippines-country-assessment_0), Accessed on March 15, 2011
8. (For details refer: Decentralised domestic wastewater and faecal sludge management in Bangladesh- An output from a DFID funded research project (ENG KaR 8056) May 2005).

FIGURE 3.2: The Vacutug being used to desludge a cesspool

Source : DFID 2005

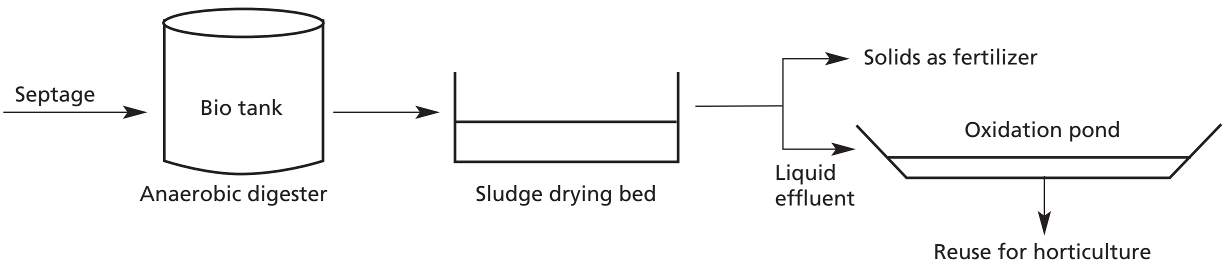
limitations and high density of housing in slums, this system was inaccessible to many places and became limited in its approach. To overcome this drawback, Vacutug was redesigned and manufactured locally to offer flexibility and mobility without losing the capacity to collect a substantial volume of faecal sludge within one operation. A larger 1900-litre and a small tank of 200-litre capacity was manufactured. This new Vacutug was mounted on wheels and could be attached to other vehicle. It was operational in July 2001. It took 10- 20 minutes to fill. One complete operation took 90 minutes which included preparation and cleaning of the Vacutug after use.

The Vacutug system garnered interest from other areas also. Apart from providing services to households in slums and squatter settlements, the facility also responded to demands from households in middle and higher income neighbourhoods, schools and other institutions and factories, which were located in other parts of the city. As a result, within a few months the revenue generated from the Vacutug services was enough to cover the staff salary and maintenance expenses (DFID, 2005).

3.6 CASE STUDY 5: SEPTAGE MANAGEMENT IN THAILAND[9]

Thailand generates 18.5 million cubic meters of septage each year (USAID, 2010). Most of the treated septage is used as a fertilizer as it does not contain any harmful chemical or heavy metals. The septage treatment facilities are based on anaerobic digestion, co-treatment with sewage or constructed wetlands (USAID, 2010). A septage treatment plant is running successfully in Nonthaburi municipality. Nonthaburi has 270,000 populations and is situated in the north of Bangkok. This treatment plant is considered as successful effort to tackle septage in the city. The plant is based on anaerobic digestion tanks (called "bio-tanks"), sludge drying beds and oxidation ponds to transform septage into fertilizer. The process is shown in Figure 3.3.

FIGURE 3.3: Septage treatment process at Nothanburi treatment plant



9. For detailed information, visit we blink http://issuu.com/lindashi/docs/thailand-country-assessment_0/1, Accessed on March 15, 2011

FIGURE 3.4: Anaerobic digestion tanks/bio tanks at septage treatment plant Nonthaburi

Source: USAID 2010

The collected septage from the septic tanks first undergoes anaerobic digestion. Then the digested sludge goes to the drying beds. The liquid portion filters through sand beds from the sludge drying beds and goes into the oxidization ponds. The treated liquid effluent is then used as fertilizer in the city's public parks and surrounding green areas. The plant also has its own collection vehicles.

The Nonthaburi septage treatment plant is designated as a remarkable endeavour because of its concerted approach for its public outreach as a service provider, spreading awareness in the community about the facility and also generating revenues by selling the fertilizer. There is a growing demand for both septage collection and fertilizer in the area which has influenced Nonthaburi to expand its facilities. Swiss Federal Institute for Environmental Science and Technology (EAWAG) and Asian Institute of Technology (AIT) performed a collaborative research on septage treatment efficiency of Constructed Wetland (CW) under tropical conditions in Thailand. The seven year pilot scale experiment was conducted from 1997 on three vertical flow CW units planted with cattails (*Typha augustifolia*). Under optimum conditions of loading rate of 250 kg TS/m^2.yr or constant volume loading of 8 m^3/week, once-a-week application and percolate impounding periods of 6 days with plant harvesting of twice a year; the removal efficiencies of CW units are in the range of 80 – 96% for COD, TS and TKN. The solids accumulation @ 12 cm per year, resulted in an 80-cm sludge layer after seven years of continuous septage loading and no bed clogging was observed. Thus with a free board of 1.0m for the AIT pilot plant, solids accumulation could last upto 10 years (Koottatep. *et al*, 2005).

Ministry of Public Health has formulated policy and technical guidelines to collect and treat septage. Public Health Act (1992) has commissioned local government authorities for septage management. 78 % of the major local government authorities had adopted these guidelines (USAID, 2010). In accordance with the Public Health Act, no operator can charge more than $7 to de-sludge first cubic meter of septage and $4 for each subsequent unit. To consolidate the implementation, Ministry released a "Manual on Integrated Septage Management" in

2001 (revised in 2008) that provides a general framework for designs of septic tanks, anaerobic treatment systems, standards for health and safety, encourages record-keeping and cost estimation for the construction of facilities (USAID, 2010).

3.7 CASE STUDY 6: SLUDGE TREATMENT PLANT AT MUSIRI, TAMILNADU[10]

Musiri is a panchayat town at Tiruchirappalli district in Tamil Nadu. To prevent the nuisance due to sludge in the water bodies, Sludge Treatment Plant (STP) is constructed in Musiri. This STP was a joint initiative by a regional NGO- Society for Community Organisation and Peoples Education (SCOPE), international organization-WASTE Netherlands and District Rural Development agency of Trichy District. It is operating since July 2010 and is based on constructed wetland model.

To treat the sludge from the septic tanks, a vertical flow constructed wetland is built as a Pilot cum Demonstration Unit (PDU). The treatment unit consist of three compartments for rotation of sludge application. All the three compartments have a common feed channel for loading of sludge and a common under drain for removal of percolates. The feed channel is located on the one side of the beds and the percolate channel at the centre. At the bottom of the beds, a slope of 1/8 is provided towards the channel. The media in each compartment is supported by a stainless steel mesh laid on the top of the channel. The beds are planted with locally available species of reeds namely *Phragmites karka* and *Typha latifolia*. The organisation has also planned

FIGURE 3.5: **Sludge Treatment Plant at Musiri, Tamilnadu**

Source: Society for Community Organisation and Peoples Education (SCOPE), Sludge Treatment Plant (STP) at Musiri

to expand the treatment system by constructing additional units of Horizontal flow constructed wetland (HCWL) for percolates in order to tackle the increased amount of loading rates.

Preventative measures are also proposed to prevent the inconvenience caused due to the foul odour emanated from the anaerobic digested sludge. Steps like: loading of the beds only during night time, usage of dilute lemon grass oil spray to mask bad odour as well as for vector control and planting of trees along the periphery of the unit to provide a green belt has been contemplated.

The PDU is operational for over 6 months (up to Dec. 2010). All the three beds are used and 240 trucks of septic sludge applied (each truck capacity of 1500 litres). It is estimated that 75-80 percent of the volatile solids (VSS) in the sludge will be reduced by this process. As a result of this reduction, a 3m-deep annual application will be reduced to 6-10 cm of residual sludge. In order to take full advantage of the PDU, the Town Panchayat is planning

10. Email on dated 11 February 2011 , Mr M.Subburaman , Director, SCOPE provided CSE the following information regarding the case study' Sludge Treatment Plant at Musiri, Tamilnadu '

to take up the following:

1. Monitor the performance of the PDU in terms of treatment of sludge, quality of percolate growth rate of reeds etc.
2. Construct the percolate treatment unit (horizontal flow constructed wetland)
3. Conduct the cost benefit analysis of the technology
4. Conduct a study of the Social-economic benefits.

These case studies present a variety of options which can help in adopting a particular option of septage management. However, a well defined regulation and guidelines is needed to implement the options. In the next chapter an attempt is made to propose policy percept, regulatory measures and guidelines for septage management in India.

4. Policy Framework for Septage Management

4.1 BACKGROUND

In wake of a large number of initiatives taken by the government and rising prosperity in the country sanitation has significantly improved. A large part of improved sanitation is dependent on septic tanks and other form of onsite sanitations and hence the septage problem is growing fast in India. Without a proper septage management policy, plan and programme, the improved sanitation facilities will continue to remain significant source of waterborne diseases and water pollution. Strengthening septage management by developing the enabling policies and physical infrastructure for septage collection, transport and treatment capacity can be an effective and practical solution to the problem. Presently there is no regulation or guidelines existing for safe handling, transport and disposal of septage in the country. Most of the current laws and policies deal with water, wastewater and sanitation services but the septage management is not covered in a holistic manner This necessitates a well defined regulation, guidelines and management strategy for septage in the country.

4.2 EXISTING FRAMEWORK FOR WASTEWATER MANAGEMENT

The existing provisions for regulating sewage management under environmental laws are as follows:

4.2.1 Water (Prevention and Control of Pollution) Act, 1974

Water pollution in India is regulated under the provision of Water (Prevention and Control of Pollution) Act, 1974. The Act provides for a permit system or “Consent” procedure to prevent and control water pollution. The Act generally prohibits disposal of polluting matter in streams, wells and sewers or on land in excess of the standards established by the state boards.

A person must obtain consent from the state board before establishing any industry operation or process, any treatment and disposal system or any extension or addition to such a system which might result in the discharge of sewage or trade effluent into a stream well or sewer or onto land. The state board may condition its consent by orders that specify the location, construction and use of the outlet as well as the nature and composition of new discharges.

The Act empowers a state board, upon thirty days notice to a polluter, to execute any work required under consent order which has not been executed. The board may recover the expenses for such work from the polluter. The Act gives the state boards the power of entry and inspection to carry out their functions. Moreover, a state board may take certain emergency measures if it determines that an accident or other unforeseen event has polluted a stream or well. These measures include removing the pollutants, mitigating the damage and assuming orders to the polluter prohibiting effluent discharges.

Under the provisions of the Water Act, there is no difference between industrial and domestic pollution. However, because the responsibility of sewage or septage treatment lies with concerned Urban Local Bodies (ULBs) and most of the time they do not have adequate resources to fulfill this responsibility with septage/sewage treatment in most of the cases is lagging behind. This is the biggest cause of pollution in India. According to former additional director of CPCB, Water Act, 1974 does not discriminate between pollution from industrial and domestic sources, however domestic pollution is not regulated in the same manner (personal communication). The urban bodies and other public bodies are providing a highly subsidized service to society in order to help the ULBs, the Government of India launched the Ganga Action Plan and subsequently National River Action Plan and established several STPs. However, today their operation and maintenance is in a dismal condition.

4.2.2 Environment (Protection) Act, 1986

The potential scope of the Act is broad with environment which includes water, air and land and interrelationship among water, air, land, human beings, other creatures, plants, micro organisms and property. Section 3(1) of the Act empowers the Center to take all such measures as it seems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution. Central Government is authorized to set new national standards for ambient quality of the environment and standards for controlling emissions and effluent discharges; to regulate industrial locations; to prescribe procedures for managing hazardous substances; to establish safeguard for preventing accidents; and to collect and disseminate information regarding environmental pollution.

The EPA was the first environmental statute to give the Central Government authority to issue direct written orders including orders to close, prohibit or regulate any industry operation or process or to stop or regulate the supply of electricity, water or any other services (Section 5). Other powers granted to the Central Government to ensure compliance with the Act include the power of entry for examination, testing of equipment and other purpose (Section 10) and power to take samples of air, water, soil or any other substance from any place for analysis (Section 11). The Act explicitly prohibits discharge of pollutants in excess of prescribed standards (Section 7). There is also a specific prohibition against handling of hazardous substances except in compliance with regulatory procedures and discharges (section 8). Persons responsible for discharges of pollutants in excess of prescribed standards must prevent or mitigate the pollution and must report the discharge to government authorities (Section 9.1).

The Act provides for severe penalties. Any person who fails to comply with or contravenes any of the provisions of the Act, or the rules or directions issued under the Act shall be punished for each failure or contravention, with a prison term of up to 5 years or a fine up to 1 lakh or both. The Act imposes an additional fine up to Rs. 5000 for every day of continuing violation (Section 15 (1)). If a failure or contravention occurs for more than one year after the date of conviction an offender may be punished with a prison term which may extend to seven years (Section 15 (2)).

