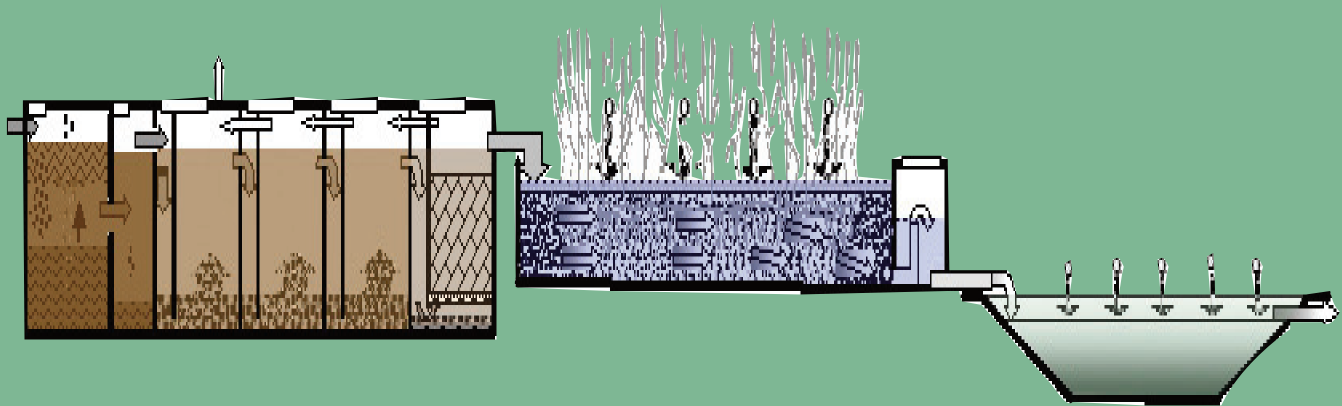
Decentralised Wastewater Treatment

A Way to Manage Septage in Shimla



CENTRE FOR SCIENCE AND ENVIRONMENT
New Delhi

We are grateful to the Ministry of Urban Development, Government of India for their support to CSE as a Centre of Excellence for Sustainable Water Management.

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Cover photo shows a DEWATS comprising of baffled reactor, rootzone treatment and polishing pond

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Abbreviations

BOD	Biological Oxidation Demand
COD	Chemical Oxidation Demand
CSE	Centre for Science and Environment
DEWATS	Decentralized Waste Water Treatment System
DPR	Detailed Project Report
EM	Effective Micro-organisms
HGF	Horizontal Gravel Filter
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LPCD	Liters Per Capita per Day
MC	Municipal Corporation
MLD	Million Litres per Day
MoUD	Ministry of Urban Development
O & M	Operation and Maintenance
SBT	Soil Biotechnology
SMC	Shimla Municipal Corporation
SPA	Shimla Planning Area
STP	Sewage Treatment Plant
TSS	Total Suspended Solids
UASB	Up-flow Anaerobic Sludge Reactor
WWTP	Waste Water Treatment Plants

Executive Summary

1. This is a proposal from the Centre for Science and Environment (CSE) for the implementation of decentralised wastewater technologies in the municipal zones of Shimla where currently centralised sewage treatment systems do not exist.

2. CSE has been recognized by the Ministry of Urban Development as a Centre of Excellence in the area of water management. As part of its activities, the Ministry has approved a proposal for CSE to take up the city of Shimla as a pilot case to implement decentralised wastewater treatment technologies.

3. The Municipal Corporation(MC) of Shimla is currently one of the 63 JNNURM cities and is in the process of implementing reforms measures under the programme. The Detailed Project Report for the rehabilitation of the existing sewerage network and addition of new network and sewage treatment plants is in process.

4. The first sewerage system was laid in Shimla in 1880 for a population of about 16,000 people leading to 5 disposal points based on septic and sedimentation tanks. In 2005, the MC undertook an augmentation of the sewerage network by laying new lines and constructed 6 new sewage treatment plants with an installed capacity of 35.63 mld at Lalpani, Summer hill, North disposal, Dhalli, Sanjauli-Maliyana and Snowdon.

5. However,
   - the old sewerage lines were not adequately connected to the new network.
   - some areas in North Disposal, Dhalli & Sanjouli-Malyana are situated below the sewer network.
   - the old sewer pipes have become unusable in some of the areas as they are leaking or choked and need to be rehabilitated.
   - There is no piped sewerage system for zones of Totu and Jutog.

6. The net result is that the new treatment plants receive only 4.8 mld for treatment.

7. The key proposals of the DPR for implementation under the JNNURM are as follows:
   - Rehabilitation of the main sewerage network
   - Provision of sewerage network for areas of Dhalli, Tutu, New Shimla and special areas of Ghanahatti, Kufri and Shoghi
   - Provision of missing links to connect the refurbished old sewerage network with new sewerage network.

8. The total estimated capital cost of the entire project is Rs. 164.48 crore. The annual maintenance and operational (O & M) cost is estimated to be Rs. 4.56 crore.

9. **CSE's proposal**: CSE proposes that in the new areas where there is no centralised sewerage system, it would be a better option to go in for decentralised sewage treatment technologies, for the following reasons:
   - The sewerage network and the treatment plants of the centralised system have very high capital and operational costs. As can be seen by the figures provided by the MC, despite the augmentation of the sewerage network, hardly 10% of the sewage generated is being treated. Decentralised treatment systems provide a cost-effective alternative, as they reduce the cost of costly conveyance and treatment plants as well as use locally available materials for construction.
   - A decentralised treatment plant provides treatment facilities close to the areas served and is ideally suited for some of the locations in Shimla where the areas to be served are situated below the sewerage network and cannot be served by a gravity drainage network. It will also obviate the need for pumping stations, thus saving on energy costs.
   - Decentralised systems offer the opportunity of wastewater recycling and reuse thus reducing water demand substantially.
   - As septic tank systems already exist in these areas, the required investment is little more than improving the existing technology by introducing improved forms of treatment prior to disposal.
   - The newly added zones comprise peri-urban areas where there is a good potential to use treated wastewater for agricultural use and can thus improve agricultural productivity.

Area/Zone	**Proposal as per DPR for 2025 demand**	**CSE's recommendations**	**Pilot projects proposed by CSE**
North Disposal - sub-zone – II	6.69 Km of pipeline and 1 STP of 0.3 mld capacity at Rs. 5.00 crore	3 DEWATS plants of 50 Kld each (total 150Kld)	Police ground , Bharari. Existing septic tank augmented with horizontal reed-bed system and polishing pond at Rs. 7 lakh.
			Nirmal Awas Apartments, Existing septic tank to be augmented with vertical reed-bed system at Rs. 6 lakh.
			Himachal Pradesh State Museum – Existing septic tank to be augmented with Dewats system at Rs. 3.5 lakh.
Dhalli – sub-zone II	9.99 Km of pipeline and 1 STP of 0.2 mld capacity at Rs. 6.35 crore	4 Rootzone/soil bio-technology units of 30 Kld each (total 120Kld)	
Sanjauli Malyana – sub-zone II	19.74 Km of pipeline and 1 STP of 0.2 mld capacity at Rs. 10.83 crore	4 DEWATS plants of 30 each (total 120Kld)	
Totu zone	27.21 Km of pipeline and 1 STP of 2.5 mld capacity at Rs. 22.58 crore	14 DEWATS plants of 100 Kld each	Forest Colony. Existing septic tank system to be augmented with baffled reactor and 2 vertical reed-bed systems at Rs. 14 lakh.
Jutogh zone	10.59 Km of pipeline and 1 STP of 1.0 mld capacity at Rs. 22.58 crore at Rs. 10.15 crore	10 DEWATS plants of 55 Kld each	

1. Water profile of Shimla city

1.1 THE CITY OF SHIMLA

Shimla is the capital city of Himachal Pradesh and was the summer capital in pre-independence era. It is situated at an altitude of 2130 m. above mean sea level. In 1985, the Planning Commission delineated areas with average slope of 30 percent and above as hilly. As per the above classification, Shimla town is classified as a hilly town. It has been a prime tourist destination.

