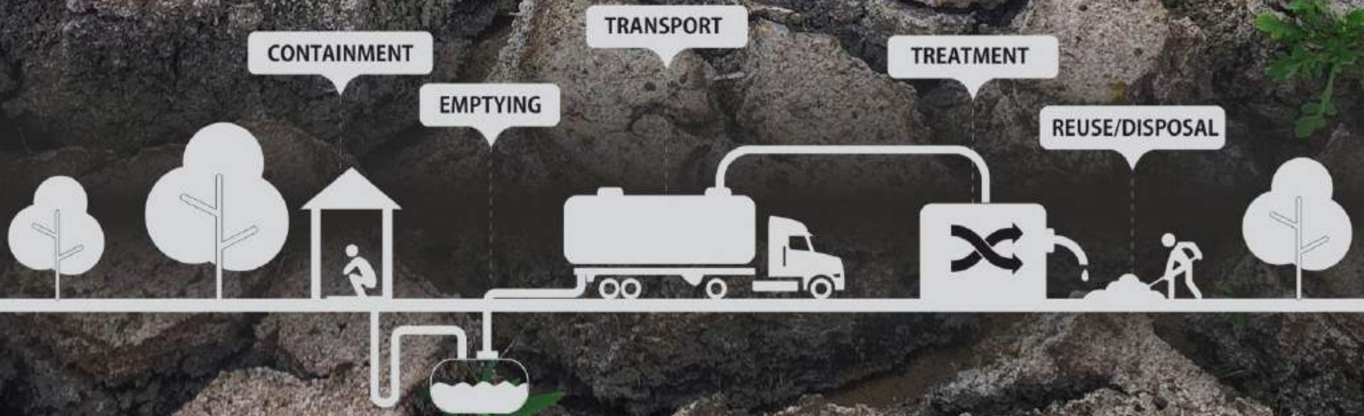
SCBP

Decentralized Liquid Waste Management

Feb 18th - 21st, 2019
Department of Civil Engineering
College of Engineering Pune



National Institute of Urban Affairs

ECOSAN SERVICES FOUNDATION

Winter School

on

Decentralized Liquid Waste Management

Presentation Slides

TITLE

WINTER SCHOOL MODULE ON DECENTRALIZED LIQUID WASTE MANAGEMENT

RESEARCH PROJECT

SANITATION CAPACITY BUILDING PLATFORM,

ANCHORED BY

NATIONAL INSTITUTE OF URBAN AFFAIRS, DELHI

CONTENT

The module is prepared by College of Engineering, Pune and Ecosan Services Foundation (ESF), Pune

GRAPHIC DESIGN

Dhawal Patil, Ecosan Services Foundation

DISCLAIMER

CONTACT

National Institute of Urban Affairs
1st and 2nd Floor, Core 4B,
India Habitat Centre,
Lodhi Road, New Delhi 110003, India
Website: www.niua.org, www.scbp.niua.org

Decentralized Liquid Waste Management

AGENDA

DAY 1: 18th February 2019		
TIME	**SESSION**	**RESOURCE PERSON**
10.00 - 10.45 hours	Introduction- Introduction of NIUA, SCBP, CoEP, ESF and participants Aims and objectives of the winter school Setting the ground rules	Prof. Raval, CoEP & Mr. Dhawal Patil, ESF
10.45 - 11.45 hours	**Water and Sanitation in Developing Countries** Environmental health, Water supply and environmental sanitation, Resource and waste systems, Objectives of water supply and sanitation systems **Environmental Health** Global burden of diseases, Transmission routes of pathogens and related diseases	Prof. Raval, CoEP
11.45 - 12.00 hours	COFFEE BREAK	
12.00 - 12.45 hours	**Urban Challenges** Deficiencies and challenges in urban water and sanitation; Challenges faced at household and communities; Challenges at city and town level; Challenges at the international level	Prof. Raval, CoEP
12.45 - 13.45 hours	LUNCH BREAK	
13.45 - 14.45 hours	**Non Technical Aspects** Enabling environment; Technical and physical criteria; Socio-cultural aspects, Political and institutional aspects; Financial and economic aspects. **Decentralized Liquid Waste Management Systems.** Shift in paradigm, Limitation of centralised systems; Potential of the decentralized sanitation approach; Constraints in implementing decentralized approach.	Mr. Dhawal Patil, ESF
14.45 - 15.45 hours	**Sanitation Systems** Definition and objectives; Sanitation coverage challenges; Waste products, Main parameters to describes wastewater; Characteristics of waste and their value	Mr. Saurabh Kale, ESF
15.45 - 16.00 hours	COFFEE BREAK	
16.00 - 17.00 hours	GUEST LECTURE 1	

DAY 2: 19th February 2019		
TIME	**SESSION**	**RESOURCE PERSON**
10.00 - 10.45 hours	Recap and discussions	
10.45 - 11.45 hours	**Group Work:** Mapping my locality, defining boundaries; Presentation by groups	Mr. Saurabh Kale, ESF
11.45 - 12.00 hours	COFFEE BREAK	
12.00 - 12.45 hours	**Sanitation Systems and Technologies** Classifications of sanitation systems, Functional groups and technological options	Mr. Dhawal Patil, ESF
12.45 - 13.45 hours	LUNCH	
13.45 - 14.45 hours	**Group Work:** Understanding sanitation systems, identifying problems/gaps, Conceptualising sanitation system	Mr. Dhawal Patil, ESF
14.45 - 15.45 hours	**Control Parameters** Volume; Solids; Oil, grease and fats; Turbidity, colour and odour; COD & BOD; Nitrogen; Phosphorus; Temperature & pH; Volatile fatty acids; Dissolved oxygen; Pathogens **Dimensioning Parameters** Hydraulic load, Organic load, Sludge volume	Prof. Sadgir, CoEP
15.45 - 16.00 hours	COFFEE BREAK	
16.00 - 17.00 hours	GUEST LECTURE 2: Malaprabha - Biogas plant linked toilets	Prof. Sameer Shastri