The Act empowers the central government to establish standards for the quality of the environment in its various aspects, including maximum allowable concentration of various environmental pollutants (including noise) for different areas. These standards could be based on ambient levels of pollutants which are sufficiently low to protect the public health and welfare. Emission or discharge standards for particular industries could be adjusted to ensure that such ambient levels are achieved. The Environment (Protection) Rules, 1986 allow the State or Central authorities to establish more stringent standards based on recipient system.

The EPA includes a citizen's suit provision (Section 19.6) and a provision authorizing the Central Government to issue orders directly to protect the environment (Section 5). The Central Government may delegate specified duties and powers under the EPA to any officer, state government or other authority (Section 23). The Central Ministry of Environment and Forests (MoEF) is responsible for making rules to implement the EPA. The Ministry has delegated the powers to carry out enforcement to the Central and State Pollution Control Boards in the country.

The MoEF has so far enforced several rules and regulations. It has adopted industry specific standards for effluent discharges and emissions from different categories of industries. The Ministry has also designated certain state and Central Officials to carry out specified duties under the Act and has designated specific laboratories for testing the samples of air water and soil obtained under the Act.

4.2.3 Other legislation

There are several other pieces of legislation that impact on the control of water pollution. A more complete list is presented in Table 4.1.

TABLE 4.1: Important policies, legal provisions and authorities related to water pollution

Central/State Legal Provisions	Main Objectives
Constitutional Provisions on sanitation and water pollution	Statutory powers conferred on states to make law on water and sanitation
Policy Statement for Abatement of Pollution, 1992	Suggests developing relevant legislation and regulation, fiscal incentives, voluntary agreements, educational programs, information campaigns, need environmental considerations into decision making at all levels, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making
The National Conservation Strategy and Policy Statement on Environment and Development, 1992	Promotes judicious and sustainable use of natural resources, preservation of biodiversity, land and water
The National Environment Policy, 2006	Promotes conservation national resources, protection of wild life and ecosystems, prevention of pollution, reuse and recycling of wastewater, adoption of clean technology, application of 'polluter pay principle' and amendment in the existing law from criminal to civil suit provisions
National Sanitation Policy, 2008	Aimed at awareness generation, behaviour change, open defication free cities, safe disposal of wastes and propoer operation and maintenance of sanitary installations. It requires different states and cities to develop their sanitation policies, startegies and goals
The water (Prevention & Control of Pollution) Cess Act, 1977, as Amended in 1993 and 2003	To charge cess on water consumption for polluting activities to strengthen the pollution control boards by providing financial support for equipment and technical personnel and to promote water conservation by recycling
Central Ground Water Authority	To regulate and control abstraction, development and management of groundwater resources
The Public Liability Insurance Act, 1991	To provide for public liability- insurance for the purpose of providing immediate relief to the persons affected by accident occurring while handling any hazardous substance

Continued on next page

TABLE 4.1: Important policies, legal provisions and authorities related to water pollution

Central/State Legal Provisions	Main Objectives
Hazardous waste (Management and Handling) Rules, 1989	Legislative framework for laws enactment related to storage transport, handling and disposal of hazardous wastes
Manufacture, Storage and import of Hazardous Chemical Rules, 1989	Rules for manufacture, storage and import of hazardous chemical
Municipal Solid waste (Management and Handling) Rules, 1999	Rules for Municipal Solid waste Management at urban cities
The National Environment Tribunal Act, 1995	To provide for strict liability for damages arising out of any accident occurring while handling any hazardous substance and for the establishment of a National Environment Tribunal for effective and expeditious disposal of related cases.
Environment Impact Assessment Notification, 1994	To impose restrictions and prohibitions on the expansion and modernization of any activity or new projects being undertaken in any part of India unless environmental clearance has been accorded by the Central Government or the State Government.
73rd and 74th Constitutional Amendments - Role of Local Self Government	Obliging state governments to constitute Urban Local Bodies (ULBs) and transfer responsibility for water supply and sanitation services to them
Municipalities Act, District Municipalities Act or the Nagar Palika Act	Complete authority and jurisdiction over all urban amenities, including water supply and sanitation with municipality
Town Planning Act/Urban Development authorities Act	To establish development and planning authorities, having powers over any development activity in the area under their jurisdiction

Source: Compiled by Centre for Science and Environment, CSE

All the current legal provisions deal with diverse water, wastewater and sanitation services and have resulted in multiple bodies and jurisdictions in India. However, the septage management is not covered in a holistic manner except prohibition of its discharge into water bodies.

4.2.4 Enforcement of Regulations

The above environmental laws enforcement framework for industrial pollution control could bring a large change in the behaviour of the industries and was successful in reducing industrial pollution in the country from large and medium industries. However, nearly 80% of the water pollution is caused by discharge of untreated domestic wastewater from urban centers, responsibility of which lies often with the government supported PHEDs and ULBs. Due to lack of technical, managerial and financial capacities these agencies are not able to carry out their duties. Thus even if all the industrial effluents are fully treated to the stipulated levels, the water quality objectives cannot be achieved without similar surveillance and strict adherence to water quality protocol for domestic sources including pollution from increasing septage. The following section discusses the various constraints in regulating sewage and septage.

4.3 KEY CHALLENGES

In order to formulate any policy guidelines or regulatory mechanism, it is important to go into the details of the key challenges in septage management before the country. Following are some important challenges identified:

4.3.1 Urban Sanitation

- No physical infrastructure to treat septage in the country, and very limited use of mechanized de-sludging
- Manual scavenging still widespread, although prohibited by law; on-site sanitation not viewed as a problem or priority
- Emphasis on centralized, advanced engineering solutions for sanitation; septage management not perceived as a solution
- Most cities and states do not have policies on septage management and lack data concerning onsite sanitation systems in their jurisdictions
- Low prioritization and awareness of the public and government agencies;
- Lack of explicit policies on sanitation, particularly safe disposal;
- Abundance of fragmented agencies that lack sanitation;
- Focus on project- and technology-based investment decisions rather than city wide planning;
- Lack of attention on access by the poor to safe sanitation; and
- Supply-driven rather than demand-responsive sanitation solutions.

4.3.2 Fragmented Policy Frameworks and Weak Enforcement

Inadequate policies and piecemeal implementation.

Despite the widespread use of septic tanks, still there are no comprehensive policies, legal and institutional frameworks for septage management. The interconnection of water supply and sanitation are often ignored. This leads to weak septage management strategies even though it impacts public health and water quality in direct and profound ways. Many policies are also segmented hierarchically and developed without consulting the needs of the local implementers and service providers.

Lack of clear delineation and delegation of responsibility.

Since implementation of septage management policies require involvement at multiple government levels, it is important to establish a coherent institutional framework that clearly delineates roles and responsibilities among responsible agencies, including decentralizing or devolving authority in line with national and local laws. In Thailand, for instance, the Ministry of Public Health is responsible for guiding municipalities on managing the septage inside the septic tank, while a separate regulation requires the Ministry of Natural Resources and Environment to manage the liquid waste discharged from septic tanks (see chapter 3 of this report).

4.3.3 Inadequate Human and Institutional Capacity

Limited Stakeholder Awareness.

Policymakers, government officials, civil society and even common man has a limited awareness about the importance of effective OSS management and implementation strategies, costs and various environment impacts of developing it. The government agencies typically prioritize water above sanitation, and only place emphasis on toilet construction in sanitation programmes; and often septage management only an afterthought.

For households, septic tanks are often constructed below or behind the house and are difficult and inconvenient to access and open; the lump-sum expense of de-sludging also discourages frequent emptying. Moreover, few people know where desludged septage goes once it leaves their houses, or understand how improperly disposed septage can impact water quality and human health. This lack of awareness about septage is consistently cited as the main cause of inadequate septage management services.

Lack of Skilled Manpower

In addition to a lack of awareness, there is a significant capacity gap on the technical and institutional aspects of septage management at all levels of government. Moreover, universities and training centers have not incorporated septage management into their curricula. Accordingly, when responsibilities are delegated to local governments, they are unable to undertake effective or timely implementation.

Inadequate Regulation and/or Partnership with Private Service Providers.

In most regions, private entrepreneurs play an important role in providing either all de-sludging services or supporting limited public de-sludging services. Their presence demonstrates the inability of public service providers to meet existing de-sludging needs. In the absence of any regulation, the operators either sell the septage to farmers for use as a fertilizer or illegally dump septage to avoid traveling long distances to designated disposal sites. These practices degrade the quality of service, impact the environment, and endanger the health of workers and others. Cities do not have the capability and resources to regulate private service providers, nor do they form strategic public-private partnerships.

Insufficient Wastewater Planning

Urban growth in most Indian cities out-paces the public sector’s ability to plan or provide sanitation services, especially for new residential and commercial developments. As a result, the gap between the need and facilities for sewerage/sanitation continuously widens.

4.3.4 Funding Capital and Operational Costs

Inadequate Public Funding and Over-reliance on External Aid

While allocating funds for water and sanitation projects at national levels, most of the funding is for water and centralized wastewater treatment, and not for septage management. In addition, many of the target cities rely on central development assistance to fund sanitation and wastewater projects. Dependence on external assistance can reflect a lack of long-term commitment and project ownership.

Low Wastewater Tariffs and Inadequate O&M Funding

Cities and utilities that have constructed centralized wastewater treatment and septage treatment facilities often have difficulty generating funds to cover O&M cost. National regulations have either reduced tariffs over time, or kept them the same, even while costs have inflated. In case of OSS the household payments (if any) for desluidging cover only collection costs not treatment costs.

4.3.5 Institutional Issues

Traditionally, the ULBs have been facing many problems in providing adequate waste management services in the cities. Major problems are listed below:

- Shortage of government finances;
- Inefficiency of ULB-run system;
- Paucity of qualified and experienced human resources and finances; and
- Administrative: frequent transfer of trained staff leads to weak commitment, political changes and management changes leave many plans inconclusive, local leaders may impose their agenda for vested interest, which may not be in line to make sewage management service viable and self sustaining.

4.4 POLICY RECOMMENDATIONS

In order to properly manage the septage in the country it is important to address following issues in the policy:

4.4.1 Septage Collection and Treatment

Septage generation rates vary widely from place to place depending on septic tank use practices, number of users, water used for flushing, efficient functioning of tank and contamination control. It can be considered that the volume of sludge evacuated from a septic tank corresponds more or less to the volume of the septic tank, plus some cleansing and rinsing water. The size of a septic tank in individual houses in India ranges from 1 to 4 m3, the size of a septic tank in office or apartment buildings from 10 to 100 m3. Assuming that about 20% of the population has combined septic tank of about 50 m3 and rest is connected to individual septic tanks of about 2.5 m3. Thus there are about 24 million individual septic tanks and 0.3 million larger septic tanks. If a septic tank is emptied every five years, the annual generation of septage would be around 24/5=12 MMC+3 MMC=15 MMC. Being highly concentrated waste, if discharged into a water body, it may create serious impact on water body due to shock load discharged instantly at one time. With large number of initiatives on improving sanitation in the country and rising prosperity in the country, the number of septic tanks would steeply grow and the problem of septage disposal would become very serious. Thus, there is a need to develop policies, guidelines and regulation for septage management.

4.4.2 Regulatory Measures for Septage/Sewage Pollution

The following framework is proposed for implementation:

- Septage should be regulated in the same way as industrial effluents are regulated; i.e., through consent and compliance monitoring as per the Water Act, 1974 or it can be regulated in the manner municipal solid wastes or biomedical wastes or hazardous wastes are regulated under different rules notified.
- Respective ULBs should be made responsible for compliance, keeping in view the adverse effect of septage on land, low lying areas or receiving surface water or groundwater bodies. There is a need for establishing good collection system for septage and its proper disposal.
- The "*Polluter Pays*" principle needs to be imposed for recovering the full cost of collection and treatment of septage from the beneficiaries.
- ULBs should have effective management and monitoring system to ensure regular collection, transport and proper treatmen including monitoring discharges into land/water bodies.

4.4.3 Techno-Economic Aspects

- Effective technologies need to be selected based on local needs.
- It is suggested to pilot a few privatized septage management services with appropriate tools of process monitoring to further refine and develop an effective model for septage management at national level.
- Effective management system needs to be established to monitor the collection, transport, treatment and disposal of septage. Presently the ULBs have implicit roles of a provider, manager and regulator. This should be changed and the regulation function should be given to independent bodies similar to those in the power and telecom sectors.

4.4.4 Additional Regulatory Measures

- Strengthening the monitoring of compliance by SPCBs and vigilance monitoring by CPCB/MoEF, by increasing the number of qualified and trained personnel to the level necessary to with the task at hand. This makes it necessary to empower these agencies acquire the financial resources to ensure long term sustainability.