The Government of Himachal Pradesh constituted the Shimla Planning Area (SPA) through notification in November 1977, which includes the Shimla Municipal Corporation, special areas of Dhalli, New Shimla, and Totu and special areas of Kufri, Shoghi and Ghanahatti. Shimla Planning Area (SPA), the only Class I city in the Himachal Pradesh, has a population of 0.17 million persons (2001 census), which accounts for 24% population of the Shimla district. The population of SPA recorded a decadal growth rate of 34.63 per cent between 1991 and 2001. It is assumed that population of SPA is anticipated to increase at the rate of 35 % during the decades of 2011 and 2021, which is likely to be 0.23 million and 0.32 million respectively. Shimla city being the premier tourist centre of Himachal Pradesh, has a very high floating population in the summer months. With the accent on promotion of tourism in the coming years, the floating population is likely to increase.

Under the ambitious Jawaharlal Nehru National Urban Renewal Mission (JNNURM) program of the Government of India, Shimla has been recognized as one of the 63 urban centres eligible for fast-track development. Water supply and sewage management have been recognized as the major focus areas (with collective allocation of more than a fifth of the total funding under the JNNURM scheme) among others such as tourism promotion, decongestion, environment and heritage conservation, housing etc. Despite having three rivers, namely Pabbar, Yamuna and Giri flowing through it, the city depends heavily on spring water sources for its drinking water which is partly responsible for the water shortage the city faces during the lean period from February to May every year.

1.2 WATER PROFILE OF SHIMLA

1.2.1 Water supply

The authorities responsible for water supply in Shimla are the Irrigation and Public Health (I&PH) department and the Shimla Municipal Corporation (SMC). The I&PH looks after bulk supply and treatment of water while the SMC is concerned with distribution and pumping, metering and billing of potable water to domestic and commercial connections.

The water supply system of Shimla dates back to 1875 and new water sources have been identified to augment the supply to meet the ever-increasing demand for water. Surface water from rivulets is pumped and supplied at varying elevations from Dhalli Catchment Area, Cherot Nallah, Jagroti Nallah, Chair Nallah, Gumma Khad and Ashwani Khad (Annexure I: Picture 1). The total installed capacity is 47.54 mld. Four water treatment plants exist at Gumma Khad, Ashwani Khad, Cherot Nallah and Dhalli catchment area. The treatment process involves sedimentation followed by pressure filtration and chlorination.

The present water demand is estimated to be 29 mld (based on a per capita requirement of 135 lpcd. According to a field survey conducted by CSE, total water supplied to Shimla is 36 mld. To meet the growing demand of water for both the increase in population as well as increase in floating population, there are plans for augmenting the water sources further by tapping the rivers Giri and Pabbar in the coming years as part of the JNNURM projects.

The cost of water supply is very high as water is generally sourced from the valleys and pumped up to the residential areas. The energy cost incurred in order to raise water to head of about 1470 m results in a high cost of production of Rs 35/KL. This cost is incurred by I&PH, which supplies SMC bulk water at the rate of Rs. 8.80 per KL. SMC, in turn, charges Rs. 3.85 per KL of water for domestic purposes even though SMC incurs an additional cost of Rs. 6.50 per KL towards operation and maintenance costs. Therefore, water supply is heavily subsidized to consumers, more than 90%. In 2003, the water charges were revised from flat rates to slab rates and since then, the charges are revised annually over past three years.

The local distribution system of core area of Shimla is more than 100 years old. Leakage losses are high due to leakage from corroded and damaged old pipes and leaking joints. Moreover, there is also considerable loss arising from theft and illegal tapping of water. A study conducted by National Environmental Engineering Research Institute (NEERI) showed that leakage losses are more than 45%.

Way ahead: Rainwater Harvesting

In order to tackle the water scarcity problem of Shimla, there is a need for focused and large-scale action on rainwater harvesting. Shimla city passed a law making it mandatory for all buildings to have rainwater harvesting systems way back in 1994. However, implementation is very poor and it has not been implemented widely.

TABLE 1. Water demand and supply of Shimla

Population (as per DPR for 2010 – permanent + floating)	216033
Present water demand (based on 2010 population @ 135 lpcd)	29.0 mld
Average water supplied (As per CSE survey in 2009)*	36mld
T & D losses	>40%
Net total water supply(after leakage losses)	21.6 mld
Net per capita supply	100 lpcd
Supply Frequency	45 minutes on alternate days in lean period and 90 minutes daily on non-lean period

Source: CDP

TABLE 2. Details of the freshwater sources drawn for water supply to Shimla city

Name of water source/rivulet	Year of augmentation	Transmission type	Installed capacity (mld)	Head (m)
Dhalli Catchment Area	1875	Gravity	4.54	None
Cherot Nallah	1889	Pumping	4	800
Jagroti Nallah	1914			
Chair Nallah	1914	Pumping	3	950
Gumma Khad	1924 and 1981-82	Pumping	24	1440
Ashwani Khad	1992	Pumping	12	965

Source: DPR

TABLE 3: Water supply charges

Type of Connection	Usage 1000 Liter per month	Charges (Rs. per 1000 litre)				
		2003-04		2004-05		2005-06
		Upto 06.10.03	After 06.10.03	upto 06.10.04	After 06.10.04	Till date
Residential	0-30	2.5	3.5	3.5	3.85	3.85
	30-75	2.5	5	5	5.5	5.5
	>75	2.5	7.5	7.5	8.25	8.25
Commercial	0-30	10.5	15	15	16.5	16.5
	30-75	10.5	20	20	22	22
	>75	10.5	27.5	27.5	30.25	30.25
Construction	>0	NA	NA	NA	30.25	30.25

Source: CDP

1.2.2 The sewage management system

The first sewerage system was laid in 1880 for a population of about 16000 persons. The network led to disposal sites at Lalpani, Kasumpti, North Disposal, Snowdon and Summer Hill with a total length of 49564 metres. The disposal works were based on septic tanks and sedimentation tanks which were cleaned and flushed during heavy rains. The system stood the test of time for over a hundred years and was designed as an appropriate system for hilly areas with steep slopes and curves.

In 2005, augmentation work was undertaken and new lines were laid and 6 sewage treatment plants were constructed. The treatment plants have a capacity of 35.63 mld and the total length of the network is 220.6

Km. The old sewerage network was tapped and connected to the new network. However, even after the construction of this new network, only about 4.8 mld of sewage is treated by the STPs. The reasons for this are attributed as follows:

i) There are many missing links where branch sewer lines of the old systems have not been connected to the new network;

ii) Some of the grey-water drains, may not be connected to the new network, reducing the quantity of sewage reaching the STPs;