DAY 3: 20th February 2019		
TIME	**SESSION**	**RESOURCE PERSON**
9.30 - 10.45 hours	**Site Visit to CoEP Hostel Campus** Sustainable wastewater management with reuse of reclaimed water.	Ms. Radhika Boargaonkar and Mr. Nirmal Thakare, ESF
10.45 - 11.45 hours	**Process of Wastewater Treatment** Basics of biological treatment; Aerobic and Anaerobic Treatment; Phase separation; Separation of Solids; Elimination of Nitrogen; Elimination of Phosphorus; Removal of Pathogens	Prof. Sadgir, CoEP
11.45 - 12.00 hours	COFFEE BREAK	
12.00 - 12.45 hours	**Design of Treatment Components** Grease trap & Grit chamber; Septic tank	Prof. Sadgir, CoEP
12.45 - 13.45 hours	LUNCH	
13.45 - 14.45 hours	**Visit to plumbing lab of Indian Plumbing Association** To understand the various fixtures and flow of the water in the sanitation systems.	Prof. Mohite, CoEP
14.45 - 15.45 hours	**Design of Treatment Components** Anaerobic Baffled Reactor	Ms. Radhika Boargaonkar ESF
15.45 - 16.00 hours	COFFEE BREAK	
16.00 - 17.00 hours	**Design of Treatment Components** Constructed Wetlands	Ms. Radhika Boargaonkar ESF

DAY 4: 21st February 2019		
TIME	**SESSION**	**RESOURCE PERSON**
10.00 - 10.45 hours	**Economics of DLWM** Economy of wastewater treatment; Treatment alternatives; Parameters for economic calculation	Prof. Sadgir, CoEP
10.45 - 11.45 hours	**Group Work** Planning of decentralized liquid waste management systems	Mr. Dhawal Patil and Mr. Saurabh Kale, ESF
11.45 - 12.00 hours	COFFEE BREAK	
12.00 - 12.45 hours	**Treatment of Faecal sludge and Septage** Objectives of treatment, Stages of treatment, Processes of treatment, Components of treatment, Disposal of endproducts	Mr. Dhawal Patil, ESF
12.45 - 13.45 hours	LUNCH	
13.45 - 14.45 hours 14.45 - 15.45 hours	**Group Work** Presentation of the group works	CoEP & ESF
15.45 - 16.00 hours	COFFEE BREAK	
16.00 - 17.00 hours	Closing ceremony	CoEP & ESF

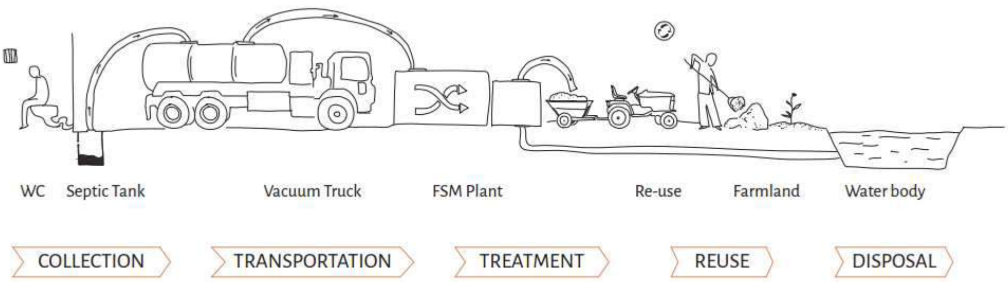
SANITATION CAPACITY BUILDING PLATFORM

Water and Sanitation in Developing countries

Prof. Pratap Raval,
College of Engineering,
Pune

CONTENT

- Overview
- Environmental health,
- Water supply and environmental sanitation,
- Resource and waste systems,
- Objectives of water supply and sanitation systems

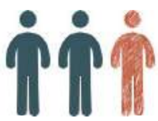


SANITATION DEFINITIONS

The United Nations-World Health Organization Joint Monitoring Programme (2008, 2010) for Water Supply and Sanitation defines 'improved' sanitation as: <u>the means that hygienically separate human excreta from human contact and hence reduces health risks to humans.</u>

A lack of adequate sanitation and systems for managing excreta remains a massive threat to the health of populations and the environment in low and middle income countries.

WATER AND SANITATION IN OUR WORLD TODAY



1 in 3 people don't have access to toilets or latrines

With no other choice, **1 billion** people defecate outside.

WATER QUALITY

2 million tones of human waste enter water sources every day.

1.8 billion people use faecally contaminated water, polluted water and poor sanitation practices spread diseases such as diarrhoea, cholera and malaria.

WASTEWATER IMPACT IN DEVELOPED WORLD

- **A family of four can use 220,000 litres of water a year. This requires 120 kWh of energy to provide it and 100 kWh to treat it as sewerage. The energy used release 200 kg of CO_2 into the atmosphere each year**
- **Despite the efforts devoted to water treatment at sewage plants in the Netherlands, upwards of 50,000 tonnes of pollutants enter surface aquatic ecosystems annually from municipal water system, including almost 500 tonnes of heavy metal. The system also produces 3.2 million tonnes of unusable solid sewage sludge.**
- **The World Water Vision statement say that trend of freshwater withdrawal and consumption will continue to increase over next twenty-five years. Related to 1995 figures, water withdrawal and consumption in municipalities will respectively by 43% and 100% greater in 2025.**

UN STATISTICS ON THE WATER CRISIS

- **"WATER SCARCITY AFFECTS MORE THAN 40 PERCENT O F THE GLOBAL POPULATION AND IS PROJECTED TO RISE."**
- **"MORE THAN 80 PERCENT OF WASTEWATER RESULTING FROM HUMAN ACTIVITIES IS DISCHARGED INTO RIVERS OR SEA WITHOUT ANY TREATMENT, LEADING TO POLLUTION."**
- **"MORE THAN 2 MILLION PEOPLE DIE EVERY YEAR FROM DIARRHOEAL DISEASES. POOR HYGIENE AND UNSAFE WATER ARE RESPONSIBLE FOR NEARLY 90 PERCENT OF THESE DEATHS AND MOSTLY AFFECT CHILDREN."; "MORE THAN 800 CHILDREN DIE EVERY DAY FROM DIARRHOEAL DISEASES LINKED TO POOR HYGIENE"**

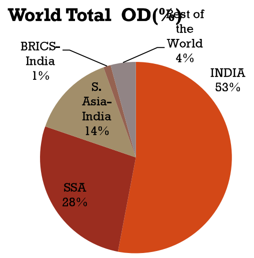
HTTP://WWW.UN.ORG/SUSTAINABLEDEVELOPMENT/WP-CONTENT/UPLOADS/2016/06/WHY-IT-MATTERS_SANITATION_1P.PDF