- Regulation of de-sludging frequency of septic tanks, handling, transport, treatment and disposal of septage on land or in a water body under either Water Act or under separate Septage (Handling and Management) Rules under Environment (Protection) Act similar to MSW Rules imposing a consent or authorization conditions and their effective monitoring for compliance.
- Strict regulation of groundwater pollution under the Water Act. This needs to be adequately regulated. This will also require repealing of the Indian Easement Act.
- Corporate Responsibility for Environmental Protection (CREP) programme needs to be further strengthened for septage management.
- Incentives should be given to new residential developments having their own recycling and reuse systems and their own fully functional septage/sewage treatment systems.

4.4.5 Capacity Building

Technological capacity building for effective septage management and enforcing septage handling and management guidelines/regulations needs to be strengthened in the country. Skill development in septage management, professionalization of waste management groups and strengthening environmental mediation are some of the major steps needed in this direction.

Capacity building must be based on an examination of the magnitude of problem on septage/sewage sector to analyze their physical and institutional characteristics in detail, define opportunities and key constraints for sustainable development, and then select a set of short and long-term action programmes.

Very often the waste management sector performs poorly because of non-coordinating and vertical institutional arrangements. If these can be improved, structural constraints to effective coordination can be removed. In order to achieve the objectives of Millennium Development Goals, India must build “capacities” which is effective in service delivery, efficient in resource use and has sustainabiity. These include the following:

- Institutional development, including community participation.
- Changing the emphasis from capital creation to effective operation and maintenance for enhanced efficiency.
- Human resources development and strengthening of managerial systems.
- Price setting, cost recovery and the enforcement of rules, are more difficult to implement than regulation (of water quality, for example). Therefore, strategies to achieve these deserve priority.
- Allocating the right mandates and reviewing the performance of the arrangements regularly. This will render organizations more alert and target-orientated.
- Facilitation of O&M and cost recovery.
- Development of the right expertise profile in organizations.
- A number of tools can be applied in capacity building. These are:
    - Technical assistance for institutional change, which may include policy, micro or macro-economic structures, management systems, and administrative arrangements.
    - Training for change at different levels of decision-makers, senior staff and engineers with managerial assignments, junior staff and engineers with primarily executive tasks, technicians (plumber, masons) and operators, students and instructors and other stakeholders (such as caretakers and people in local communities who have undertaken to operate or to manage community-based septage collection and treatment systems).

- Education of prospective experts who will play a role in the septage sector. This encompasses physical and technological sciences, as well as financial and administrative management, and behavioral sciences.
- ‘Septage management’ subject needs to be included in the curriculum at appropriate levels.

4.4.6 Wastewater as a Resource

If there is no dilution available in a receiving water body, it is important that no septage/wastewater is discharged into it even after treatment. The effort should be to use all the septage/wastewater after proper treatment. There are many cases where the sewage or industrial wastewater is treated and used for various inferior uses. Many companies are coming in this business. Focus should be to promote such business. This will benefit the water quality in many ways:

- reduce pollution
- save water
- save nutrients
- reduce over-exploitation of water resources
- These are discussed in detail in chapter 5 of this report.

4.4.7 Financing Septage/Sewage Management

Funding septage management through the exchequer places an unreasonable strain on the nation’s finances. This is not only detrimental to the economy of the country – it also engenders a lack of accountability and immediate responsibility among the ULBs to generate revenue for septage/sewage management. Thus, it is important that the beneficiaries also share the responsibility of waste management following the ‘Polluters pay principle’. As per the present pace of economic growth in India, the government’s financial capacity would be strengthened due to higher collection of taxes and private participation is also expected to increase. Therefore, it is necessary to draw up a long term financing and investment plan for septage/sewage management based on expected economic development. It is important here to consider options for public-private partnerships (PPP), as being done in many countries and also in many cities of India for emptying the septic tanks and its collection and disposal. Since charge collection serves as important conditions of PPP project implementation, PPP requires formation of a suitable charge system from the beginning. Setting up a rational charge system also has the effect of asking citizens for the formation of environment friendly consumption patterns, such as saving water and waste reduction through a price mechanism. Application of PPP is a complex issue, which needs to be addressed by the government through its administrative and financial reforms. Key issues are: 1) policy framework development for PPP 2) target setting, 3) tariff design, 4) role of government, and 5) contractual arrangements of PPP projects. Some of these aspects are described in the Table 4.2:

The involvement of the private sector must be under very controlled conditions.

TABLE 4.2: Public Private Partnership

Issues	Existing System	PPP Scheme
Policy	• Public works • Decision by government • Monopoly of ULBs • Low efficiency • Delay in construction	• Private sector participation and deregulation • Construction according to local needs, strengthening of local role • Improvement of efficiency • Increase in speed of construction • Streamline procedures of site inspection and time bound clearance of invoices with assured quality control.
Implementation body	• ULBs	• Private sector and public sector: various combinations of roles and responsibilities. • Involvement of RWAs to optimise costs.
Role of ULBs	• Direct service provider	• Manager, supervisor and negotiator
Financial resources	• Construction: revenue, national/local bonds, beneficiary charges	• Construction cost: private sector (equity capital, corporate bonds, stocks, bank loans, beneficiary charges and support from government revenue) • O&M cost and repayment: charge income, revenue (government)
Project finance	• Operating body: ULBs • Financing method: national bond, local bond, policy oriented finance, multilateral international agencies etc	• Operating body: private sector • Financing method: loan from commercial banks etc
Risks	• Risk sharing: ULBs pays unitary • Contents of risks: aggravated of raising funds by budget deficit and inefficient management, lack of technical development incentives, stagnation of construction level	• Risk sharing: risk sharing between ULBs and private sector • Content of risks: financial risk, monopoly formation, consider lack of social equity
Contract form	• Construction turn-key contract under the responsibility of ULBs	• Construction: BOT, concession, joint venture etc • O&M: service, management and lease contract

Source: Compiled by Centre for Science and Environment , CSE

4.5 TECHNICAL AND MANAGERIAL GUIDELINES

In order to effectively manage the septage, there should be a comprehensive description of technical requirement of the entire septage management system. This description is detailed in chapter 2 of this document. Some important aspects to be covered are as follows:

- Description of the Septage Management System
- Design, Operation, and Maintenance
- Septic Tanks – Design and Construction Requirements
- Desludging Procedures
- Septage Treatment Facility
- Administration and Enforcement Provisions
  a. Management
  b. Monitoring and Evaluation
  c. Finances and User Fees,
  d. Administrative Procedures
  e. Violations and Penalty Provisions

4.5.1 Septage Management System

The septage management system includes designing, operation and maintenance, desludging, institutional mechanism, monitoring, financial arrangements, legal provisions and administrative procedures.

4.5.2 Design of Septic Tanks

The detailed design for the conventional septic tanks is given in the CPHEEO manual, 1993 (Part II, Chapter 21, Section 21.2) and that for the improved septic tanks in Chapter 2 of this report. Some important aspects regarding its construction and maintenance are suggested as follows:

Construction

- Concrete structures are preferred.
- They should be water tight and multichambered.
- Bottomless septic tanks should be prohibited.
- Must be sized so that the volume is at least 1.6 times the daily flow but preferably 2 or 2.5 times the daily flow.
- The bigger the tank, the less frequently it will need to be desludged. Multiple chamber septic tanks should be designed for new installations.
- Must also be accessible (have a removable cover and not be located directly under the house) to pump sludge when sludge level becomes too high.
- Small housing blocks may share a community septic tank to reduce per household costs.

Maintenance

- When the septage occupies two-thirds of the depth of the tank, it needs to be removed; otherwise there is a risk that excreta will pass directly through the tank and overflow into the disposal system.
- Septage should be taken to an approved sludge treatment and disposal site by means of a vacuum tanker.
- Households should be encouraged to minimize their use of water and be careful about what they put into their septic tanks.
- The septic tank should be desludged every 2 to 5 years[11] depending on the capacity and design.
- The desludging schedule should be prepared (preferably computerised) and should be notified to the household about their due date.

4.5.3 Desludging Procedure

There is a widespread promotion of OSS. However, all the programmes and city agencies still do not address adequately the issue of septage that accumulates inside septic tank/ OSS. Due to lack or inadequate public services, private service providers have emerged to empty OSS by hand or with vacuum trucks. Operators with mechanized equipment often transport and dispose of septage several kilometers from people's homes in drains, waterways, open land, and agricultural fields. Manual desludging is also done in low-income areas and squatter settlements. They are often inaccessible by truck and hence deposit the septage within the household, into nearby lanes, drains, open land or waterways. Thus, the poorest have the highest health risk both because they are the most likely to provide manual desludging services, and because their homes are closest to the actual dumping grounds.

11. The National Building Code of India (2005) states that septic tanks should be regularly maintained and desludged on yearly basis. However, desludging interval increases for improved septic tanks as described in chapter 2.

In carrying out manual desludging all the precautions should be taken to protect the workers as provided under Municipal Solid Waste Rules. The sludge after removal should be transported in a controlled manner to avoid leakages or spillage en-route.

Before desludging, if the liquid level in the tank is higher than the outlet pipe, this may indicate clogging in the outlet pipe or in the drain field. The sludge then may be collected through safe containers or pumping. Before pumping, the scum mat is manually broken up to facilitate pumping. Before this is done, the liquid level in the septic tank first is lowered below the invert of the outlet, which prevents grease and scum from being washed into the drain field. After the scum mat is broken up, the contents of the tank are removed. Normally, the vacuum/suction hose draws air at a point where 1 to 2 in. (2.5 to 5 cm) of sludge remains over the tank bottom; this material should be left in the tank. Washing down the inside of the tank is not required unless leakage is suspected and the inside must be inspected for cracks, if internal inspection is warranted, fresh air should be continuously blown into the tank for at least 10 minutes.

4.5.4 Septage Transportation

The sludge after collection should be transported through trucks to the treatment or disposal sites, with proper regulation. In India there is a comprehensive regulation on transport of solid wastes (municipal solid wastes, biomedical wastes and hazardous wastes), however similar regulation is not existing for transport of septage. The septage transport should be regulated in the same manner as provided under Municipal Wastes (Handling and Management) Rules 2000.

4.5.5 Septage Treatment Facilities

There are number of treatment options available. Treatment using natural processes, including waste stabilization ponds, unplanted sludge drying beds, constructed wetlands, and composting, are considerably cost-effective solutions. Anaerobic digestion (with biogas generation), lime treatment, and mechanized systems, such as activated sludge process, are also widely used technologies in treating septage. Important considerations include the cost of land, the capacity of staff to operate and maintain the system, and the location of the treatment facility with respect to OSS. Digested sludge from OSS is 100 times more concentrated than domestic wastewater flowing in the sewer systems, and therefore should not be treated with wastewater in sewage treatment plants. If the dried sludge meets established standards, it can be used as a soil amendment for reclaimed land, landfill cover, landscaping compost, or fertilizer for non-edible plantations. For use as compost for edible crops, treatment facilities need to ensure that the end product attains standards for agricultural reuse.

There are different techniques for the treatment of septage. Following main options are available:

- Land application after stabilization
- Treatment at wastewater treatment plants
- Treatment at independent septage treatment plants
- The details of technologies are provided in chapter 2 of this report.

4.5.6 Decentralizing Physical Infrastructure

In all the large cities there is difficulty of collecting septage and hauling it across cities to designated disposal and treatment sites. It is important to consider decentralized treatment and reuse of wastewater and nutrients may be the best option. This may significantly reduce collection and haulage costs. Capital, operating and maintenance costs decrease with increasing plant size. However, since larger treatment plants require longer haulage distances between pits and disposal sites, costs escalate for collection companies, which in turn increase the risk of indiscriminate and illegal dumping. The optimum plant size has to be determined on a case-by-case basis as it depends on the local context (e.g., labor cost, land price, treatment plant scale, haulage distance, and site conditions).

4.5.7 Administrative and Enforcement Provisions

It is proposed that each city/town or Panchayat may have Septage Management Authority, or Administration with following important functions:

a. Survey or inventory of septic tanks
b. Inspect construction of septic tanks
c. Issue certificates of compliance
d. Conduct of education and information campaign on septage management
e. Supervise the operation of septage treatment plant
f. Direct and supervise day-to-day operations of septage system
g. Preparation of desludging schedule
h. Notifying the households about their due dates
i. Informing the septage desludging agencies for executing the desluging as per schedule and monitor them for effective functioning
j. Ensuring that all the septage is reaching to the treatment plant
k. Ensuring that the treatment plant is working effectively and the monitoring results are complying with standards.
l. Fee collection to be handled by water supply authority. This is because it will require modifying their billing structure.