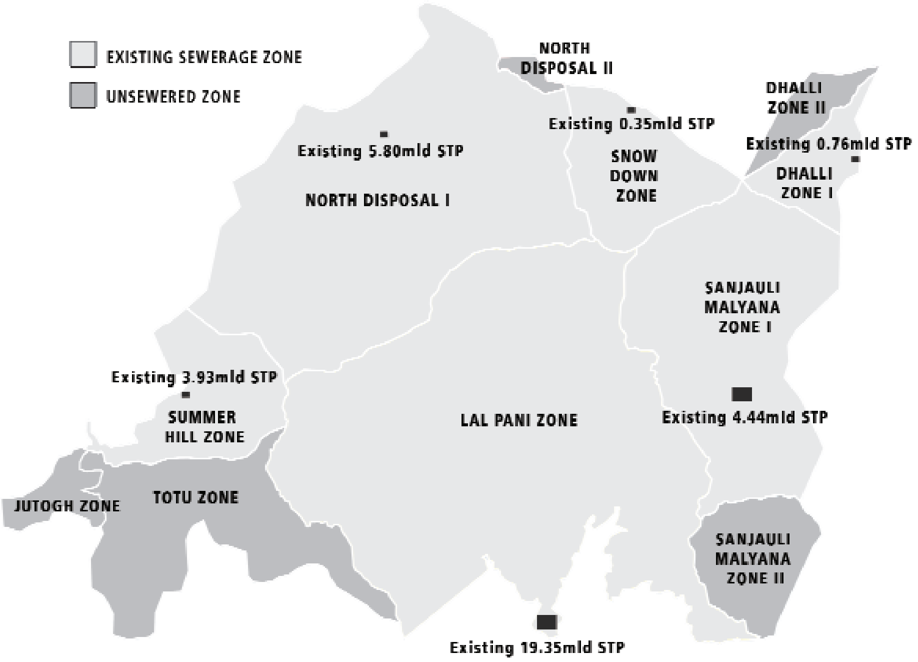
iii) Newly added municipal zones of Totu and Jatog have not ben connected to the sewerage network.

TABLE 4: Details of existing sewage treatment plants

Name of Sewage Treatment Plant	Capacity (mld)	Technology
Lalpani	19.35	UASB
Sanjauli Malyana	4.44	Extended Aeration Process
Dhalli	0.76	Extended Aeration Process
Snowdown	1.35	Extended Aeration Process
North Disposal	5.80	Extended Aeration Process
Summer Hill	3.93	Extended Aeration Process

The treated effluents from STPs are disposed off in adjoining *nallahs.* Sometimes this treated sewage is let into streams that are the sources of drinking water leading to incidents of jaundice and hepatitis outbreaks (Annexure I: Picture 2). The recycling and reuse of treated sewage from the STPs for non potable purpose in the city is not feasible as the STPs are located in the valleys and a separate distribution network will have to be constructed with pumping facilities.

SEWERED AND UNSEWERED ZONES OF SHIMLA



News clipping 1

Shimla, Feb.13, 2010 (ANI): Residents of Shimla are a worried lot these days following a contaminated water supply to their houses which has become a major health hazard. The administration collected samples and sent them to the National Centre for Disease Control (NCDC) in New Delhi. According to the officials,the samples tested have been found okay. Till now, over 200 patients, including tourists and locals, have been treated for viral infections due to consumption of contaminated water.

The most affected areas being Shimla's Vikasnagar, Kasumpti and New Shimla. The affected localities are supplied water from the Ashwani Khud drinking water scheme, managed by the Irrigation and Public Health Department (IPH) and distributed by the Shimla Municipal Corporation. Local administrative authorities, however, claim that all the water sources in the area are regularly tested and verified in different laboratories.

News clipping 2

Shimla, February 23, 2007, The Tribune Chandigarh: Chief Minister Virbhadra Singh today asserted in the Vidhan Sabha that the outbreak of jaundice was confined to a few localities in the state capital and it could not termed as an epidemic. In all, 492 cases had been reported over the past one month.The situation was under control and there was no cause for alarm, he said. Replying to a call attention motion of Mohinder Singh (BJP), the Chief Minister said the maximum number of 285 cases had been reported from Kusumpati, Vikasnagar, Maili, Chaili and Jiwnu Colony area, followed by Khalini (86) and Chhota Shimla (73).

The water supply from Ashwini Khad and the Patyog Water Supply Scheme was found contaminated.

Experts from the National Institute of Virology, Pune, were also carrying out tests to identify the disease causing virus. Besides, 17 samples had been sent to the National Institute of Communicable Diseases, New Delhi. A study on the contamination showed that the cause was a broken pipe which had been contaminated with faeces.

Under the JNNURM programme, it is proposed to augment the sewerage system further by:

- Rejuvenation of sewerage network
- Rehabilitation of missing lines & worn-out network in the existing sewerage system
- Coverage of left-out areas in the newly added zones of the Shimla municipal corporation (laying of network and construction of STPs).

The total estimated cost of this project is Rs. 164.48 crore.

2. Decentralised sewage management options in non-sewered zones of SMC

2.1 WHY DECENTRALISED WASTEWATER TREATMENT SYSTEMS?

Decentralised systems are small, individual or cluster type wastewater facilities to provide wastewater treatment services to residents. In India, more than 75% of wastewater is not addressed by centralised treatment facilities. The state of pollution of rivers and water bodies, big and small, shows that conventional, centralised approaches to wastewater management have generally failed to address the needs of communities for the collection and disposal of domestic wastewater and faecal sludges. The recent focus on the state of the rivers such as the Ganga and Yamuna shows that there is a need for a holistic approach to the issue of wastewater management. Both communities and watersheds require a framework for management that is diverse in its approach, suited to local ecological and conditions and cultural practices, is affordable, adaptable and responsive to local needs. Decentralised systems are not to be viewed simply as an answer to public health problems but rather as one of the parts of water resource management. The aim of these systems is to manage wastewater both as a resource as well as a pollutant. There is a growing body of science and practice which demonstrates the opportunities for implementing wastewater management systems, based on a decentralised approach that may lead to wastewater re-use and resource recovery as well as improvements in local environmental health conditions. These systems are designed to limit pollution by enhancing the assimilative and regenerative capacities of the natural system. Designing and managing these systems can be done at a fraction of the cost of conventional, centralised traditional sewerage system.

It is widely recognised today that for areas that are not connected to centralised sewerage systems, it is more viable to look at alternative and decentralised approaches. The implementation of wastewater recycling and reuse systems is part of the optional reform under the JNNURM programme. It is to be hoped that this will become mandatory in the near future.

2.2 WHY DECENTRALISED WASTEWATER TREATMENT SYSTEMS FOR SHIMLA CITY?

The main city of Shimla is connected to a centralised sewerage network while the outer areas are not adequately connected to this network. Five zones have been identified which presently do not have any sewerage network and is not connected to sewage treatment pant. These zones are-

- North Disposal zone (sub zone II)
- Dhalli zone (sub zone II)
- Sanjauli-Malyana zone (sub zone II)
- Totu zone
- Jutogh zone

These areas are already using septic-tank based sewage treatment systems. Converting these systems to decentralised systems by making improvements to the existing system offers a huge opportunity for cost-saving and long-term sustainability of the system. Shimla city, being highly undulating presents problems in laying conventional, gravity flow sewer lines that will connect each and every house in all residential areas.

The augmentation of the old sewerage system in 2005 has failed to treat all the sewage generated within the network. Even though, the present sewerage coverage as per records is 90% of Municipal Area, the amount of treatment is only about 4.8 mld (18%). The treated wastewater is currently not reused and is disposed off in drains, sometimes into drains which serve as water supply sources, causing frequent incidents of jaundice , hepatitis and other diseases. On-site treatment of wastewater for individual localities is a necessity in areas without proper sewerage. All the areas including those recently included in Shimla Municipal Corporation like Dhalli, Totu, New Shimla, and Special areas of Ghanahatti, Kufri and Shoghi are surviving on private septic tanks for sewage disposal.

2.3 WHAT ARE DECENTRALISED WASTEWATER TREATMENT SYSTEMS?

Before the development of the centralised sewerage systems, sewage management systems consisted of septic tanks, cesspools and wastewater stabilisation ponds. Recent developments in the technology of sewage treatment has greatly improved upon these systems and today there are a range of methods and technologies to treat sewage at source with the least possible use of energy or machines and in a manner that enhances the natural habitats.