UN STATISTICS ON THE WATER CRISIS

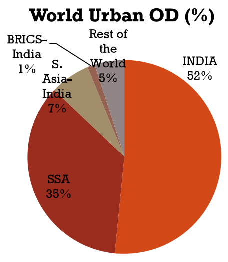
- **"EXTENDING BASIC WATER AND SANITATION SERVICES TO THE UNSERVED WOULD COST US$28.4 BILLION PER YEAR FROM 2015 TO 2030, OR 0.10 PER CENT OF THE GLOBAL PRODUCT OF THE 140 COUNTRIES INCLUDED IN ITS STUDY"**
- **THE ECONOMIC IMPACT OF NOT INVESTING IN WATER AND SANITATION COSTS AN ENORMOUS 4.3 PER CENT OF SUB-SAHARAN AFRICAN GDP. THE WORLD BANK ESTIMATES THAT 6.4 PER CENT OF INDIA'S GDP IS LOST DUE TO ADVERSE ECONOMIC IMPACTS AND COSTS OF INADEQUATE SANITATION**

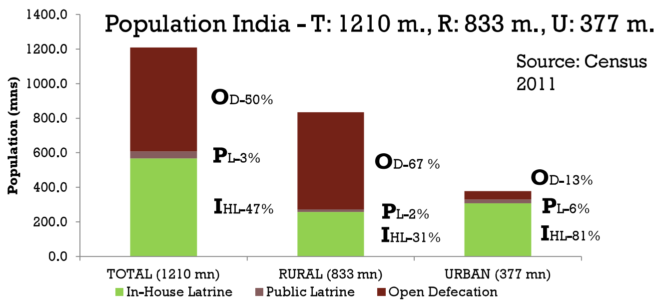
HTTP://WWW.UN.ORG/SUSTAINABLEDEVELOPMENT/WP-CONTENT/UPLOADS/2016/06/WHY-IT-MATTERS_SANITATION_1P.PDF

SCALE OF CHALLENGES : INDIA AND THE WORLD



Source: WHO-UNICEF JMP Report 2014

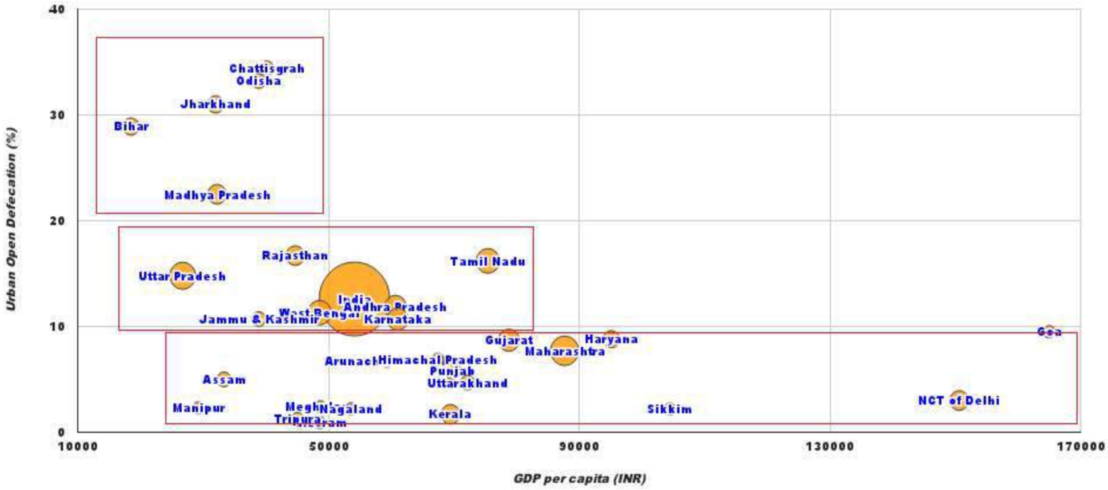




MDG Goal/ Target/ Indicator	India's Baseline - 1990	India's Target for 2015	India's achieveme nt in 2012
Safe drinking water (T)	70	85	93
Improved Sanitation (T)	18	59	36
Improved Sanitation (U)	50	75	60
Improved Sanitation (R)	7	71	25

Source: MOPSI 2013

STATE DIFFERENCES: URBAN SANITATION



Source: Census of India (2011), Planning Commission (2012)

Urban Open defecation in India, as against per capita State GDP shows three clear clusters

1. Smaller, higher income states, have lower OD; 2. Large sized states have OD similar to India's average : 3. Medium sized lower urbanized states have higher OD

Source: S. Dasgupta, Center for Policy Research, New Delhi

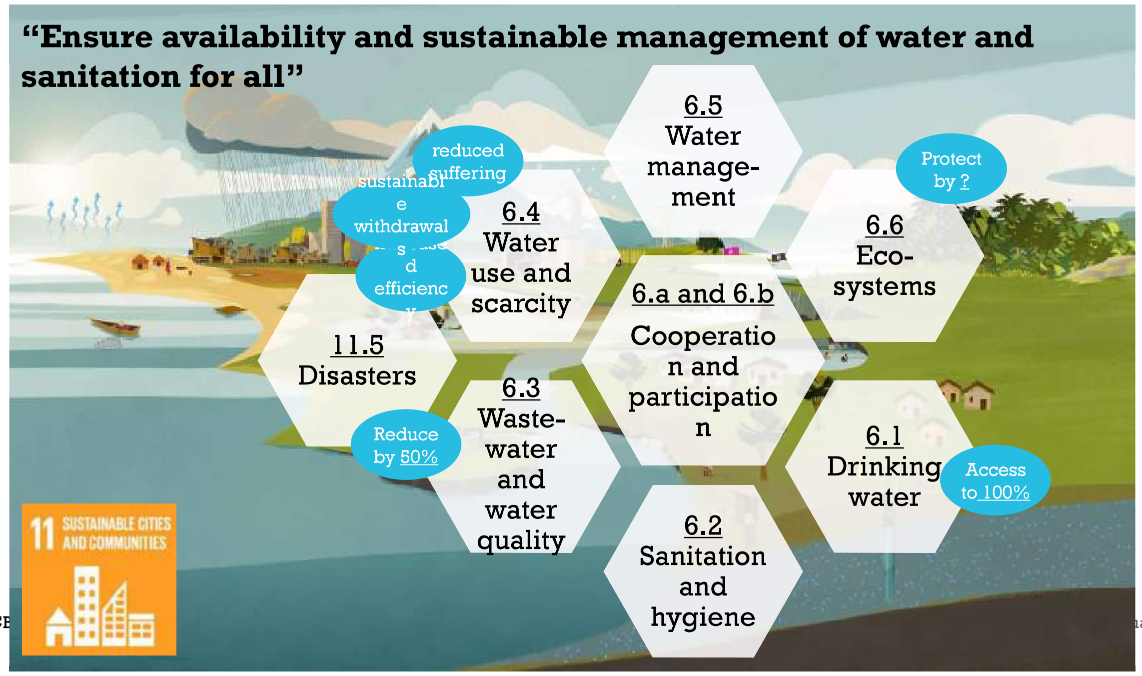
Millennium Development Goals MDGs

- UN-led
- 8 goals and 21 targets, focusing on poverty reduction
- Relevant to low income countries
- 2 water and sanitation targets under MDG 7
- 3 core indicators on water and sanitation
- Monitoring through household surveys