4.5.8 Constitution of the Authority

City/Panchayat Septage Management Authority (CSMA) will be chaired by mayor or Sarpanch and composed of representatives from the following offices:

a. State Pollution Control Board/Pollution Control Committee
b. City/village Health Officer or representative
c. Representative from Desludging Agency
d. Representative from Transporter agency
e. Representative from Finance Department
f. Representative from Water supply authority
g. Representative from Legal Office
h. Representative from Public Health Engineer’s Office
i. NGO (appointed by the Mayor or Sarpanch)
j. Other persons who may be invited to provide technical advice to the CSMA

4.5.9 Costs and Cost Recovery

Neither local authorities nor water supply authorities in India have adequate capital or leverage to finance expensive sewer networks or sewage/septage collection and treatment facilities. Thus, major sanitation improvements are dependent on a mix of government funding, external assistance and increased user charges. Project design should incorporate institutional building and financial viability. Obtaining funds and enacting necessary reforms (e.g., linking revenues with expenditures) requires careful negotiation and cooperation between local stakeholders, especially when elected officials are sensitive to popular concerns regarding tariffs. Multi-sourcing of funds can be used to effectively reduce the funding requirements of ULBs by encouraging project investment and O&M costs.

Operation and maintenance (O&M) expenses for septage management programs typically include the following:
a labor
b. overhead (e.g., benefits, employment taxes)
c. utilities
d. transportation for processed and incoming materials
e. vehicles and other equipment maintenance
f. taxes
g. disposal costs for dried cake
h. licenses and permits; insurance
i. testing and other monitoring and
j. miscellaneous supplies

Revenue Generation Plan

1. Political approval and effective administration of such taxes and charges have proven to be too difficult. Many cities in the country are increasingly realizing the importance of septage management and trying to introduce the taxes to recover at least the part of the cost with water bill. Charges can be linked to water consumption; disconnection of water supply provides an effective sanction against non-payment.
2. The disadvantages are that the water service provider is not always willing (or able) to collect sanitation charges, and, while there are strong synergies in financial management, sanitation services require different skills and resources to those needed for water supply.
3. Government funding is also essential, notably for the provision of sanitation services to the urban poor who remain excluded from public sanitation services and unable to develop private alternatives.
4. Some cities charge a flat rate (or zero) tariffs, collect revenues lower than their O&M costs and, are dependent on subsidies from the ULBs or, where managed by a Water Supply Authorities, on cross-subsidies from water supply income.
5. The other part of the arrangement is between the Sewage Treatment Facilities and ULBs (or the contractor collecting the septage). The tipping fee is perhaps the only variable of the facility's financial system. Calculating the desired tipping fee requires "working backwards." The cost to process the septage is determined by the facility's monthly operating expenses.
6. The tipping fee (per unit basis) is determined by dividing the total tipping revenue by cubic meters of incoming septage. Therefore, to determine the tipping fee, the tipping revenue must first be calculated using the following equation: Tipping Revenues = Operating Expenses + Profit Margin – Material Revenues.
7. In most cities, desludging is done only when requested by households and usually when the septic tank overflows. Costs are paid by the household directly to a private desludging company. To implement a city-wide septage management program, there is a need for the ULB and/or water supply authority to develop a system to ensure that all septic tanks are desludged regularly and that the septage removed is treated. Each ULB should develop a system that works for them. ULB/water supply authority could collect fees from the households and pay the contractor for each truck-full of septage brought to the treatment facility. This would give the contractor an incentive not to simply dump the septage, as is currently being done. This can be a

source of revenue generation.

8. In case sewage, septage, or sludge is collected, transported, treated & disposed by a third party, the final disposal of the treated sewage, septage or sludge shall comply with relevant MINAS Standards notified under Environment (Protection) Act, 1986.
9. Reuse of treated sludge for agriculture application should comply with the standards notified for compost under EPA. A more detailed guideline in this regard is proposed in the next chapter.

4.6 PUBLIC PARTICIPATION

Public awareness and interest on the issues related to the conservation of natural resources have steadily increased and their participation needs to be promoted in the septage management programmes. The effective management of septage is of concern to a broad segment of the population as it affects the day-to-day life of individuals and communities. Communities should become involved in decisions concerning the development and siting of septage disposal point and desludging procedures, handling, transport and treatment methods and possible adverse effects including health effects of septage mis-management. Hence a strong public awareness programme is very important to implement the septgae management policy. The ultimate aim of the public awareness programme is to shape human behavior of all concerns including septic tank users, desludging staff. An education system is to be established in order to achieve effective awareness generation programme and to promote responsible citizenship behaviour. Following four areas need to be focused:

a. Sensitivity: to help citizens and social groups gain a variety of experiences in, and acquire a basic understanding of septage and associated problems.

b. Attitude: to help citizens and social groups acquire a set of values and feelings of concern for septage and motivation for actively participating in septage management.

c. Skill: to help citizens and social groups acquire skills for identifying and solving septage related problems.

d. Motivation: There should be a system to motivate the citizens through various incentives e.g. image boosting for better work and rebate in charges on septage collection and disposal .

In order to ensure public participation in septage management, it is important to consider/develop the followings:

4.6.1 Training Material

In order to maximize the learner's behavior in septage management, a training material needs to be developed. Following components should be addressed:

- Teaching material on environmentally significant septage management concepts and environmental and health relationships.
- Teaching material on the economics of septage including its economical value in terms of energy, nutrients and soil conditioner and also cost on health if not managed properly.
- Teaching materials on the economic benefits of proper septage management including improvement in property value, health, scenic beauty, hygiene, tourism and environment.
- Teaching material on religious importance of our rivers and consequences of throwing septage in them.
- Teaching material for learners to achieve some level of sensitivity towards management of septage that will promote a desire to behave in appropriate ways.
- Provide a curriculum that will result in in-depth knowledge of issues and develop skill of problem understanding, analysis and remedies.

4.6.2 Awareness generation cell

The ULBs may consider creating a Mass Awareness Cell. This cell will be responsible for creating awareness programmes on septage management. The cell should constitute committees at various levels and involve various stakeholders including representatives of citizens, RWAs, ULBs authorities, NGOs, transporters and others. In organizational aspect, the cell should-

- Assess current practices
- Identify the role of key community members
- Identify the resources available from the authorities and resources to be contributed from the citizens, businessmen, industrial units, dairies etc.
- Highlight personal responsibilities and obligations in keeping septic tanks clean as per schedule
- Inform people about the duties and responsibilities of both individuals and community in cooperating with municipality in septage management
- Inform people about advantages of desludging septic tanks regularly
- Inform people about need of septage treatment before disposal in terms of health and environmental impacts
- Inform people about the need to pay for septage collection and its disposal
- Development of monitoring mechanism for effective implementation of awareness programme

4.6.3 Mechanism of communication

All the above information will help define a proper strategy for communicating with different stakeholders. To reach out to the community media, group campaigns, video forums, pamphlets, home visits and other outreach formats can be prepared. The various means of public contacts could be-

- Print media, hoardings, posters, leaflets, publicity materials, radio, TV
- Open forum, signature campaign
- Direct communication, through RWAs, seminars, meetings
- Door-to-door awareness and motivation programme
- School programme
- Involvement of National Cadet Corps, National Social Service, scouts
- Involvement of religious leaders
- Involvement of mahila mandal and women associations
- Organize best septic tank management awards at local levels

5. Reuse of Septage/Sewage

5.1 BACKGROUND

Reuse of domestic sewage/septage is a common practice in India since historical time. The sewage/septage is used either raw or partially treated due to non-existence of any kind of treatment system in majority of cases. In spite of ill effects of untreated sewage/septage on human health and the environment, the practice continues in India, as it is highly reliable, nutrient rich and provides year-round income and employment. In many cities/towns the sewage/septage is sold to farmers by municipal authorities. Due to continuous rise in water demand and high pressure on water resources, reuse of sewage is being promoted in several policy percept and regulatory measures by Government of India. While initial emphasis was mainly on reuse for agricultural and non-potable reuses, the recent trends prove that there are direct reuse opportunities to applications closer to the point of generation. Since the generation of sewage/septage is steeply growing in the country, it is very important that sewage/septage reuse is promoted and regulated. Hence there is a need to develop proper regulations and guidelines for reuse of sewage/septage.

5.2 RECYCLING AND REUSE OF WASTEWATER

Recycling of wastewater is essentially, reusing treated waste water for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a ground water basin (referred to as ground water recharge) (USEPA,1993). Recycling and reusing are both aimed at conservation and waste reduction, but they are not the same thing. Recycling is a process, while reusing is a practice.

5.2.1 Classification of wastewater

Classification of wastewater is in two main categories namely, grey and black water. While, grey water is the term used for water from kitchen, baths, laundries and sinks and black water is wastewater contaminated by faeces or urine, and includes wastewater arising from toilet, urinal, or bidet. Both require different degree of treatment and require different treatment mechanisms. Waste water treated in appropriate technology can be reused for a large number of uses and reduce intake of freshwater from the supply systems or groundwater.

5.2.2 Benefits of Reuse of wastewater

The major benefits are as follows:

- Helps save water, since it reduce the demand for freshwater for various uses, thus it helps to supplement potable water for non potable uses
- Helps reduce pollution in the water bodies, since water is being recycled and treated
- Recharges ground water and replenishes surface water bodies
- Provision to develop and use a reliable in-house water source availability
- Reduction in fresh water cost and reduction in disposal cess-pools

- An approach towards zero liquid discharge
- A low-cost method for sanitary disposal of municipal wastewater
- Reduces pollution of rivers and other surface water bodies
- Conserves nutrients, thereby reducing the need for artificial fertilizer
- Provides a reliable water supply to farmers
- Protection of environment and effectively combat the water scarcity

Reuse of wastewater can be a supplementary source to existing water sources, especially in arid/semi-arid climatic regions in India. In such regions people already face severe water scarcity problem and there is competing demand of water for irrigation, industrial and domestic needs. For this reason wastewater reuse schemes form an important supplement to the water resource in such regions. Costs associated with water supply or sewage/septage disposal may also make reuse of sewage/septage an attractive option. Positive influences on treatment costs of sewage/septage and water supplies, and scopes for reduction in costs of head works and distribution systems, for both water supply and sewage/septage systems has been the motivation behind many reuse schemes in countries like Japan. Reuse is also practiced as a method for groundwater recharging through highly treated sewage/septage to prevent depletion of aquifer levels to restore groundwater yields or preventing saltwater intrusion (in coastal zones). Avoidance of environmental problems arising due to discharge of treated/untreated sewage/septage is another factor that encourages reuse. While the nutrients in sewage/septage can assist plant growth when reused for irrigation, their disposal, in extreme cases, is detrimental to ecosystems of the receiving environment. In addition, there may be concerns about the levels of other toxic pollutants in sewage/septage.

5.3 QUALITY CONCERNS

Despite a long history of sewage/septage reuse in India, the quality issues linked with safety of sewage/septage reuse still remains an enigma. Public health concern is the most important issue in any type of reuse of sewage/septage, be it for irrigation or non-irrigation use. There is always a difficulty in delineating acceptable health risks and wastewater reuse is a serious debate all over the world. The fundamental precondition for water reuse is that its application should not cause unacceptable public health risks. Untreated wastewater poses a serious risk of water-borne diseases, such as cholera, typhoid, dysentery, plague and helminthiasis. Use of untreated wastewater for irrigation should be discontinued and replaced with irrigation using treated wastewater that meets public health guidelines in order to minimize the exposure of farm workers and consumers. For agricultural applications, the WHO has published guidelines for wastewater for restricted and unrestricted irrigation (WHO 2006). Governments have also developed more stringent criteria for agricultural applications. For non-agricultural applications, no global water quality standards exist, and various governments have issued their own standards (Annexure 2). Some of the key pathogens that are found in raw wastewater are summarized in Table 5.1.

Besides these pathogens, untreated wastewater may contain chemical substances that are harmful to humans and the environment. The other issue is related to socioeconomic considerations including community perceptions, and the costs of reuse systems. Generally no public accepts potable use of wastewater, whereas non-potable reuse option is a technically accepted option. Almost all the guidelines and standards for sewage reuse deal mainly with the reuse of sewage for irrigation purposes available. Irrigation is the highest water consuming activity in India, hence it should be the first option considered in any reuse planning.

TABLE 5.1: Some important pathogens associated with municipal wastewater

Pathogens	Examples
Waterborne bacteria	Salmonella sp, Vibrio cholerae, Legionellaceae
Protozoa	Giardia lamblia, Cryptosporidium sp
Helminths	Ascaris, Toxocara, Taenia (tapeworm), Ancylostoma (hookworm)
Viruses	Hepatitis A virus, Rotaviruses, Enteroviruses

Source: UNEP, 2004

5.3.1 Pathogen Survival

Public health concerns centre around pathogenic organisms that are or could be present in sewage/septage in great variety. Survival of pathogens in sewage/septage and in environmental conditions other than their host organisms (mainly humans) is highly variable. Table 5.2 presents the survival periods of various types of pathogenic organisms under various conditions.