DEWATS: In the decentralised wastewater treatment systems (DEWATS), both aerobic and anaerobic techniques are applied. The anaerobic modules comprise of settlers, baffle reactors and anaerobic filters. The aerobic modules have horizontal planted gravel filters and polishing ponds. DEWATS is based on different natural treatment techniques, put together in different combinations according to need. It is used for recycling both “grey” and “black” domestic wastewater. DEWATS systems include:

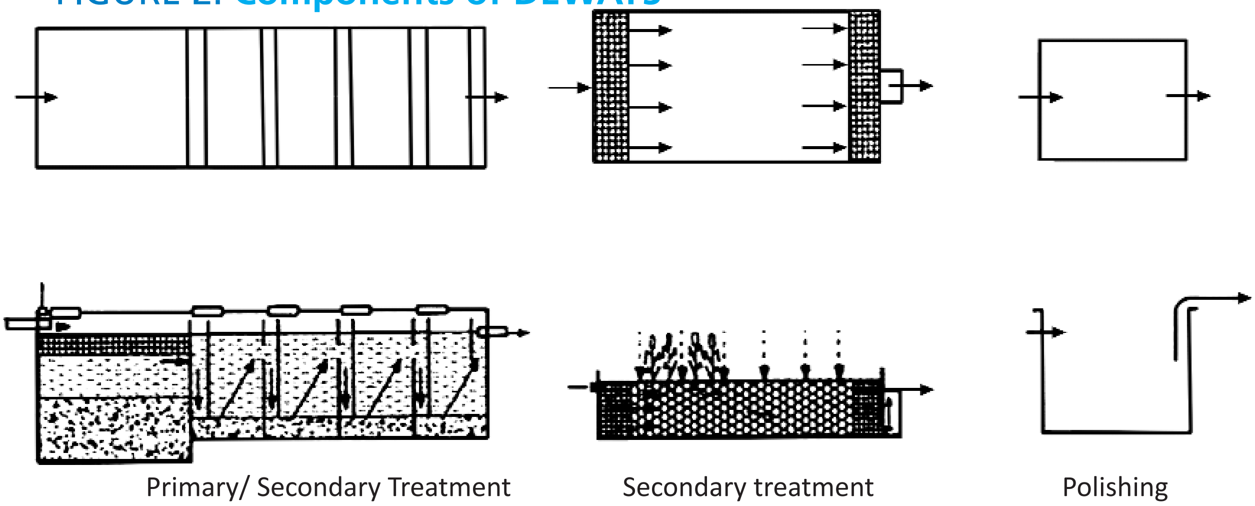
- Primary treatment, which includes pre-treatment and sedimentation in settlement tank or septic tank;
- Secondary anaerobic treatment in baffled reactors;
- Tertiary aerobic/anaerobic treatment in reed bed system; and
- Aerobic treatment in ponds

Waste stabilisation ponds include anaerobic, aerobic and facultative ponds that combine aerobic and anaerobic processes. In soil biotechnology, soil is used as a media for treating the wastewater and is a synthesis process which harnesses the energy, carbon and other elements of the waste and converts them to precious “bio-energy” products like vegetation, energy rich soil, complete bio-fertiliser and water. Bioremediation uses methods that utilise the naturally occurring physical principals combined with biological activities of microorganisms.

The key features of DEWATS are:

- Can treat a wide range of wastewater types
- Does not need energy
- Low-cost and minimal maintenance
- Can treat wastewater flows from 1-1000 m^3 per day
- Tolerant to inflow fluctuation
- Wastewater is turned into a resource for irrigation or reuse of water
- Fulfils discharge standards and environmental laws
- Does not require deep sewer line construction
- Reliable and sustainable

FIGURE 2: Components of DEWATS



- Can be integrated into the landscape
- Involves local communities in the management

2.3.1 Primary treatment

Pre-treatment is used for the screening and sedimentation process, in which the liquid part is separated from the solid matter. A unit called a septic tank is used for this phase. It is a sedimentation tank in which settled sludge is stabilised by anaerobic digestion. Dissolved and suspended matter leaves the tank untreated. The treatment efficiency of a septic tank is in the range of 30 per cent BOD removal. Desludging at regular intervals is absolutely necessary. A septic tank can also be incorporated into an anaerobic baffled tank as the first section of a settler device. The space requirement is 5 sq m/cu m daily flow

2.3.2 Secondary treatment

In the secondary treatment phase, biological and natural chemical processes are used to digest and remove most of the organic matter. A device called an anaerobic baffled tank reactor is used for this phase. Several tanks (upflow chambers) are built in a series todigest degradable substances. Baffled walls direct the water stream between the chambers from top to bottom and up again. During the process, the fresh influent is mixed and inoculated for digestion, with the active blanket deposit of suspended particles and microorganisms occurring naturally at the bottom of each chamber in such conditions. Because of the physical separation (multiple chambers), various microorganisms are present at different stages, allowing high treatment efficiency (see Figure 4: Baffled tank reactor). Anaerobic filter: At the end of the treatment device, a chamber can be set aside as an anaerobic filter in order to improve the treatment efficiency. Nearly 90 per cent of the original pollution load is removed at this stage. Since the system works in a closed environment without oxygen supply, the effluent will continue to smell, despite the fact that substantial treatment has taken place already. Due to this reason, a planted gravel filter is included in the design for additional treatment. The space requirement is 1 sq m/cu m daily flow

2.3.3 Tertiary treatment

A horizontal planted gravel filter acts through the combined effect of the filter material and plants growing on the filter media. The wastewater is resupplied with oxygen while passing through the planted gravel filter. The effluent is odour free. Since baffled reactor is being used to provide secondary treatment, the size of the planted filter is reduced. This leads to a cost reduction, less needed space above ground and with an additional benefit of having available larger amounts of reusable treated wastewater, due to the decrease in the high rate of evapo-transpiration normally occurring in large planted filters.

The advantages of this system are that it can achieve high treatment efficiency at low-cost, if filtering material is available at site and there is no wastewater above ground, nor any odour. It is possible to landscape it decoratively. The disadvantages are that it has a high permanent space requirement and also requires to be constructed with care using technical knowledge. If desired quality of gravel is not available in the area, it can become expensive. It also requires intensive maintenance and supervision during first one or two years.

Vertical flow reed beds: Vertical flow reed beds are usually preceded by some form of primary treatment, although some are built to receive raw sewage. 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 (Phragmites australis). The wastewater 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. The system can achieve a high degree of treatment, does not need power if a gradient is available, will begin to perform even before plants have grown and maintenance is technically simple and system is robust. Its drawback is that it requires a fall of at least 1.5 m to provide good treatment and is sensitive to hydraulic overloading.

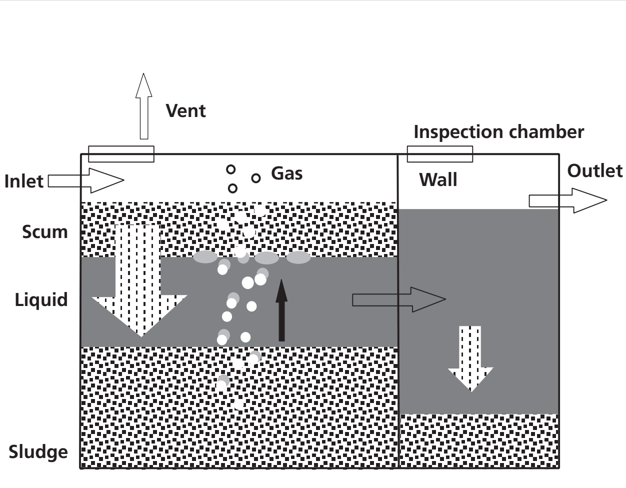
Polishing ponds: Here, both aerobic degradation and pathogen removal takes place. It is simple in construction, reliable in performance if properly designed, high pathogen removal, can be used to create an almost natural environment, fish farming is possible in large and low-loaded polishing ponds. The disadvantages of polishing ponds are that they require large permanent space and if they are too small, mosquitoes and odour can be a problem and algae can raise the BOD of the effluent. The space requirement is 1.2 sq m/cu m of daily flow.