Sustainable Development Goals SDGs

- Country-led
- 17 goals and 169 targets, focusing on the three pillars of sustainable development
- Relevant to all countries
- 8 water and sanitation targets under SDG 6
- 11 core indicators on water and sanitation
- Monitoring by national authorities, feeding into regional and global reporting

SDG 6



GOAL 6: ENSURE ACCESS TO WATER AND SANITATION FOR ALL

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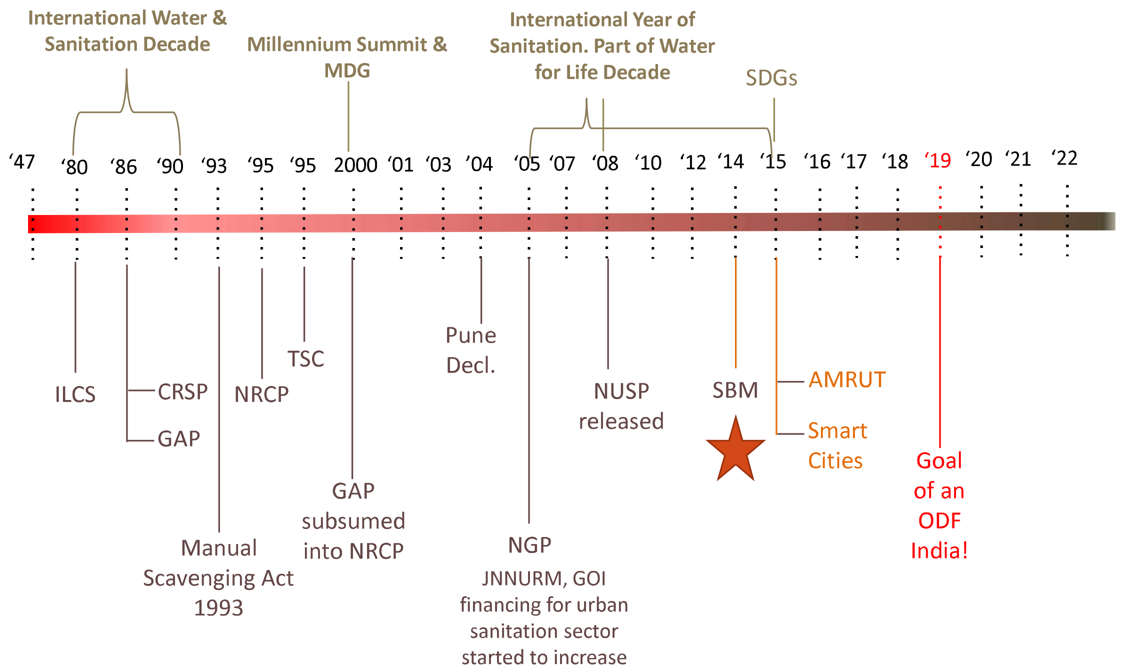
- **BY 2030, ACHIEVE UNIVERSAL AND EQUITABLE ACCESS TO SAFE AND AFFORDABLE DRINKING WATER FOR ALL**
- **BY 2030, ACHIEVE ACCESS TO ADEQUATE AND EQUITABLE SANITATION AND HYGIENE FOR ALL AND END OPEN DEFECATION, PAYING SPECIAL ATTENTION TO THE NEEDS OF WOMEN AND GIRLS AND THOSE IN VULNERABLE SITUATIONS**
- **BY 2030, IMPROVE WATER QUALITY BY REDUCING POLLUTION, ELIMINATING DUMPING AND MINIMIZING RELEASE OF HAZARDOUS CHEMICALS AND MATERIALS, HALVING THE PROPORTION OF UNTREATED WASTEWATER AND SUBSTANTIALLY INCREASING RECYCLING AND SAFE REUSE GLOBALLY**
- **BY 2030, SUBSTANTIALLY INCREASE WATER-USE EFFICIENCY ACROSS ALL SECTORS AND ENSURE SUSTAINABLE WITHDRAWALS AND SUPPLY OF FRESHWATER TO ADDRESS WATER SCARCITY AND SUBSTANTIALLY REDUCE THE NUMBER OF PEOPLE SUFFERING FROM WATER SCARCITY**

NATIONAL: INCREASED ATTENTION TO SANITATION POLICY



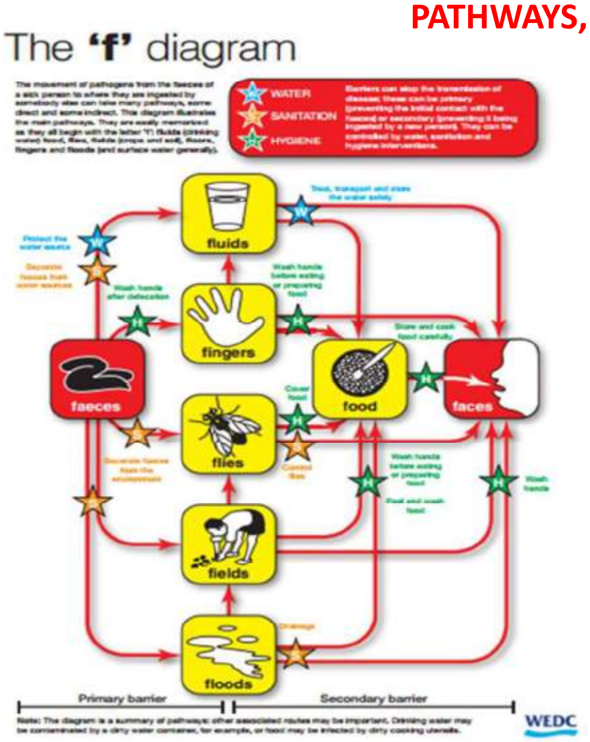
ILCS- Integrated Low-cost Sanitation, CRSP- Central Rural Sanitation Programme, GAP- Ganga Action Plan, NRCP- National River Conservation Programme, TSC- Total Sanitation Campaign, NGP- Nirmal Gram Puraskar, JNNURM- Jawaharlal Nehru National Urban Renewal Mission, NUSP- National Urban Sanitation Policy , SBM – Swachh Bharat Mission, NUDM – National Urban Development Mission