Although sewage/septage reuse is risky due to associated health hazards, it is also important to understand the factors which reduce the risk. The factors include the level of sewage/septage treatment previously applied leading to settling, adsorption, desiccation of pathogens, as well as soil moisture, temperature, UV irradiation due to sunlight, pH, antibiotics, toxic substances, biological competition, available nutrient and organic matter, leading to pathogen die-off and/or removal from the sewage/septage source until final ingestion by humans to result in infection. The method and time of application of sewage/septage and the soil type will also have an influence. Another aspect of indirect pathogen contamination due to sewage/septage reuse has been the contamination of soil and subsequent entry of pathogen into groundwater. The principal methods of pathogen

TABLE 5.2: Survival of pathogens in different environment

Type of pathogen	Survival time in days		
	In faeces and sludge	In sewage/septage and freshwater	In soil
Enteroviruses	<100 (<20)	<120 (<50)	<100 (<30)
Fecal coliforms <70 (<20)	<90 (<50)	<60 (<30)	<70 (<20)
Salmonella spp.	<60 (<30)	<60 (<30)	<70 (<20)
Shigella spp.	<30 (<10)	<30 (<10)	-
Vibrio cholerae	<30 (<5)	<30 (<10)	<20 (<10
Entamoebahystolytica cysts	<30 (<15)	<30 (<15)	<20 (<10)
Ascaris-lumbricoides eggs	many months	many months	many months

Note: Figures in bracket shows the normal survival time.
Source: Feachem et al 1983

transport in soils include movement downwards with infiltration water, movement with surface runoff and transport on sediments and waste particles. One of the important processes that control the contamination of groundwater is the adsorption or retention of organisms on soil particles. Another process assisting in the removal of bacteria and viruses from water percolating through the soil is filtration.

5.3.2 Other Risk Factors

Other water quality parameters of concern in sewage/septage reuse are:

i. Toxic metal accumulation in soil
ii. Salinity due to salt present in sewage/septage

The availability of heavy metals to plants, their uptake and their accumulation depend on a number of soil, plant and other factors. The soil factors include, soil pH, organic matter content, cation exchange capacity, moisture, temperature and evaporation. Major plant factors are the species and variety, plant parts used for consumption, plant age and seasonal effects. Dissolved salts causing salinity in sewage/septage exert an osmotic effect on plant growth. An increase in osmotic pressure of the soil solution increases the amount of energy which the plant must expand to take up water from the soil. As a result, respiration is increased and the growth and yield of plants decline. However, it has been found that not all plant species are susceptible. A wide variety of crops normally are tolerant to salinity. Salinity also affects the soil properties such as dispersion of particles, stability of aggregates, soil structure and permeability.

5.4 SEWAGE/SEPTAGE QUALITY STANDARDS IN PRACTICE

Although, no specific standards exists for sewage/septage reuse, however General Effluent Standards notified under Environment (Protection) Act, 1986 (Schedule - VI, Part A, GSR 801(E) dt. 3 1.12.93) by Government of India for disposal on land for irrigation are applicable. These standards specify limits on suspended solids, pH, oil and grease, biochemical oxygen demand, arsenic; cyanide, radioactive substances and toxicity (refer annexure-1). Considering the wide-ranging potential for sewage/septage reuse, it may be difficult to set some common quality standards for all types of reuses. World Health Organization (WHO) and US Environmental Protection Agency (USEPA) have developed detailed guidelines which form basis for many countries to regulate sewage/septage reuse. Standards or guidelines for other possible reuses such as groundwater recharge, industrial uses etc., are not common, mainly because such types of reuses are not widespread. First water quality criteria for reuse of sewage/septage in irrigation were set in 1933, by the California State Health Department. These standards are for microbiological parameters that indicate the presence of pathogenic organisms in sewage/septage. In 1971, the WHO meeting of experts on reuse of sewage/septage recognized that mere presence of pathogens is not sufficient to declare water for reuse as unsafe, and considered that the California standards were overly strict and hindered widespread reuse practice, and recommended a much relaxed microbiological standard for sewage/septage irrigation. Table 5.3 presents the microbiological quality guidelines for sewage/septage reuse in agriculture, recommended by WHO.

a. For example, for secondary treatment, filtration and disinfection: BOD5, <10 mg/l; turbidity, <2 NTU; Cl2 residual, 1 mg/l; pH, 6−9; and faecal coliforms, not detectable in 100 ml (State of California, 2001).
b. When children under 15 are exposed additional health-protection measures should be used (see Section 5.3 for details).
c. A rolling arithmetic mean should be determined throughout the irrigation season. The mean value of ≤1 egg per litre should be obtained for at least 95 per cent of samples in order to allow for the occasional high-value sample (i.e. with >10 eggs per litre) (See Section 5.3).

TABLE 5.3: WHO guidelines for using treated wastewater in agriculture

Type of irrigation	Health-based target for helminth eggs	Required pathogen reduction by treatment (log units)	Verification monitoring level (E. coli per 100 ml)	Notes
Unrestricted	≤1 per litre (arithmetic mean)b,c High-growing crops: d,e No recommendation Low-growing crops:d ≤1 per litre (arithmetic mean) E	4 3 2 4 6 or 7 ≤103	≤103 ≤104 ≤105 ≤103 ≤101 or ≤100	Root crops. Leaf crops. Drip irrigation of high-growing crops Drip irrigation of low-growing crops. Verification level depends on the requirements of the local regulatory agency.
Restricted:	F G H	3 2 0.5	≤104 ≤105 ≤106	Labour-intensive agriculture (protective of adults and children under 15) Highly mechanized agriculture. Pathogen removal in a septic tank.

Source: WHO, 2006

Standards for other polluting parameters are intended to prevent pollutant inputs becoming harmful to consumers of the harvested food, and to the soil. If pollutants are allowed to accumulate in the soil, its potential use, over the long term, may become limited. By regulating land application, accumulation of pollutants in the sewage/septage receiving soil can be prevented. However, it is often argued that reuses regulations based on stringent pollutant loading limits, tend to discourage the land application option. Moreover, such limits do not consider the capacity of soils to attenuate pollutants. Through proper management of land applications, the agronomic benefits of sewage/septage can be realized, and accumulation of pollutants in the soil can be controlled not to reach harmful levels. A comparison of water quality standards for physico-chemical, and toxic polluting parameters for irrigation reuse of sewage/septage in some of the countries of the world is presented in Annexure 2.

5.5 CATEGORIES OF SEWAGE/SEPTAGE REUSE

Wastewater can be recycled/ reused in many ways such as agriculture, aquifer recharge, aquaculture, fire fighting, flushing of toilets, industrial cooling, parks and golf course watering, formation of wetlands for wildlife habitats, recreational impoundments, and essentially for several other non-potable requirements. Potential reuses of sewage/septage depend on the hydraulic and biochemical characteristics of sewage/septage, which determine the methods and degree of treatment required. While agricultural irrigation reuses, in general, require lower quality levels of treatment, domestic reuse options (direct or indirect potable and non-potable reuses) need the highest treatment level. Level of treatment for other reuse options lie between these two extremes. The important reuse categories are summarized in Table 5.4.

5.5.1 Irrigation

Irrigation is the largest user of water in India. It is also estimated that nearly half of the domestic sewage/septage generated in India is used for irrigation. Irrigation reuse is also more advantageous, because of the possibility

TABLE 5.4: Categories of wastewater reuse

Wastewater reuse categories	Issues/constraints
Agriculture irrigation Crop irrigation Commercial nurseries Landscape irrigation Parks School yards Free way medians Golf courses Cemeteries Greenbelts Residential	1. Surface and groundwater pollution if not managed properly 2. Marketability of crops and public acceptance 3. Effect of water quality, particularly salts, on soils and crops 4. Public health concerns related to pathogens (bacteria, viruses and parasites) 5. Use for control of area including buffer zone 6. May result in high user costs
Industrial recycling and reuse Cooling water Boiler feed Process water Heavy construction	1. Constituents in reclaimed wastewater related to scaling, corrosion, biological growth and fouling, 2. Public health concerns, particularly aerosol transmission of pathogens in cooling water
Groundwater recharge Groundwater replenishment Salt water intrusion control Subsidence control	1. Organic chemicals in reclaimed wastewater and their toxicological effects 2. Total Dissolved Solids, nitrates and pathogens in reclaimed wastewater
Recreational/environmental uses Habitat wetlands Lakes and ponds Boating Marsh enhancement Stream-flow augmentation Fisheries	1. Health concerns of bacteria and viruses, 2. Eutrophication due to nitrogen (N) and phosphorus (P) in receiving water, 3. Toxicity to aquatic life
Miscellaneous uses Fire protection Air conditioning Toilet flushing	1. Public health concerns on pathogens transmitted by aerosols, 2. Effects of water quality on scaling, corrosion, biological growth and fouling 3. Cross-connection
Aquaculture	1. Constituents in reclaimed wastewater, especially trace reservoir organic chemicals and their toxicological effects 2. Aesthetics and public acceptance 3. Health concerns about pathogen transmission, particularly viruses

Source: Tchobanoglous and Angelakis, 1996

of decreasing the level of purification, and hence the savings in treatment costs, due to the role of soil and crops as biological treatment facilities. As the water supply requirements of large metropolis are growing, the option of reuse of sewage/septage for domestic purposes is increasingly being considered. Based on international experience, there is potential for reuse at all levels, from household level to the large irrigation schemes. Reuse has advantages as well as disadvantages at each level. The choice is conventionally technical and economic one, though it is important that the community as a whole should become more involved in the working of reuse systems. The major issues of this reuse are:

- surface and groundwater pollution, if poorly planned and managed;
- marketability of crops and public acceptance;
- effect of water quality on soil, and crops;
- public health concerns related to pathogens

However, many research studies have proved that in addition to providing a low-cost water source, other side benefits of using sewage/septage for irrigation include increase in crop yields, decreased reliance on chemical fertilizers, and increased protection against frost damage. A summary of current regulations for reuse of wastewater for irrigation is provided in Table 5.5.

TABLE 5.5: Regulations of different countries for sewage/septage reuse in irrigation

Country	Main regulatory parameters
US EPA	200 FC/100mL + residual chlorine depending on the type of crop.
Cyprus	50–100 FC/100mL and 200–1000 FC/100mL, for areas with unlimited public access, and crop irrigation with limited public access, respectively.
France	200–1000 FC/100mL depending on the type of crop
Israel	120–250 FC/100mL. Regulations for BOD, SS, DO and residual chlorine
Japan	No detectable coliform bacteria for landscape irrigation. Less than 10/mL for reuse as toilet flush
Spain	Less than 1000 FC/100mL and less than 1 nematode per liter
Saudi Arabia	2.2–100 and 23–200 FC/100mL for unrestricted and restricted irrigation, respectively. Intestinal nematodes 1 per liter
Tunisia	Intestinal nematode less than 1 per liter

Source: Vigneswaran and Sundervadivel, 2009

Irrigation of Landscape and Recreational Area

In India, sewage/septage is generally an urban problem and in urban areas the agricultural land is hardly available. Hence the scope for irrigation use is reduced. In such case, application of treated sewage/septage for landscape irrigation includes use in public parks, golf courses, urban green belts, freeway medians, cemeteries, and residential lawns. This type of application is one of the most common applications of sewage/septage reuse worldwide. Examples of such uses can be found in USA, Australia, Japan, Mexico and Saudi Arabia (Vigneswaran et al, 2009). These schemes have been operating successfully in many countries for many years. This type of application has the potential to improve the amenity of the urban environment. However, such schemes must be carefully run to avoid problems with community health. Because the water is used in areas that are open to public, there is potential for human contact, so reuse water must be treated to a high level to avoid risk of spreading diseases. Other potential problems of application for landscape irrigation concern aesthetics such as odor, insects, and problems deriving from build-up of nutrients.

5.5.2 Domestic and Industrial Use

Reuse of wastewater for purposes other than irrigation may be either for:

- industrial reuse;
- non-potable purposes;
- indirect potable purposes; or
- direct potable purposes

a. Industrial Reuse

Industrial reuse of reclaimed wastewater represents major reuse next only to irrigation in both developed and developing countries. Reclaimed wastewater is ideal for many industrial purposes, which do not require water of high quality. Often industries are located near populated area where centralized treatment facilities already generate reclaimed water. Depending on the type of industry, reclaimed water can be utilized for cooling water make-up, boiler feed water, process water etc. Cooling water make-up in a majority of industrial operations represents the single largest water usage. According to former additional director of CPCB, in India many industries located in water scarce areas have already adopted use of treated wastewater as a source of water e.g. Madras Refineries, Madras Fertilizers, Pragati Power Station in Delhi and many more industries are using wastewater at large (personal commuinication). Operational problems encountered in cooling water recirculation systems are irrespective of the quality of make-up water used. They are scaling, corrosion, biological growth, and fouling. A major problem associated with reuse of wastewater will be biofilm growth in the recirculation system. Presence of microorganisms (pathogens or otherwise) with nutrients such as nitrogen and phosphorus, in warm and well-aerated conditions, as found in cooling water towers, create ideal environments for biological growth. The important options to overcome the problems associated with industrial use are summarized in Table 5.6.