2.3.4 Soil Biotechnology (SBT)

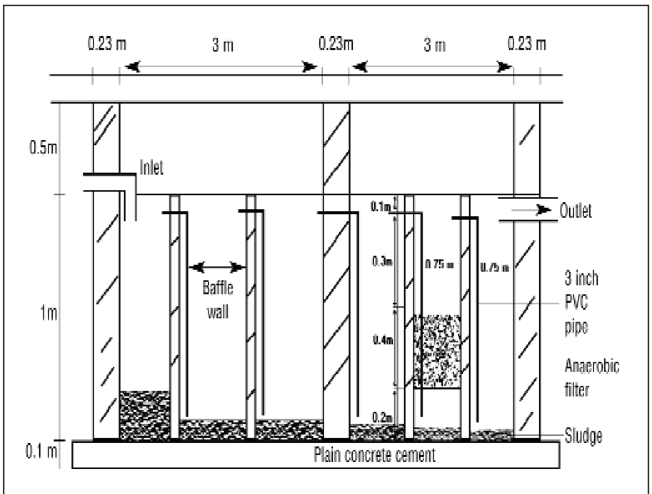
In soil biotechnology, soil is used as a media for treating the wastewater. SBT is a synthesis process which harnesses the energy, carbon and other elements of the waste and converts them to precious “bio-energy” products like vegetation, energy rich soil, complete bio-fertiliser and water. SBT involves removal of organic matter by adsorption followed by biological degradation and oxygen supply by natural aeration to the treatment system. The photosynthetic activity of green cover serves as a bio-indicator for the kind of micro-habitat in SBT. The SBT, is designed to provide the requisite filtration, aeration and bio-chemical processing for removal of toxicity, including BOD, COD, nitrate, phosphate, suspended solids, colour, odour, and bacteria.

In this method, wastewater is pumped or sprayed on the top of the sand bed. The bed consists of specially cultured soil media, consisting of a layer of boulders, pebbles and sand. The filtering materials are placed over a thick layer of plastic sheets, to prevent seepage loss of wastewater. The wastewater is repeatedly pumped

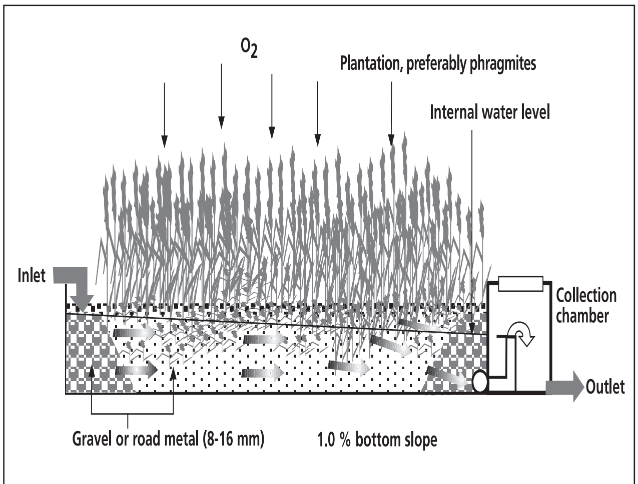
FIGURE 2: Decentralised wastewater treatment systems



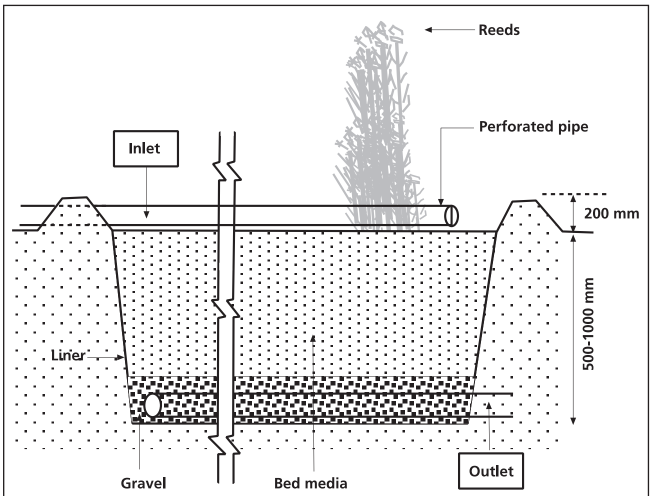
Conventional septic tank



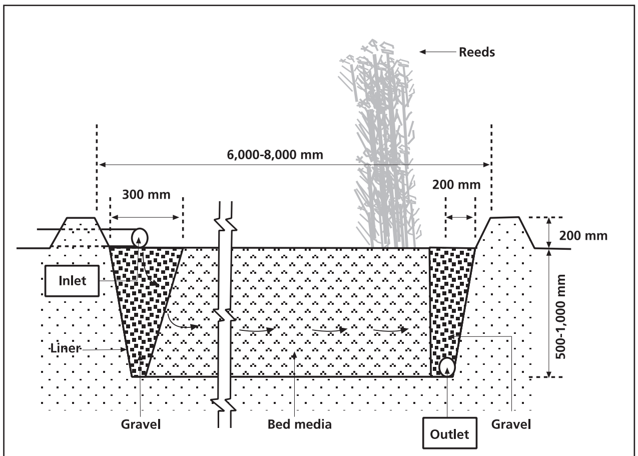
Baffled reactor



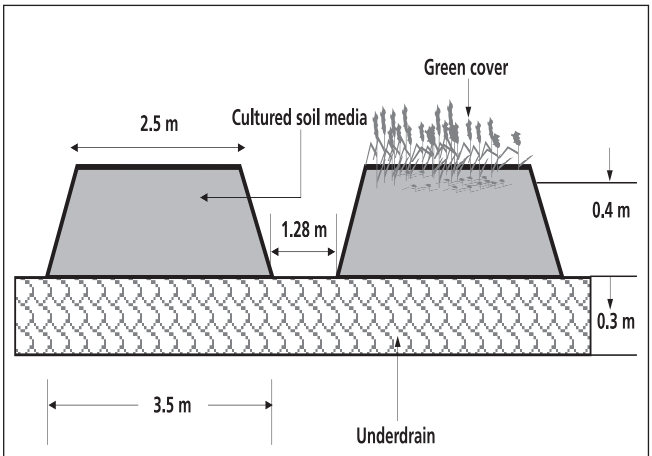
Root-zone treatment (planted filter)



Vertical reed bed filter



Horizontal reed bed filter



Soil biotechnology

on the top of the soil media using a pipeline network. The treated water, which is collected in the furrows between the soil bunds, is finally diverted to a collection well. The collection well also acts as an aeration tank. This water is finally pumped out and used for irrigation. Locally available wild plants are grown on the top of the soil, to enhance the treatment process.

Note: Since the hilly areas have slopes, there is no need to pump the water from one bed to the other. Rather, natural gradient could effectively be used leading to complete energy savings.

Space requirement: Typically, the space required per person (@100 lpd) is 0.27 sq m per person for sewage treatment. Out of this area, the system includes 0.25 sq m of green belt. Effectively, the system uses 0.02 sq m of area per person for sewage treatment. At places with less space, the system can be constructed in the form of multi-level bio-towers.