ENVIRONENTAL HEALTH

Global Burdon of Diseases

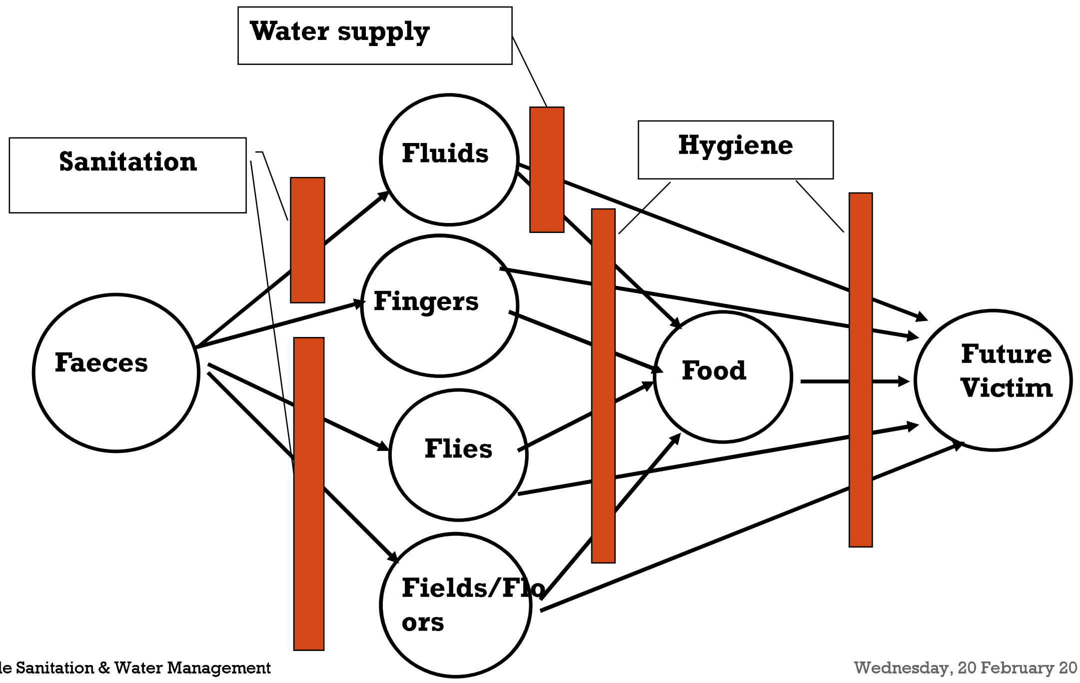
- **Faecal-oral (focus of this presentation)**
  - **Diarrhoeal disease**
    - **2 million deaths/year from diarrhoea, mostly under 5**
      - **Jumbo jet crash every hour and a half...**
    - **One billion cases/year**
    - **4.3% of Burden of Disease DALYs**
    - **88% (?) attributable to inadequate WSH**
  - **1/3 of developing world pop'n carry intestinal worms**
  - **200 million infected by schistosomiasis (bilharzia)**
- **6-9 million blind from trachoma (1/4 reduced by adequate water supply)**

TRANSMISSION ROUTE OF PATHOGENS FAECAL – ORAL PATHWAYS, RISKS, IMPACT

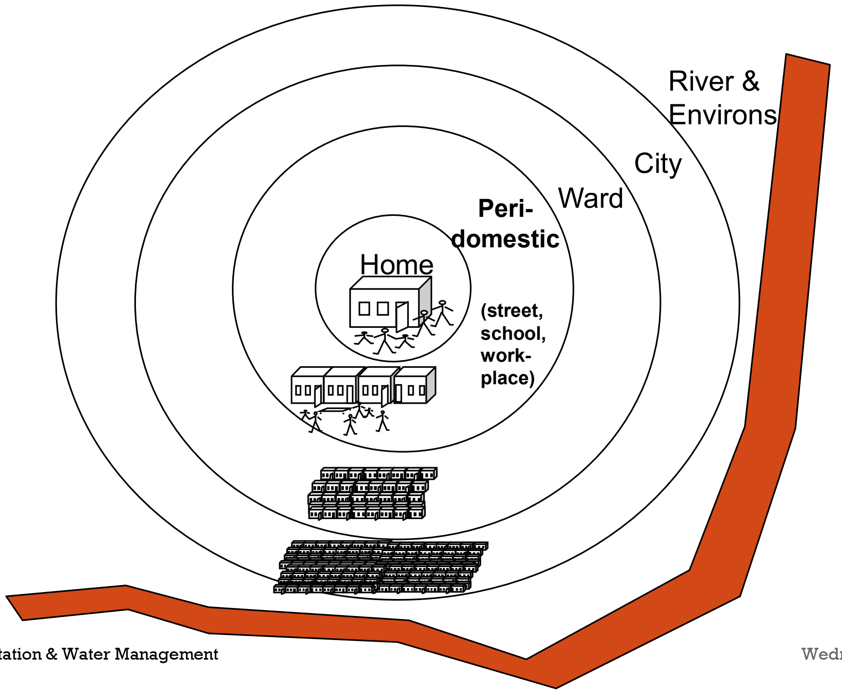


- Water borne diseases
  - Diarrhoea: estimated 600 mill. adult cases, 300 mill. U-5
    : about 400,000 U-5 deaths
- Vector borne
  - Malaria: 900,000 (2013) reported cases to 24 mill. annual cases (estimated 2012)
  - Dengue : ~ 50,000 cases & 250 deaths (2012)
- Stunting
  - undernutrition in India is largely explained by open defecation, population density, and lack of sanitation and hygiene