TABLE 5.6: Industrial water reuse: concerns, causes, and treatment options

Concerns	Causes	Treatment options
Scaling	Inorganic compounds, salts	Scaling inhibitor, carbon adsorption, filtration, ion exchange, blowdown rate control
Corrosion	Dissolved and suspended solids pH imbalance	Corrosion inhibitor, reverse osmosis
Biological growth	Residual organics, ammonia, phosphorous	Biocides, dispersants, filtration
Fouling	Microbial growth, phosphates, dissolved and suspended solids	Control of scaling, corrosion,microbial growth, filtration chemical and physical dispersants

Source: Asano and Levine, 1998

b. Non-potable Domestic Reuse

Adequately treated wastewater meeting strict quality criteria, can be planned for reuse for many non-potable purposes. Non-potable reuse leads to both: a reduction in water consumption and a reduction in wastewater flow rate. Therefore, non-potable reuse schemes can avoid adverse environmental consequences associated with conventional water sources and wastewater disposal systems. Non-potable domestic reuse can be planned either within single households/building, or on a larger-scale use through a reticulation system meant only for use for non-potable purpose.

Systems for individual households/buildings/facilities

In many parts of the world, it has become apparent that it may not be possible to provide a centralized sewage collection facility for all the households, due to both geographic and economic reasons. Wastewater from individual dwellings and community facilities in such locations with out sewerage connectivity is usually managed by on-site treatment and disposal systems. Although a variety of onsite systems have been used, the most common system consists of a septic tank for the partial treatment of wastewater, and a subsurface disposal field for final treatment and disposal. By segregating the "grey" sullage from "black" toilet wastes, potential for reuse with minimal treatment within the household enhances manifold. There are several different schemes for reusing grey water at the household levels. In California, systems which use grey water treated to a primary level for subsurface irrigation of gardens have been in use for many years, and studies have shown no health problems associated with the use. In areas of Australia which are not sewered, water scarce conditions in some regions of Victoria have prompted interest in grey water recycling for garden irrigation (WHO 2006). Collection and recycling systems for bathroom and laundry water have recently been tested in Victoria. A simple valve arrangement for diversion of laundry grey water for garden watering has been developed. Australian authorities are currently considering the introduction of comprehensive guidelines for grey water recycling systems in individual households. When the grey water is not separated from toilet wastes, improvements in the quality of treated wastewater can be brought about by many alternative ways. One of the alternatives includes intermittent and recirculation granular-medium filters. The effluent from a recirculation filter has been found to be of such high quality, it can be used in a variety of applications, including drip irrigation. In Japan, the major in-house grey water reuse system is the hand basin toilets, which uses a hand basin set on the top of the cistern, so the water from hand washing forms part of the refill volume for toilet flushing. Hand basin toilets are reportedly installed in most new houses in Japan (WHO 2006).

Large-scale non-potable reuse through a dual reticulation system

A dual reticulation system is the wastewater reuse concept for urban areas where a centralized sewage collection system is in place, on a large scale. This system supplies treated wastewater to houses, and commercial/official/shopping complexes through a separate water supply network, to be used primarily for toilet flushing, and irrigation of lawns. Thus, households will have two water supply lines, one for potable and human-contact use purposes, and the second for non-potable, non-contact uses such as toilet flushing, use in the yards and gardens etc., hence the name "dual reticulation system." Such systems are in practice in Tokyo, Japan.

c. Indirect Potable Reuse

Indirect potable reuse of treated wastewater may occur unintentionally, when wastewater is disposed into a receiving water body that is used as a source of potable water supply like Yamuna River used in Delhi, Mathura and Agra. It can also be through planned schemes, such as that of Cerro del la Estrella sewage treatment plant in Mexico City. In Mexico City, treated wastewater which meets the criteria for potable reuse except for total dissolved solids, is diluted by water from other sources to meet these criteria, and used for potable purposes. Another planned indirect potable reuse can be through groundwater recharge of treated wastewater. Deliberate (artificial) recharge of groundwater aquifers with treated wastewater can be carried out to achieve one or more of the following objectives:

- as storage during periods of low water demand;
- as an additional treatment method;
- as a measure to recharge depleting groundwater
- as a measure to improve the overall quality of groundwater by injecting reclaimed water of specific qualities.

5.5.3 Septage Sludge Reuse

Wastewater sludge is the solid/semi-solid substance, concentrated form of mainly organic, and some inorganic pollutants, generated because of treatment of wastewater. With the expansion of sewerage, system comes the ever-increasing problem of how best the sludge generated in wastewater treatment facilities can be disposed.

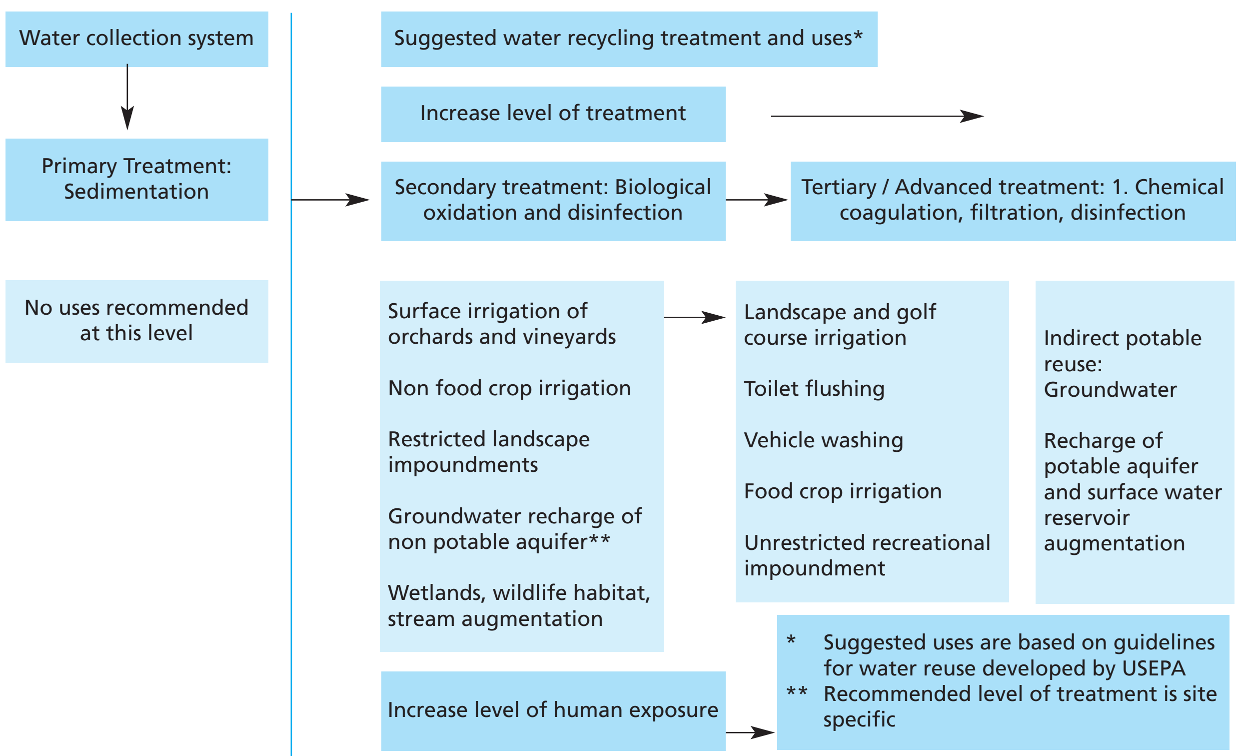
It is traditionally suggested that the sludge can be applied on land as soil conditioner and as fertilizer; however there are concerns involved in its handling, transportation, and odor nuisance because open disposal of sludge poses threat to health and environment. Thus the need of proper treatment of sludge is a prerequisite for its reuse (USEPA, 1984).

Properly treated sludge can be reused to reclaim parched land by application as soil conditioner, and as a fertilizer in agriculture. Deteriorated land areas, which cannot support the plant vegetation due to lack of nutrients, soil organic matter, low pH and low water holding capacity, can be reclaimed and improved by the application of sludge. Sewage sludge has a pH buffering capacity resulting from an alkalinity that is beneficial in the reclamation of acidic sites, like acid mine spoils, and acidic coal refuse materials. Sludge with a solid content of 30 percent or more handled with conventional end-loading equipment, and applied with agricultural manure spreaders. Liquid sludge, typically with solid content less than 6 percent managed and handled by normal hydraulic equipment. Agricultural use of sludge matches best with priorities in waste management. Sewage sludge contains nutrients in considerable amounts, which lead to fertilization of soil and organic matters that improve the soil through humic reactions.

5.6 WASTEWATER TREATMENT-TECHNOLOGICAL OPTIONS

It is important to identify technologies suitable for delivering different qualities of treated water, both conventional (secondary) and advanced (including disinfection). Based upon different reuse applications, suitable treatment should be given to meet international guidelines and standards (see Figure 5.1).

FIGURE 5.1: Suggested treatment for wastewater reuse applications



Source: USEPA, 1998

5.6.1 Wastewater treatment technologies

Several wastewater treatment systems are in use ranging from conventional low cost and small systems to large, expensive systems each having its distinct advantages and disadvantages. In the present scenario, emphasis has to be laid upon on site treatment of wastewater rather than offsite treatment. Various technologies such as up flow Anaerobic Sludge Blanket (UASB), Rotating Biological Contractors (RBC), Sequencing Batch Reactor, Membrane Bio- Reactors (MBR), Submerged Aeration Fixed Film (SAFF) etc. could effectively be implemented at small scale to recycle and reuse the wastewater at local levels.

It is equally important to explore the alternative natural technologies for wastewater treatment such as Root Zone Treatment Systems (RZTS)/ constructed wetlands, Soil Biotechnology (SBT), Decentralised Wastewater Treatment Systems (DWWTS), Duckweed Pond System (DPS) and Bioremediation. These technologies adopt the science from old practices and improve the treatment process. They are designed to enhance the natural aerobic and anaerobic processes and create conditions in which wastewater can be treated with the least use of energy and machines. Annexure 5 provides a comparative analysis of different technologies commonly used for treating wastewater.

5.6.2 Pathogen Reduction

Disinfection is most commonly used technology and an essential step prior to wastewater reuse in order to minimize environmental and health risks. The main purpose of disinfection is to kill or inactivate pathogenic microorganisms, viruses and parasites from treated water. Commonly, disinfection is carried out using strong oxidizers such as chlorine, ozone and bromine, but they do not inactivate helminth eggs. Chlorine is the most common chemical widely used for disinfection since it is relatively inexpensive and can also be produced easily as a by-product of other industrial processes, such as caustic soda production. Chlorine must be injected in the appropriate dosage and for the appropriate contact time, depending on the targeted water quality and microorganisms. The effectiveness of chlorine is influenced by the presence of suspended solids, organic matter and ammonia in water. Suspended solids act as a shield for microorganisms from chlorine. In wastewater reuse, chlorine can act not only to secure the safety of recycled water but also to control biological growth such as slime formation in water distribution pipes. Chlorine residuals that remain in wastewater can prolong disinfection even after initial treatment. On the other hand, the residual chlorine may have negative effects on some applications of reuse, such as crop irrigation, as well as the aquatic environment. The injection of reducing agents such as Sulphur dioxide or carbon absorption can be used for de-chlorination (USEPA, 1999a). However, the de-chlorination process could be costly and might increase the cost of wastewater treatment so much as to make it unaffordable for agricultural purposes.

Ultraviolet (UV) radiation has been recognized as one of the viable alternatives for disinfection. UV radiation is a physical disinfection. It penetrates the cell wall of a microorganism in wastewater and destroys the cell's ability to reproduce. It does not produce by-products such as Trihalomethanes and it leaves no residual effect. The effectiveness of disinfection depends on some factors including the intensity of UV radiation and the amount of exposure time (USEPA, 1999c).

Ozone is also used for disinfection. It is a strong oxidizer, and is more effective than chlorine in destroying viruses and bacteria. However, an ozone generator is relatively expensive and is not readily available.

In addition, coagulation with high-alkaline chemicals, such as lime, can show disinfection effects, even though treated wastewater needs to be neutralized before discharge. Membrane filtration also has a function of disinfection by removing bacteria and viruses. In order for any disinfectant to be effective, it is important that wastewater is adequately treated prior to disinfection. For example, coagulation, sedimentation or sand filtrations are common treatment methods prior to disinfection. While these treatments remove suspended solids, they can also remove protozoan cysts and bacteria to a significant degree. Highly treated water will maximize the effectiveness of the following disinfection process, and minimize generation of by-products in chlorine disinfection. Based on the evaluation of advantages and disadvantages, the most appropriate technology may be selected for effective disinfection.