2.3.5 Additives for treating wastewater

Biosanitizer: The novel idea of using the Biosanitizer (biocatalyst) was developed by Uday S Bhawalkar of the Bhawalkar Ecological Research Institute (BERI), Pune. The biocatalyst includes two products namely *Vermi++* and *Sujala.* As claimed, these products are for one time use. Once incorporated in the system, they stay inside the treatment unit and treat the domestic wastewater.

Effective microorganisms (EM): Effective microorganisms (EM) denotes a liquid mixture of several microorganisms in a molasses-based medium. It was developed in the 1970s by Teruo Higa, professor of agriculture at the Ryukyus University in Okinawa, Japan, and introduced in 1982. From 1989 onwards, EM has been made public in international conferences globally, and now is being used in more than 120 countries. In India, this product is being manufactured since 2000. EM contains microorganisms which are mostly used in food processing like lactobacilli used in curd or yeast for bread and beer or photosynthetic bacteria used in cheese-making. It does not contain any genetically modified organisms. It is easy and safe to handle, and accidental ingestion of some EM is not harmful.

Note: These additives can also be effectively used in treating “Nallahs”. Online Bioremediation can be carried out in the open drains to reduce its BOD,CODand TSS.

2.4. WASTEWATER TREATMENT - CENTRALISED VS. DECENTRALISED APPROACHES

- Wastewater treatment approaches vary from the conventional centralised, semi-centralised to decentralised systems. The problems and limitations of centralised wastewater treatment (such as Sewage Treatment Plants (STPs), Wastewater Treatment Plants (WWTPs) etc.) are gradually surfacing. Sustainable sewerage includes many components like environmental, technical and socio-cultural factors but economy of scale is the most important determinant of sustainable practices in developing countries.

- While decentralised systems treat and reuse/dispose wastewater on-site, the publicly owned centralised systems use extensive pipelines or sewerage, major excavations and manholes for access. The unavoidable costs of sewer lines in case of centralised systems may threaten the economies of scale; sewerage may cost up to five times more than the central sewage treatment plant itself.

- Centralised systems are high-cost and energy-and maintenance-intensive systems and are not so suitable for developing countries. Small and isolated villages or settlements with low population densities can be served by decentralised systems that are simpler and cost effective**.** It is estimated that collection costs account for more than 60% of the total cost in centralised waste management systems and on-site systems reduce the collection costs to a minimum.

- DEWATS serve a smaller scale area, reduce the hazards of environment and public health and also increase the reuse potential of the treated wastewater and its return within the watershed.

- The design of DEWATS can be modified on a need-basis to cater to the specific requirements of smaller communities.

- Most importantly, the huge operation and maintenance cost and the power dependency to run the plants, is of a great concern. However on-site wastewater treatment facilities set up locally are not representative of current state-of-the-art or developed technology. They rely on natural processes and landscapes to treat the waste. Centralised management of decentralised treatment systems is essential to ensure regular monitoring and evaluation of performance.

2.5 POSSIBLE OPTIONS FOR UNSEWERED AREAS

2.5.1 Summary of proposal: Five zones have been identified which presently do not have any sewerage network and is not connected to sewage treatment plants. It is eminently possible and viable to construct a clutch of DEWATS systems for the areas that are not currently connected to the central sewerage network. This will be more cost-effective and sustainable in the long-run. The summary of the decentralised options is as follows:

TABLE 5: Summary of decentralised options in unsewered areas

Area/Zone	CSE's proposal
North Disposal - sub-zone – II	3 DEWATS plants of 50 Kld each
Dhalli – sub-zone II	4 Rootzone/soil biotechnology units of 30 Kld each
Sanjauli Malyana – sub-zone II	4 DEWATS plants of 30 Kld each
Totu zone	14 DEWATS plants of 100 Kld each
Jutogh zone	10 DEWATS plants of 55 Kld each

2.5.2 Zone-wise proposal details

North Disposal zone

North Disposal has a present population of 29,275 persons. An STP having Extended Aeration process of 5.80 mld has already been set up which is sufficient for projected population upto 2025 except Bharari (North Disposal sub-zone – II) area having present population about 1350 persons (as per 2010 estimation) which can not be met with the existing network due to population situated on lower side than the existing network. As per the current population in Bharari, the total sewage generation is about 0.15 mld (based on 135 lpcd water supply).

Estimating sewage generation of 150 Kld in Bharari region as a whole, 3 individual decentralised treatment plants can be installed in this region, each treating approximately 50 Kld of domestic sewage. DEWATS can be incorporated as an extension of the already existing septic tanks providing primary treatment of the sewage.

Dhalli Zone

Dhalli zone presently has a population of 6553 persons. The projected population for the year 2025 will be 10,361 persons. Sewage treatment plant of Extended Aeration process of 0.76 mld has already been set-up which is sufficient to meet the requirement for the designed year 2025 but some residential areas (Dhalli sub zone – II) i.e. Hipa area, Lower / upper area of Sanjouli by-pass etc. having an estimated present population of 1050 persons (2010) cannot be met with the existing sewerage network of Dhalli because the elevation of above areas do not permit to meet the sewer connections with the existing network by gravity (Annexure I: Picture 3). The sewage generation in this region is around 0.12 mld (based on water supply of 135 lpcd).

Estimated sewage generation in this zone is 120 Kld. To treat this quantity of sewage, 4 rootzone treatment systems/SBT (Soil biotechnolgy) units can be installed, each having a capacity of 30 Kld as an extension of the primary treatment-providing septic tanks already in use in the region.

Sanjauli Malyana Zone

Some areas of Sanjouli Malyana (sub-zone – II) zone i.e. lower *Pantheghati*, Mehli, IAS colony & village Sargeen etc. having a present population of 1100 persons (as per 2010 estimation) cannot be met with the existing sewerage network due to topography of the area. The sewage generation of this region is 0.12 mld (based on 135 lpcd). Furthermore, the effluent of the STP treating the wastewater generated from the sewered areas of this zone is discharged into a natural nallah which, on its course, joins one of the tributaries draining into Ashwani Khad .

To meet the treatment needs of the estimated sewage generation of 120 Kld, 4 DEWATS units, treating 30 Kld of sewage each, can be installed, fed by the septage generated from the septic tanks already existing in the region.

Totu Zone

The population in Totu zone is estimated to be approximately 12909 persons (2010). The downhill region of *Chakkar* area in Totu zone cannot be connected to the main sewerage network due to the gravity flow restrictions because of being located at a lower altitude. The sewage generation in this region is estimated as 1.39 mld.

Given the huge quantum of sewage (1390 Kld) generated in this unsewered zone, a total of twelve to fifteen DEWATS/SBT units of varying capacity can be installed here, each treating approximately 100 Kld of wastewater. Totu zone has dense and sparse population patches. Also the topography of the catchment areas varies within the zone. The size and design specifications of the DEWATS/SBT units to be installed here would vary with the population density and topography of each catchment.

Jutogh Zone

Jutogh zone (covering the areas of Jatog Cant. & Dhar) is not connected to the sewerage network presently and is estimated to have a population of 5204 persons (2010). The sewage generation in this region is around 0.56 mld (based on water supply of 135 lpcd).

Estimated the present sewage generation in this zone as 0.56 mld, ten DEWATS units can be installed, each having a capacity of 55 KLD.

2.6 COST COMPARISON

The total cost (capital investment + operation & maintenance cost) involved in centralised system for treating sewage and decentralised systems is given below.