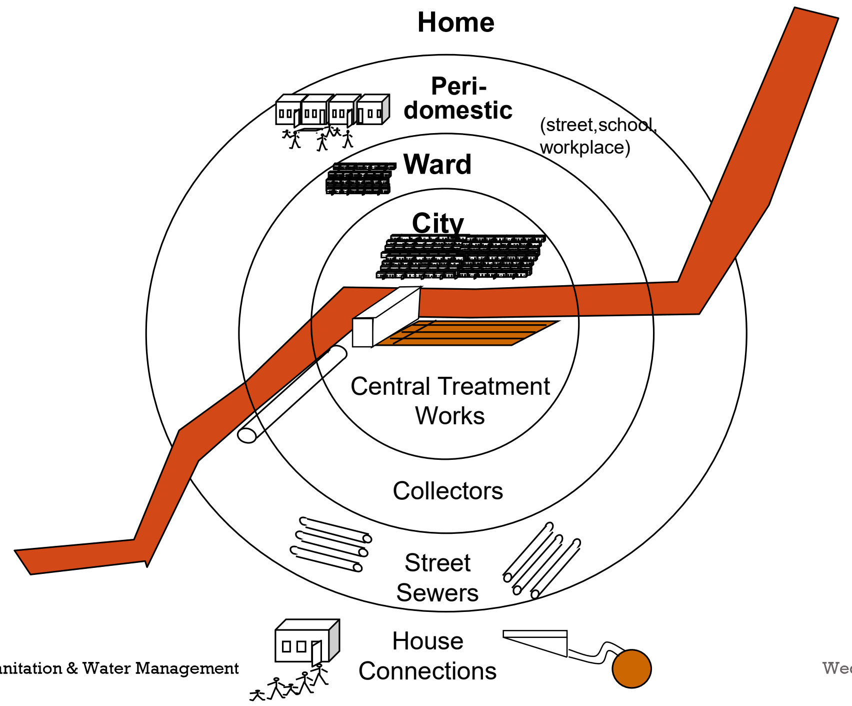
THE F-DIAGRAM



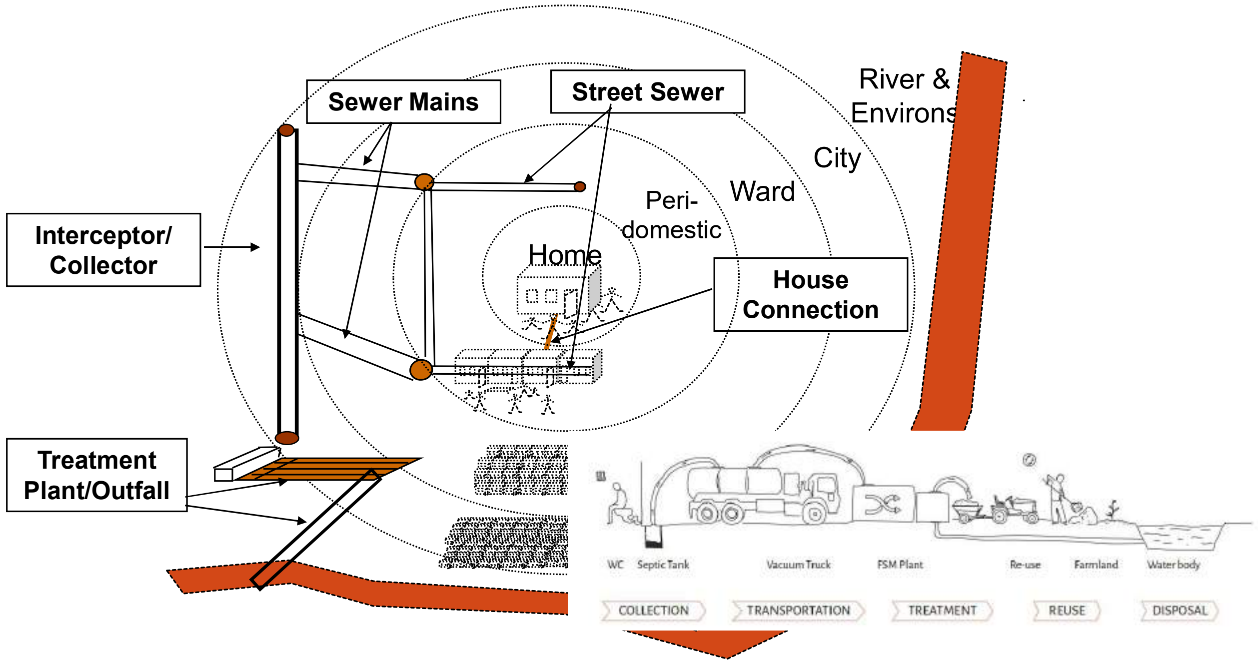
HOW PEOPLE SEE THEIR CITY



AN ENVIRONMENTAL VIEW



A PUBLIC HEALTH VIEW



FSM WAY FORWARD

- Specific urban contexts
- The way forward for urban sanitation
- Academic institute-Interface between research, implementation & dissemination

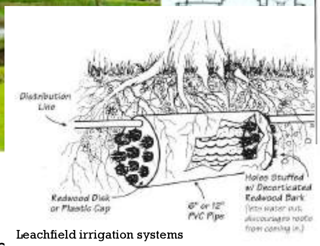
Non-tenured low-income settlem. (inner-city slums)

Tenured or non-tenured peri-urban interface

Planned urban development areas (low income)

Non-residential buildings

Thank you



Leachfield irrigation systems

Quest for sustainability

There is enough for everyone's need

There is never enough for everyone's greed

Mahatma Gandhi

Prof. Pratap Raval
pmr.civil@coep.ac.in

SANITATION CAPACITY BUILDING PLATFORM

Urban Challenges

Prof. Pratap Raval,
College of Engineering, Pune

CONTENT

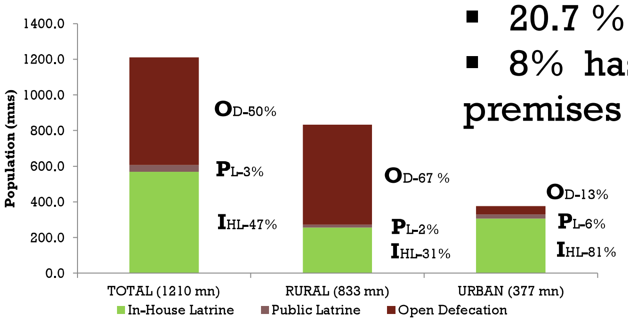
- Overview
- Challenges in Urban water and sanitation in India,
- Challenges faced at household and communities,
- Challenges at City and Town Level,

OVERVIEW- URBAN WATER &SANITATION

"More Indians have mobile phones than toilets". This sensational news first made headlines in 2010.

As per Census 2011 Access to drinking water supply (Households)

- 71.2% within their premises
- 20.7 % within 100m from their premises
- 8% has to move beyond 100m from their premises



Sanitation situation in India Census 2011 reported 13 % households does open defecation

URBAN WATER

The deficits in sanitation become more critical in the context of the absence of reliable, safe water in Indian cities.