The removal of helminth eggs is an important concern in India. Helminth ova possess a shell that consists of three basic layers secreted by the egg itself: a lipid inner layer, a chitinous middle layer, and outer protein layer. All these layers give high resistance to eggs under several environmental conditions. Helminth eggs of concern in wastewater used to irrigate have a size between 20-80 µm, a relative density of 1.06-1.15 and are very sticky. All these three properties determine the helminth ova's behavior during treatment (Jimenez, 2005). It is very difficult to inactivate them, unless temperature is risen above 40°C or moisture is reduced to less than 5 percent conditions that are not often achieved in wastewater treatment but are common in sludge treatment. Thus, in wastewater it is not common to inactivate helminth ova but to remove them. This is done by processes that remove particles through sedimentation (in stabilization ponds, or coagulation flocculation) or through filtration. Helminth ova removal from different processes is shown in Table 5.8

TABLE 5.8: Pathogen removal achieved by selected wastewater treatment processes

Treatment process	Helminth ova/eggs removal
Waste Stabilization ponds	Excellent
Waste storage and treatment reservoirs	Good
Constructed wetlands	Good
Primary sedimentation	Medium
Advanced Primary treatment	Excellent
Anaerobic up flow sludge blanket	Medium
Activated sludge + secondary sedimentation	Good
Trickling filter + secondary sedimentation	Good
Aerated lagoon or oxidation ditch + settling pond	Excellent
Tertiary coagulation flocculation	Excellent
High rate or slow rate sand filtration	Excellent

Source: UNEP, 2004

5.7 PROPOSED GUIDELINES

For any septage/sewage reuse programme a careful consideration of the local conditions is needed. It must be based on the sufficient and well-integrated analysis of technology options, financial implications, health risks mitigation, and other factors. Following guidelines are proposed:

5.7.1 Initial Planning

The first step in designing a wastewater reuse programme is to carefully evaluate the appropriateness of water and wastewater reuse applications needs against the volume of available wastewater, degree of water scarcity, availability of existing infrastructure, and receptivity of potential users. The purpose of the application, such as irrigation, industrial use, landscape, and household use, needs to be evaluated together with the water quality requirements and associated health risk. Such evaluation is useful in identifying necessary treatment and disposal technologies, as well as operational and maintenance requirements. Public perception and receptivity also need to be analyzed carefully. The public should be recognized as legitimate stakeholders, and their roles and responsibilities should be clearly defined in the planning process.

5.7.2 Financial Requirements

Economic and financial analyses are also needed to identify viable solutions and to access financial assistance when necessary. While wastewater reuse programmes have many benefits and long-term cost effectiveness, they may have a high initial cost associated with additional treatment and infrastructure needs, such as additional treatment, pumps, pipes, reservoirs, and so on. Alternatives to address this impediment, such as public assistance, incentives, and preferential private sector financing, must be explored. The decision-makers and the users should be aware of the impact on water prices resulting from wastewater reuse projects.

The cost involved in building and maintaining wastewater treatment plants, and installing water distribution lines for reuse is very high. Financing such services from exchequer's fund could be detrimental to the national economy. Hence it is important that such services are fully charged to the beneficiaries. In view of water scarcity in many parts of the country, this can be a cheaper option to augment water availability in many parts of the country than bringing water from distant places. However, by decentralised wastewater treatment systems and planning for reuse near to the source can considerably redue the related costs of wastewater treatment including reuse. Locally controlled funds or small-scale financing mechanisms (i.e. microcredit schemes) may also be established to facilitate financing. Along with the introduction of financing mechanisms, a capacity to understand and access such services needs to be fostered among utilities and potential wastewater users.

5.7.3 Setting National standards on reuse of wastewater

One of the most important factors in wastewater reclamation projects is complying with standards to minimize health risks, or establishing them if they do not exist While the WHO guidelines for agricultural applications of wastewater are available, there are no international guidelines or criteria for other types of wastewater reuse. Therefore, it is important to evolve national standards for septage/sewage reuse in India considering health risks as well as technical and economic feasibility. Technological options should be explored and suitable technology should be selected to meet such guidelines and standards and ensure the protection of human health and the environment.

5.7.4 Setting Institutional Mechanism

Wastewater reuse involves many stakeholder institutions, such as utilities and private users that implement the initiative, Ministry of Environment and Forests, Government of India, Central Pollution Control Board, State Pollution Control Boards, urban local bodies and other authorities for permits and enforcement, financial institutions for provision of funding. Their responsibilities and roles for facilitating reuse programmes need to be identified and understood clearly. In many cases, institutions need to be supported or newly established.

Many cities and towns in India have already well organized institutions for water supply, those for wastewater collection treatment and disposal may not exist at all. For providing effective waste management and reuse of wastewater services, it is very important that a well organized institutional arrangement is established. The institutional arrangement should ensure the credibility and responsibility within its target community, and developing a client-oriented organizational structure. In order to undertake wastewater reclamation projects, it is necessary to examine relevant existing institutions and strengthen them, or to create new ones and assign adequate mandates and responsibilities. It may also be worthwhile establishing collaborative frameworks with other reclamation and reuse programmes particularly with industries to achieve a critical mass for service provision.

5.7.5 Human Resources Development

Building technical and managerial capacity for operating septage and sewage management and reuse programmes is a critical necessity, due to the variable qualities of source of septage/sewage reuse and the complexity of processes. Analytical and problem-solving skills, as well as the ability to maintain and manage technologies, systems and organizations, need to be fostered. Well-trained personnel, including engineers, scientists and technicians, are necessary for successful water and wastewater recycling projects. In some organizations, resource constraints may force staff with limited training to assume supervisory and management positions, posing a challenge to implementing effective programmes. Following steps are essential to develop human resources effectively:

- Carrying out internal human resource development by training courses and on-the-job training;
- Developing human capabilities through hiring and retention of qualified personnel.

In addition, care should be taken to favour operations that enhance, rather than diminish, employment opportunities, and to utilize reliable mechanisms that can be maintained by a locally trained labour force. Community-level training is also important, as many water reuse and recycling techniques involve actions at a household or shop-floor level. Training materials and methods need to be tailored to meet the needs and qualifications of the target audience.

5.7.6 Development of Policy and Legal Framework

It is important to develop policy and law at national, state and city levels. Septage/sewage reuse projects must include regulatory mechanism to ensure the protection of human health and the environment. Necessary regulations may include permit systems to authorize wastewater discharges, technical specifications on wastewater treatment, reclaimed water quality standards for various applications, and regulations on disposal of waste (sludge, brine, etc.) from treatment. In water scarce areas, water reuse requirements or the installation of a reuse infrastructure may also be introduced. Mechanisms to enforce these regulations are also necessary, including required and voluntary monitoring, inspection programmes with adequate staffing, and clear authority to assess and collect fines and penalties. Incentives, such as grants and low-interest loans, flexible permits and priority access to the infrastructure, may also be effective in increasing interest in wastewater reuse.

5.7.7 Public Awareness

In view of water getting scarce in most parts of the country, it is very important that the public is made aware of importance of water conservation and its reuse. They should be made aware of present and future scenario of water shortages and encouraging their participation in remedial action is crucial in the implementation of wastewater reuse. The issue is of particular importance for water reuse for indirect and direct potable use, including groundwater recharge, as many initiatives have been delayed due to public resistance and legal action. To raise the awareness of stakeholders and ensure that their voices are heard, the decision-making process needs to be participatory, with clearly outlined roles and responsibilities. Proactive public outreach initiatives, such as publications, public announcements, and site visits, are some of the main means to secure wider public acceptance and support.

Civil society organizations usually play an important role in undertaking various activities aimed to raise public awareness. In some countries, local governments and local politicians also take part directly to raise the public awareness of water conservation, better usage to improve public health, and recycling water for secondary uses. Public participation can be scaled-up by bringing the community into the decision-making process. Their participation in the decision-making process also improves public participation in the implementation process. Public participation can be aimed at different objectives including the payment of user charges, conservation, minimizing unaccounted for water rates, recycling and reuse of water, and ownership and operation of the small projects, mainly in slums or peri-urban areas.

5.7.8 Promotion of onsite wastewater treatment and reuse

Finding a local reuse option is difficult in the centralized treatment of wastewater as the quantum of treated wastewater is high. As such it requires a new network for the distribution of treated effluent to various places, thereby increasing the cost besides transmission losses. While, in decentralized systems, the treated wastewater is recycled / reused on site for irrigation, toilet flushes and cooling towers. Such systems can be set up locally in offices, individual houses and institutions, thereby reducing the extra burden of laying of separate pipelines. They are not only easy to operate and maintain but also have good efficiency. Adoption of wastewater treatment systems at institutional and community level will not only reduce the load on existing STPs but also help in recycling and reuse of wastewater in an economical and sustainable way. Several cities already have incorporated recycling and reuse of wastewater in their building bye-laws (see Annexure 6- Delhi, Bengaluru, Rajkot, Chennai, and Chandigarh).

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Annexure

Annexure 1: General Effluent standards by Government of India

General effluent standards
Schedule - VI, Part A, GSR 801(E) dt. 3 1.12.93.

Parameter	Unit	Standards			
		Inland surface water	**Public sewer**	**Land for irrigation**	**Marine coastal areas**
Colour and odour		All efforts should be made to remove colour and unpleasant odour as far as practicable.	-	All efforts should be made to remove colour and unpleasant odour as far as practicable.	All efforts should be made to remove colour and unpleasant odour as far as practicable.
Suspended solids		100	600	200	a) For process effluent—100 b) For cooling water - 10 percent above total suspended matter of influent
Particle size of Suspended solids	-	Shall pass 850 micron IS sieve	-	-	a) Floatable solids–max. 3 mm b) Settleable solids–max. 850 µm.
pH	-	5.5 to 9	5.5 to 9	5.5 to 9	5.5 to 9
Temperature	°C, max.	Shall not exceed 5 0C above the receiving water temperature	-	-	Shall not exceed 5°C above the receiving water temperature
Oil and grease	mg/l, max.	10	20	10	20
Total residual chlorine	mg/l, max.	1	-	-	1
Ammoniacal nitrogen (as N)	mg/l, max.	50	50	-	50
Total kjeldahl nitrogen (as N)	mg/l, max.	100	-	-	100
Free ammonia (as NH_3)	mg/l, max.	5	-	-	5
Biochemical oxygen demand (3 days at 270 C)	mg/l, max.	30	350	100	100
Chemical oxygen demand	mg/l, max.	250	-	-	250

Annexure 1: General Effluent standards by Government of India

General effluent standards
Schedule - VI, Part A, GSR 801(E) dt. 3 1.12.93.

Parameter	Unit	Standards			
		Inland surface water	Public sewer	Land for irrigation	Marine coastal areas
Arsenic (as As)	mg/l, max.	0.2	0.2	0.2	0.2
Mercury (as Hg)	mg/l, max.	0.01	0.01	-	0.01
Lead(as Pb)	mg/l, max.	0.1	1	-	2
Cadmium (as Cd)	mg/l, max.	2	1	-	2
Hexavalent chromium (as Cr + 6)	mg/l, max.	0.1	2	-	1
Total chromium (as Cr)	mg/l, max.	2	2	-	2
Copper (as Cu)	mg/l, max.	3	3	-	3
Zinc (as Zn)	mg/l, max.	5	15	-	15
Selenium (as Se)	mg/l, max.	0.05	0.05	-	0.05
Nickel (as Ni)	mg/l, max.	3	3	-	5
Cyanides (as CN)	mg/l, max.	0.2	2	0.2	0.2
Fluorides (as F)	mg/l, max.	2	15	-	15
Dissolved Phosphates (as P)	mg/l, max.	5	-	-	-
Sulphides (as S)	mg/l, max.	2	-	-	5
Phenolic compounds (as C_6H_5OH)	mg/l, max.	1	5	-	5
Radioactive materials: a) Alpha emitters b) Beta emitters	Micro curie/ml, max.	10-7 10-6	10-7 10-6	10-8 10-7	10-7 10-6
Bioassay test	-	90% survival of fish after 96 h in 100% effluent	90% survival of fish after 96 h in 100% effluent	90% survival of fish after 96 h in 100% effluent	90% survival of fish after 96 h in 100% effluent
Manganese (as Mn)	mg/l, max.	2	2	-	2
Iron (as Fe)	mg/l, max.	3	3	-	3
Vanadium (as V)	mg/l, max.	0.2	0.2	-	0.2
Nitrate nitrogen (as N)	mg/l, max.	10	-	-	20

Annexure 2: Comparative standards applicable in different countries for Septage, manure and leachate