TABLE 6: Cost estimation for centralised system as per DPR

S.No.	Zone	STP capacity (mld)	Cost for laying sewerage network (lacs)	Cost for construction of STP (lacs)	Total capital cost, sewerage network+STP (lacs)	Operation and maintenance cost (lacs/mld)
1	North disposal(II)	0.3	354.57	145.23	499.8	85.2 per annum
2	Dhalli (II)	0.2	486.59	148.32	634.91	
3	Sanjauli-Malyana (II)	0.2	934.29	148.32	1082.61	
4	Totu	2.5	1678.61	579.89	2258.5	
5	Jutogh	1	703.24	312.09	1015.33	
	TOTAL		4157.3	1333.85	5491.15	

TABLE 7: Cost estimation for decentralised system*

S. No.	Zone	Decentralised treatment system capacity (mld)	Projected Cost for construction of Decentralised system (lacs)	Operation and maintenance cost** (lacs/mld)
1	North disposal(II)	0.3	90	15 per annum
2	Dhalli (II)	0.2	60	
3	Sanjauli-Malyana (II)	0.2	60	
4	Totu	2.5	750	
5	Jutogh	1	300	
	TOTAL		1260	

* Cost of conveyance has not been estimated
**including additive cost

Cost of additives for odour-control

S.No.	Type of Treatment	Operation and maintenance cost Rs per kld
1	EM	1.0
2	Bioclean	0.2

3. CSE's proposal for construction of pilot decentralised treatment projects in different non-sewered zones

Based on information gathered in a baseline survey of various sewerage zones, conducted in Shimla in November 2009, CSE has come across some of the prominent places which are not connected to the existing sewerage network and are surviving on the conventional septic tank system. CSE proposes that decentralised treatment options may be taken up as pilot projects in these non-sewered sites of Police Ground, Bharari, Nirmal Awas Apartments, Forest Colony and Himachal Pradesh State Museum.

CSE will be happy to provide technical consultancy free of cost for implementation of one or more pilot projects as described above. The work will be carried out by SMC and CSE will interact with SMC up till the completion of the project and will help in setting up systems for continuous operation and maintenance.

While the broad contours of the proposal for all sites is given below, full details of project design will be provided on approval of the project.

3.1 POLICE GROUND, BHARARI

Police ground in Bharari has the police building having a total peak population of around 500 people. The police building is surviving on septic tanks and the area happens to be lower in elevation than the existing sewerage network. Hence the generated wastewater cannot be directed under gravity to the nearest branch sewer. The police ground is a relatively plain area without varying slopes (Annexure I: Picture 4).

Only black water is coming to the septic tank. at 40 lpcd (total of 20 Kld).The septage from the septic tank can be taken into horizontal flow reed bed system for secondary treatment of septage. The treated water from the red bed system can then be diverted into an open pond for aeration and final tertiary treatment. This treated wastewater can be reused in the surrounding region for horticulture/gardening purposes.

Process description: The existing septic tank will act as a settler and the outlet from it will be taken into baffled reactor(a). The outlet from the reactor will be diverted to a rootzone system(b). Finally the treated water from the reed bed outlet will be exposed to atmosphere and sunlight in an oxidation pond(c) from where it could be reused for horticultural purposes.

Baffled Reactor: One underground anaerobic baffled reactor will be constructed of 20 sq.m x 1.5m depth.

Rootzone system: One rootzone system (sub surface) of 100 sq. m area each is proposed to be installed in line with the anaerobic baffled reactor.

Oxidation Ponds: One common oxidation pond will be constructed

Projected Cost:
The total projected cost for construction of one baffled reactor, one rootzone system and one oxidation pond for treating total **20 KLD** of wastewater will be around **Rs. 7 lakh**.

3.2 NIRMAL AWAS RESIDENTIAL APARTMENTS

The Nirmal Awas Residential Apartments, located opposite Nank Kutti in North Disposal zone house approximately 200 people. They are served by individual septic tanks (10 in number) and some under construction, due to being situated lower than the existing sewage network (Annexure I: Picture 5). The septic tanks which are under construction, can be modified into upgraded septic tanks with little design modifications. This can then be connected to a common vertical reed bed with a capacity of 20 KLD. The effluent can be reused for horticulture/gardening purposes in the individual apartments.

Process description:
For the black water, the outlets from the individual septic tanks will be connected to a common anaerobic baffled reactor. All the grey water of the apartment will be taken into a settler. The outlet of settler and of the reactor will then be connected to two planted filters to handle 20 KLD of wastewater (grey water + black water). The effluent can be reused for horticulture/gardening purposes in the individual apartments.

Baffled reactor
About 8000 litres of black water will be generated daily. One underground anaerobic baffled reactor will be constructed of 9 sq.m x 1.5m depth. The overflow water from the septic tank will be first diverted to the anaerobic baffled reactor. The baffled reactor is resistant to shock load and variable inflow, the operation and maintenance is simple and no open space is required since it is a sub-soil construction.

Settler & Planted filter
A settler is proposed to be constructed before the grey water enters the planted filter. The settler will be provided with a baflle wall in between for proper sedimentation. The Horizontal Gravel Filter (HGF) is made for reed planted filter bodies consisting of fine gravel. Bottom slope is 1 %. The flow direction is mainly horizontal. The filter is planted with helophytes. The main removal mechanisms are biological conversion, physical filtration and chemical adsorption. Two planted filters (sub surface) in parallel of 50 sqm area x 0.6 m depth is proposed to be installed in line with the anaerobic baffled reactor. The spatial requirements are compensated by pleasing landscapes and no pumping will be required.

Storage sump
The final treated water from the planted filter will be stored in a sump of 20 cu.m. Capacity from where it could be pumped out to meet the horticulture/gardening requirements.

Projected Cost
The total projected cost for construction of one baffled reactor and one rootzone system for treating total **20 KLD** of wastewater will be around **Rs 6 lakh.**

3.3 FOREST COLONY

The downhill region of *Chakkar* area in Totu zone cannot be connected to the main sewerage network due to the gravity flow restrictions because of being located at a lower altitude (Annexure I: Picture 6). Forest Colony situated opposite *Chakkar* in the Totu zone has about 250 households. It is estimated that 40KLD (1000 persons @ 40lpcd) of black water is generated per day which is presently being directed into two community septic tanks providing only primary treatment. The greywater does not get treated in the septic tanks and the drains carrying greywater flow separately and drain into natural nallahs. In the process it gets naturally aerated during its flow down the hill slope.

Process description

The existing septic tanks can act as a settler. A baffled reactor will be incorporated to the existing septic tanks for secondary treatment. The overflow from each settler-reactor assembly would be directed to planted filters for tertiary treatment.

Settler

The existing septic tanks will act as settler. There there will be two settlers providing primary treatment.

Anaerobic baffled reactor

The overflow from the septic tank will be first diverted to the upflow baffled reactor. In the baffled reactor, different anarobic processes will be applied in combination; partly, the process carried out by a septic tank, an UASB(upflow anaerobic sludge blanket) and fluidized bed will take place.The BOD reduction rate of the baffled reactor is about 85%. No open space is required as it is a sub-soil construction.
Dimensions: length=18m, breadth= 1m, depth = 1.5m (for 20KLD each)

Horizontal planted filters

To treat 40KLD of wastewater, it is being proposed to construct two separate horizontal planted filters.(reed bed system). It will require an area of 100 sq. m (20m x5m) and depth of 0.6-0.9 m to treat 20 kld wastewater in each of the planted filters. The filter is planted with helophytes. BOD reduction is 35%. Reduction of pathogens is over 95%. The flow is through gradient with a slope of 1% at the bottom of the bed.