Urban households in India depend on multiple sources – often separate sources for potable and non-potable uses

The most worrisome consequence of this dependence on non-public, non-networked sources, often multiple and distant, is the contamination of water, especially for potable uses

URBAN WATER

Access to drinking water-Only a little more than 60 per cent of urban households have access to public supplies of drinking water. Even households connected to the public supply system receive on average only three hours of drinking water supply a day, and an average of 75 litres per capita

Even water from public systems can be contaminated.

URBAN WATER

Differentials across urban centres-Cities in India are divided into classes according to their population, and allocation of public funding across these classes is often a matter of debate.

Conveyance and treatment deficits- Urban India faces a tremendous shortfall in facilities for safe waste collection, conveyance and treatment – for both on-site systems and networked systems

Household-level deficits in sanitation-13 per cent (10 million) households resort to open defecation, and another 3 per cent or 1.8 million households have "unimproved" sanitation (unimproved pit latrines, removal of night soil by humans, animals or direct flow into drainage).

(Census 2011)

URBAN SANITATION & ENVIRONMENT

Ground and surface water pollution

FETCH WATER FROM A HUGE WELL IN THE VILLAGE OF NATWARGHAD IN THE WESTERN INDIAN STATE OF GUJARAT

A BANGLADESHI WOMAN COLLECTS CONTAMINATED WATER TO RINSE PRODUCE AT A VEGETABLE MARKET

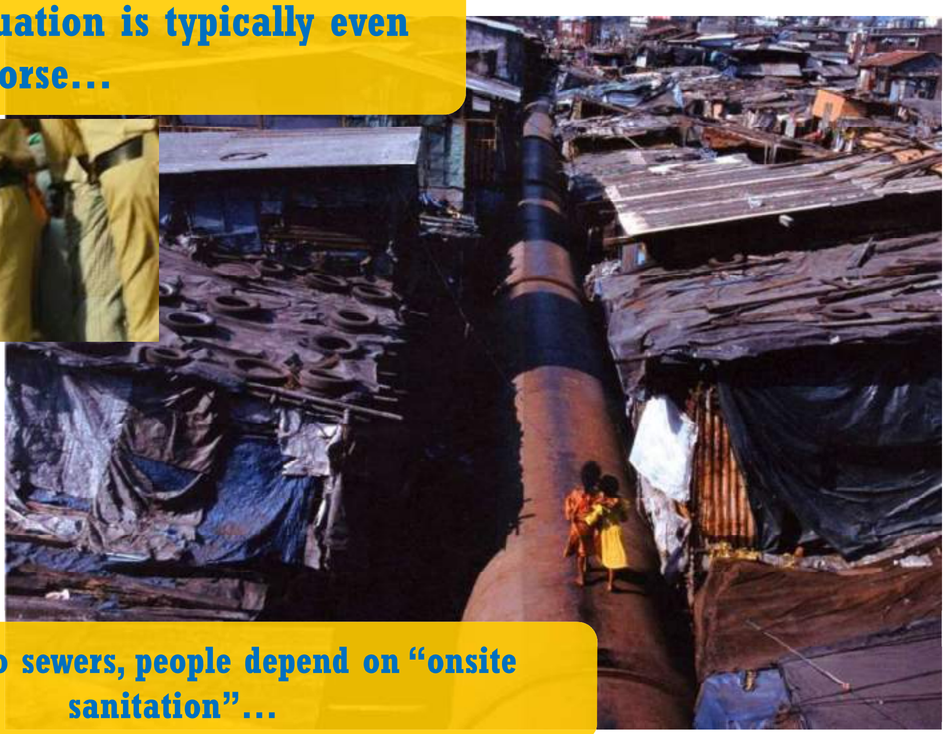
PUMPING WATER IN ALLAHABAD, INDIA AFTER A HEAVY RAIN

WATCHING FOR TRAINS WHILE COLLECTING DRINKING WATER IN MUMBAI

INTERVIEWS WITH WOMEN IN PUNE, INDIA

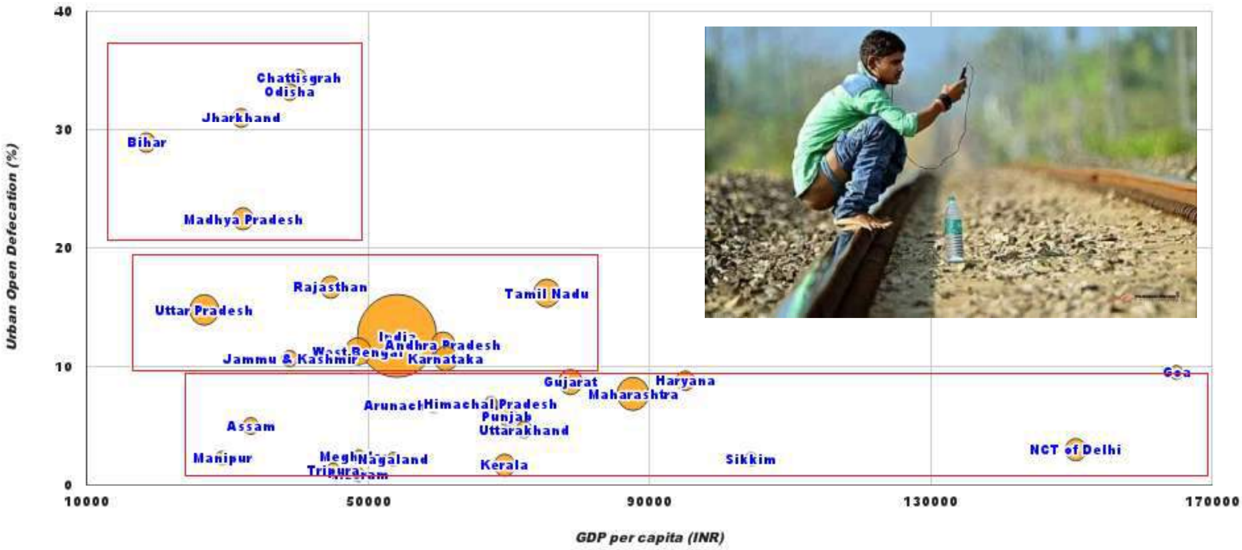
" WE FACE ACUTE SHORTAGES OF WATER. WE HAVE PUBLIC STANDPOSTS… BUT WATER IS AVAILABLE FOR ONLY 2-3 HOURS EACH DAY. LONG QUEUE... FREQUENT FIGHTS. (MAY) NEED TO WALK 20-30 MINUTES TO FETCH WATER … IT IS SO HUMILIATING! "

The sanitation situation is typically even worse…



typically no sewers, people depend on "onsite sanitation"…

STATE DIFFERENCES: URBAN SANITATION



Source: Census of India (2011), Planning Commission (2012)