Parameters	Canada	USA	Taiwan	Hungary	China	Saudi Arabia	Tunisia	India	India
	All soils	Sandy soils	All soils	All soils	Paddy crop	Vegetables	All soils	All soil	Leachate
PH	-	6.0-9.0	6.5-8.5	5.5-8.5	5.5-8.5	6.0-8.4	5.5-9.0	6.5-8.5	5.5-9.0
Total dissolved solids, mg/L	500-3500	-	-	-	1000-2000	1000-2000	-	-	2100
Suspended solids, mg/L	-	-	100	-	150	200	10	20030	-
Chloride, mg/L	-	-	175	-	250	250	280	-2000	600
Sulphate, mg/L	-	-	200	-	-	-	-	-	-
BOD, mg/L	-	-	-	-	80	80	10	100-	100
COD, mg/L	-	-	-	-	200	150	-	-90	-
Aluminum, g/L	-	5000	5000	5000	-	-	5000	-	-
Arsenic, g/L	100	100	1000	200	50	50	100	200100	200
Boron, g/L	500-600	750	750	700	1000-3000	1000-3000	500	-3000	-
Beryllium, g/L	100	100	500	100	-	-	10	-	-
Cadmium, g/L	10	10	10	20	5	5	100	-10	-
Chromium (total), g/L	100	100	100	5000	100	100	50	-100	-
Cobalt, g/L	50	50	50	50	-	-	400	-100	-
Copper, g/L	200-1000	200	200	2000	1000	1000	-	-500	-
Iron, g/L	200	5000	2000	100	-	-	5000	-5000	-
Lead, g/L	-	200	-	1000	-	-	-	1000	-
Manganese, g/L	-	-	-	10	-	-	200	-500	-
Mercury, g/L	10-50	10	5	0	1	1	1	-1	-
Molybdenum, g/L	200	200	10	1000	-	-	100	-	-
Nickel, g/L	-	20	-	-	-	-	200	-200	-
Selenium, g/L	20-50	-	-	5000	20	20	20	-50	-
Zinc, g/L	1000-5000	2000	5000	10000	2000	2000	4000	-5000	-
Cyanide (total), g/L	-	-	-	-	500	500	500	200	200
Oil and grease, g/L	-	-	5000	50000	5000	5000	5000	10000	5000
Surfactants, g/L	-	-	-	-	-	-	-	-	-
Radioactive – alpha emitters	-	-	-	-	-	-	-	10	-8
Radioactive – beta emitters	-	-	-	-	-	-	-	10-7	-
Bioassay	-	-	-	-	-	-	-	90% fish survival in 96 hrs	-
C/N Ratio	-	-	-	-	-	-	-	-	-

Source: Adopted from Andrew C. C., Albert L. P., Asano T., and Hesphanhol I., "Developing human health related chemical guidelines for reclaimed wastewater irrigation," Water Science & Technology, 33(10–11), 463–472

Annexure 3: Standards for compost quality notified under MSW Rules 2000

Parameters	Concentration not to exceed * (mg/kg dry basis , except pH value and C/N ratio)
Arsenic	10.00
Cadmium	5.00
Chromium	50.00
Copper	300.00
Lead	100.00
Mercury	0.15
Nickel	50.00
Zinc	1000.00
C/N ratio	20-40
PH	5.5-8.5

Annexure 4: Standards for Leachate Quality from solid wastes dump sites as notified under MSW Rules 2000

Parameter	Standards (Mode of Disposal)		
	Inland surface water	Public sewers	Land disposal
Suspended solids, mg/l, max	100	600	200
Dissolved solids (inorganic) mg/l, max.	2100	2100	2100
PH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
Ammonical nitrogen (as N), mg/l, max.	50	50	-
Total Kjeldahl nitrogen (as N), mg/l, max.	100	-	-
Biochemical oxygen demand (3 days at 270 C) max.(mg/l)	30	350	100
Chemical oxygen demand, mg/l, max.	250	-	-
Arsenic (as As), mg/l, max	0.2	0.2	0.2
Mercury (as Hg), mg/l, max	0.01	0.01	-
Lead (as Pb), mg/l, max	0.1	1.0	-
Cadmium (as Cd), mg/l, max	2.0	1.0	-
Total Chromium (as Cr), mg/l, max.	2.0	2.0	-
Copper (as Cu), mg/l, max.	3.0	3.0	-
Zinc (as Zn), mg/l, max.	5.0	15	-
Nickel (as Ni), mg/l, max	3.0	3.0	-
Cyanide (as CN), mg/l, max.	0.2	2.0	0.2
Chloride (as Cl), mg/l, max.	1000	1000	600
Fluoride (as F), mg/l, max	2.0	1.5	-
Phenolic compounds (as C6H5OH) mg/l, max.	1.0	5.0	-

Annexure 5: Comparative analysis of various technologies

Process technology type	Land requirement	Operation and maintenance cost	Energy requirement	Capital cost	Effluent quality	Distinct advantage
Activated Sludge Process	0.15 to 0.25 hectares / MLD installed capacity	Rs 0.3 to 0.5 million / year/ MLD installed capacity	180 to 225 Kwh/ ML treated	Rs 2 to 4 million/ MLD capacity	BOD: 10-20 mg/L Suspended solids(SS): 20 to 50 mg/L	Land requirement is very less and performance is not affected by normal variation in waste water characteristic
Trickling Filter (TF)	0.25 TO 0.65 hectares / MLD installed capacity	Slightly lower than ASP	180 Kwh/ML treated	Relatively lower than ASP	Comparable to ASP	Rugged system with simple and silent operation
Waste Stabilization Ponds (WSP)	0.8 to 2.3 hectares/ MLD installed capacity	Rs 0.06 to 0.1 million/year/ MLD installed capacity	Energy required for the operation of screen and grit chamber, negligible as compared to ASP	Rs 1.5 to 4.5 million/MLD capacity	BOD: 30-50 mg/L Suspended solids(SS): 75 – 125 mg/L The color of the water is greenish	Very easy operation and maintenance
Upflow anaerobic sludge blanket (UASB)	0.2 to 0.3 hectares/MLD installed capacity	Rs 0.08 to 0.17 million/ year / MLD installed capacity	10 to 15 KWh / ML sewage treated	Rs 2.5 to 3.5 million/MLD installed capacity	BOD: 30-40 mg/L Suspended solids(SS): 75 – 100 mg/L	Can absorb hydraulic and organic shock loading. Sludge handling is minimal
Rotating 1biological contractor (RBC)	NA	NA	Very low as compared to ASP	NA	Comparable to ASP	Ease of installation and commissioning. Simple to operate and maintain
Sequencing Batch Reactor (SBR)	0.1 to 0.15 hectares/ MLD installed capacity	Higher than ASP	150 to 200 KWh/ML treated	Higher than ASP	BOD< 5 mg/L Total Suspended solids (TSS): <10mg/L	The process is time controlled and flexible
Fluidized Aerobic Bed (FAB)	0.06 Hectares / MLD installed capacity	0.5 – 0.75 million/year/ MLD installed capacity	99-170 KWh / ML sewage treated	3-5 million/ MLD installed capacity	BOD < 10mg/L Suspended solids(SS): <20mg/L	No sludge recycling and monitoring of MLSS required
Submerged Aerobic Fixed Film (SAFF) reactor	0.05 hectares / MLD installed capacity	1.14 million/ year /MLD installed capacity	390 KWh /ML treated	Rs 7 million / MLD installed capacity	BOD < 10mg/L Suspended solids(SS): <20mg/L	More compact than the conventional STP’s
Membrane bioreactor (MBR)	0.035 hectares / MLD installed capacity	Rs 0.6 to 0.75 million/ year / MLD installed capacity	180 to 220 KWh/ ML treated	Rs 3-5 million/ MLD installed capacity	BOD < 5 mg/L Suspended solids(SS): <10mg/L colorless water is obtained	Highest effluent quality for reuse and very high life cycle cost

Continued on next page

Annexure 5: Comparative analysis of various technologies

Process technology type	Land requirement	Operation and maintenance cost	Energy requirement	Capital cost	Effluent quality	Distinct advantage
Septic tank with soak pit	0.2 hectares / MLD installed capacity	NA	Very low power required	Rs 1 million/ MLD installed capacity	BOD < 10mg/L Suspended solids(SS): <20mg/L	Little space required, simple and durable
Duckweed pond system (DPS)	2-6 hectares / MLD installed capacity	Rs 0.18 million/ year / MLD installed capacity	It is much less as compared to ASP	Is of the same order as WSP with an additional cost floating material	BOD < 10mg/L Total Suspended solids(TSS): <10mg/L	Easy to harvest, les sensitive to surrounding environmental conditions
Root zone treatment system (RZT)	0.1 to 0.2 hectares /MLD installed capacity	Rs 0.05 million/ year /MLD installed capacity	Energy requirement is very low	Rs 1 – 1.5 million/ MLD installed capacity	BOD < 5 mg/L Suspended solids (SS): <10mg/L. colorless water is obtained	Low cost, natural looking and high pathogen removal
Anaerobic baffled reactor + RZTS	0.7 to 0.8 hectares /MLD installed capacity	Rs 0.01 million/ year /MLD installed capacity	These systems do not rely on systems driven by machines and electricity	Rs 1 million/ MLD installed capacity	BOD < 5 mg/L Suspended solids(SS): <10mg/L	Less dependence on electricity and easily fits into landscaping

Source: 1. Compendium of Sewage Treatment Technologies by Vinod Tare and Purnendu Bose
2. Report on "SBR Technology: An Appraisal" by Dept. of Civil Engg., IIT Roorkee
3. "Do-it-yourself: reuse and recycle waste water" by CSE Publications.

Annexure 6: Building Bye-Laws

1. DELHI

Ministry of Urban Development & Poverty Alleviation (Delhi Division), Govt. of India by its notification dated 28.7.2001 had made modification / additions in the building bye-laws 1983 as under; Clause 22.4 Part-III (Structural Safety and Services) of the Building Bye-laws, 1983:

22.4.2: All buildings having a minimum discharge of 10,000 liters and above per day shall incorporate waste water-re-cycling system. The recycled water should be used for horticultural purposes.

The above amendments have been endorsed by Municipal Corporation of Delhi.

To enforce amendments in building bye laws regarding water harvesting and recycling of waste water, instructions were issued vide letter numbers D. No. DJB/DOR/06/20275 to 20288 dated 12.01.2007, by the Director of Revenue, Delhi Jal Board, which provided that "while sanction of individual domestic (8mm) water connection is accorded for a new house a certificate is to be given by the concerned ZE, DJB (in case of Bulk Connection, it is to be given by the concerned EE & SE, DJB) to the effect that applicant has provided the requisite systems as provided in the building plans sanctioned by the MCD/DDA/any other land developing authority, in accordance to modifications in the building bye laws-1983 under clause 22.4.1 and 22.4.2."

2. BENGALURU

BMWSSB, Bengaluru To ensure use of recycled water and prevent over-exploitation of ground water has drawn up a plan to put in place a dual water supply system in all new layouts and apartment complexes coming up in the city.

The BWSSB has asked the Bengaluru Development Authority (BDA) to set up a dual water supply system in all its new layouts. The BDA has decided to put up separate lines for potable and recycled water in all its new ventures.

The builders of over 30 new apartment complexes coming up in and around the city have been asked to install dual lines for potable and recycled water.

BWSSB is stressing on the use of recycled water for all construction activities.

3. RAJKOT

In August 2009, RMC amended building bye laws, making it mandatory, the recycling and reuse of waste water for the buildings. The use of potable domestic water for non potable uses like car washing, gardening, construction purposes, landscaping, irrigation uses is forbidden by virtue of powers vested with government

The essential parts of a recycling system will be separate pipes for collecting grey water. The term grey water refers to the waste water generated from bathroom, laundry and kitchen.

Treated grey water is pumped to a separate tank on the roof from where grey water will be supplied to toilets, garden taps, car washing taps etc. This treated grey water may be used for ground water recharge. Only water from toilets should be let in to sewerage system.

The corporation may in exceptional cases due to dearth of land or water logged areas exempt (with the approval from Municipal Commissioner) from providing facility for recycling the grey water.

The water generated after treatment should be safe for its use for flushing toilets, car washing, gardening etc. The company or the agency engaged for installation of system for recycling of waste water shall preferably confirm IS0:14000.

Provision may be made for checking the quality of recycled water with Water testing laboratory with Municipal Corporation at very nominal rates.

4. CHENNAI

City Corporation building rules way back in June 2003 clearly mandated wastewater recycling. The amended rules state that only the water from toilets must be the outlet to the sewer system. In case of ordinary buildings (ground-plus-one and residential buildings of four dwelling units), the grey water should be used for groundwater recharge after a simple organic filtration. In case of multi-storied apartments, the rules say that the recycled water should be used for toilet flushing.

Grey water recycling has been implemented for an eight-apartment complex in West Mambalam. For treatment chamber, bricks and pebbles were used in addition to charcoal and blue metal.

The Corporation has given permission to the households to construct the recycling pits on the pavements, where space is a problem.

The Corporation zonal officers have been sensitised on the programme. Corporation officials hope that the city’s beautification programme would receive a fillip through wastewater recycling.

One important outcome of the scheme, if implemented by several residents, would be a reduction of nearly 60 per cent of water reaching the sewer system.

5. CHANDIGARH

The city had come out with byelaws on reuse of recycled water since 1990.

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