Projected Cost

The total projected cost for construction of two baffled reactor, two horizontal planted filters for treating **40 KLD** of wastewater will be around **Rs 14 lakh.**

3.4 HIMACHAL PRADESH STATE MUSEUM

The State Museum of Himachal Pradesh is located in North Disposal zone. Here, the domestic sewage is treated in conventional septic tanks (Annexure I: Picture 7). A DEWATS unit of 10 KLD capacity as a model project can be installed here to meet the daily demands of sewage generated in the campus by the office staff and the visitors.

Process description

Since the existing septic tank are of huge capacity compared to black water that is being presently generated, the existing septic tank will be used be used as primary treatment unit. The overflow from this septic tank will be diverted to planted filter for secondary level treatment. This treated water will be stored in a storage pond like system from where it will be pumped for horticultural purpose.

1. Primary treatment: Septic tanks

The existing septic tanks will provide primary treatment of the wastewater generated . The septic tanks are big enough as compared to the waste generated, thus, no need to construct a separate reactor.

2. Secondary treatment: Horizontal Planter filter

The treated water from the baffled reactor will flow to the horizontal planted filter, which is above the ground level. A horizontal gravel planted filter acts through the combined effect of the filter media. While the gravel filters the suspended materials, the *cana indica* plants, which is grown on the top of the filtering materials helps in removing the nitrates, phosphates from the wastewater and also increases the oxygen level in the wastewater. The system is designed based on the hydraulic conductivity, hydraulic retention time.
Dimension of Planter filter-

Area: 60 sq. m. (12m x 5 m)
Depth: 0.8 m

3. Tertiary treatment: Polishing pond

Polishing pond is simple in construction, operation and maintenance. The ponds are made of shallow earthen basin. Its main purpose is enrichment of oxygen, elimination of pathogens through sun radiation and equalization of outlet quality. Floating hydrophytes will keep algae production controlled.
Dimensions of pond:
Diameter: 3m
Depth: 1m

Cost estimation:

The total cost of the project is estimated to be around **Rs 3.5 lakh.**

4. Conclusion

The geographical topography of Shimla suggests that are many potential hazards in laying long network pipelines to connect individual houses to distantly located centralised sewage treatment plants.

There is no sewerage network coverage in the newly included areas in SMC (Dhalli, Tutu, and New Shimla) and special areas of Ghanahatti, Kufri and Shoghi. Though there is a provision of new sewerage network for new areas (2008-11) through construction of 7 STPs along with proposed sewerage network, it will impart huge capital investments and high O&M costs. The successful implementation and operation of such a complex centralised system will still be a question mark.
Sewage treatment plants are not the solution since a substantial part of Shimla is not connected to the sewerage network.

Moreover, where there are STPs, the centralised system of collecting the sewage is a failure as it is not able to catch the sewage generated from Shimla Planning Area. All the STPs in Shimla are running under capacity and are not able to receive adequate sewage. The water is not being reused as all the STPs are located downhill and pumping water uphill for reuse would involve huge energy costs. This shows the weakness of the current sewage paradigm and hence it is important to consider decentralised wastewater treatment systems for treating the domestic sewage/septage from the septic tanks.

Thus it can be concluded that decentralised wastewater treatment system has the potential of being more economical in comparison to other centralised treatment options.

This can be attributed to the following reasons:

1. It may be standardised for certain customer-sectors, which reduces planning cost and additional attendance factors.

2. Decentralised systems does not use movable parts or energy, which avoids wear and tear and replacement costs of expensive engineering parts.

3. They are designed to be constructed with local masons. This alleviates the need to employ costly contractors, enabling lower capital cost and subsequent expenses for repair.

4. Different decentralised systems may be combined with natural or already existing treatment facilities so that the most appropriate solution may be chosen.

5. They have the least possible maintenance requirements, which spares not only manpower for daily attendance but also highly paid supervisors or plant managers.

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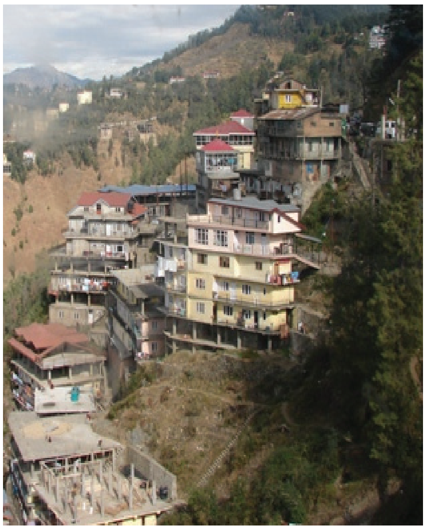
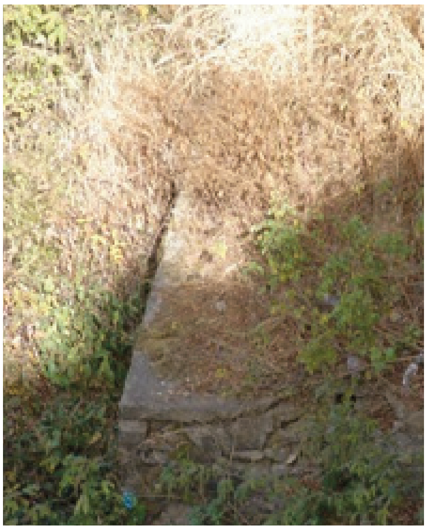
Annexure I


Picture 1 (a) Ashwani Khad – one of the freshwater sources for supply to Shimla
(b) Water Treatment Plant at Ashwani Khad


Picture 2 (a) Sewage Treatment Plant in the Sanjauli Malyana Zone
(b) The nallah thatcarries the effluent of the STP into Ashwani Khad





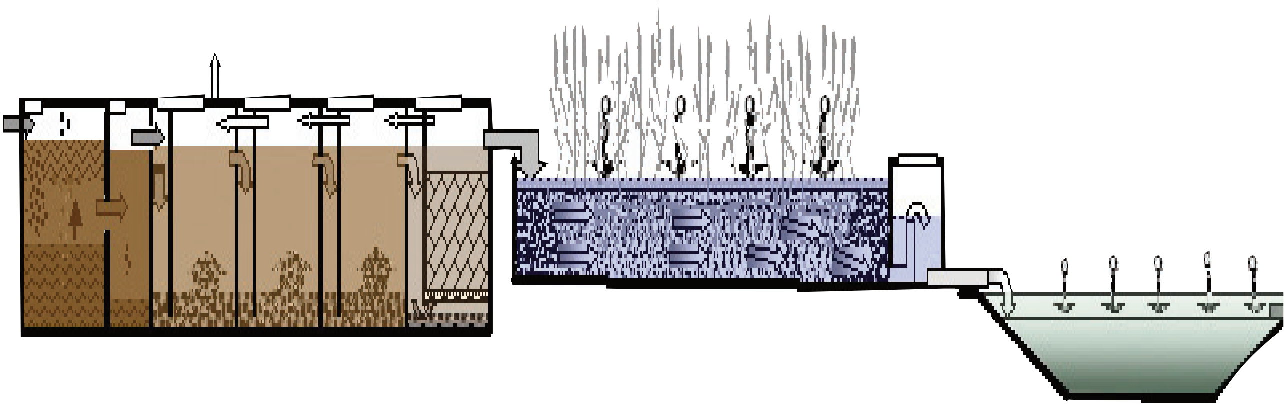
Picture 3 Dhalli Zone community Septic tanks

Picture 4 (a) Police Ground at Bharari
(b) pipeline connection to septic tank

Picture 5 Nirmal Awas Residential Apartments (a) Nanak Kutti Residential apartments
(b)A septic tank under construction (c) Broken sewage pipes

Picture 6 (a) Forest Colony (b) One of the two septic tanks in the colony

Picture 7 Existing septic tanks at HP state museum



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