Urban Open defecation in India, as against per capita State GDP shows three clear clusters

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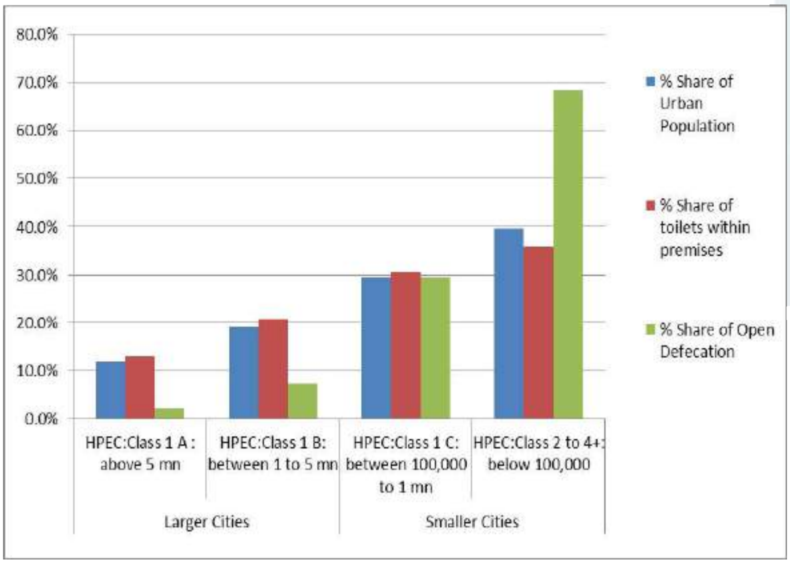
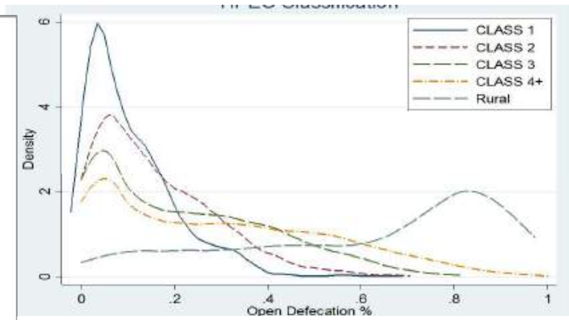
Sanitation Situation across city size: 2011

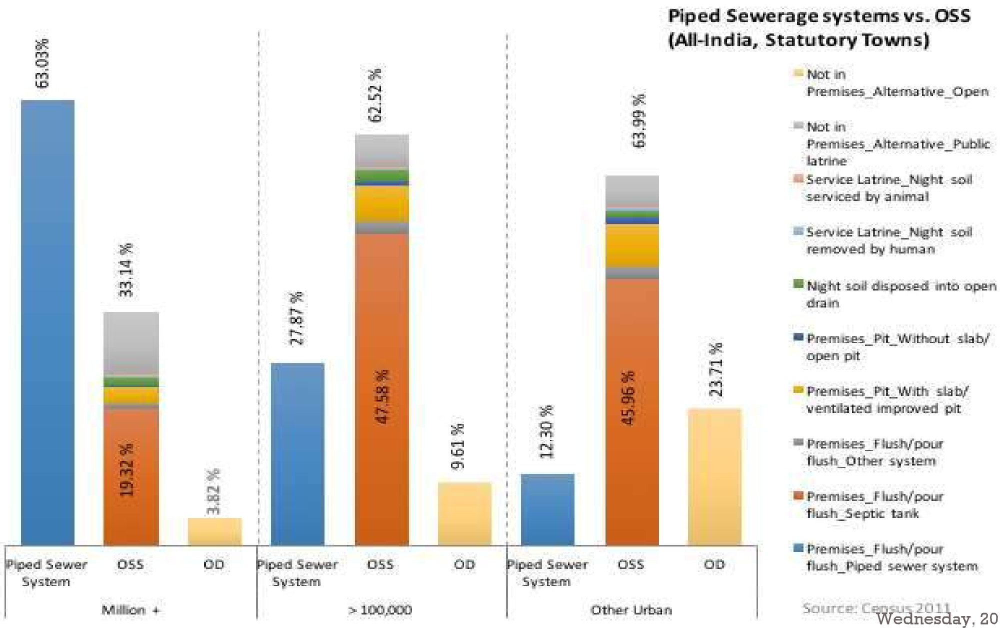




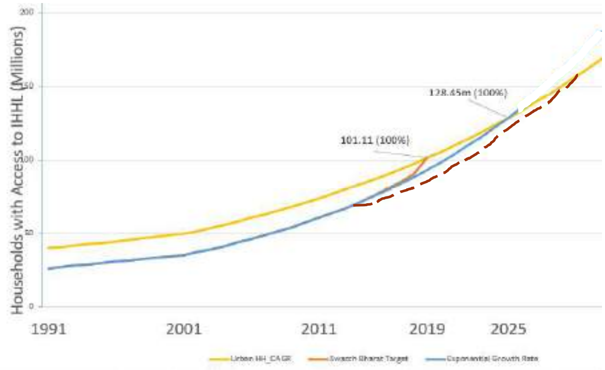
Class I: 100,000 and above;
Class II: 50,000 to 99,999;
Class III: 20,000 to 49,999;
Class IV: 10,000 to 19,999;
Class V: 5,000 to 9,999 and

High Powered Expert Committee (HPEC) on Urban Infrastructure

WITH THE DECREASE IN CITY SIZE, DEPENDENCE ON OSS ALSO INCREASES



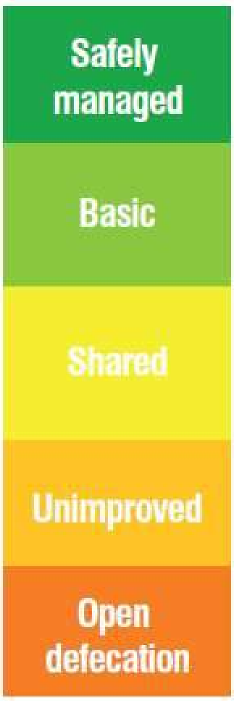
NATIONAL: SBM (U) AND AMRUT FUNDING



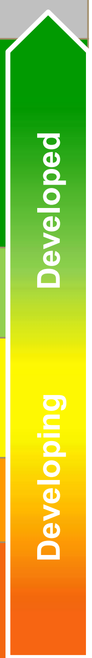
Success of SBM (U) penetration will make FSSM more critical

AMRUT Funding available for Faecal Sludge and Septage Management

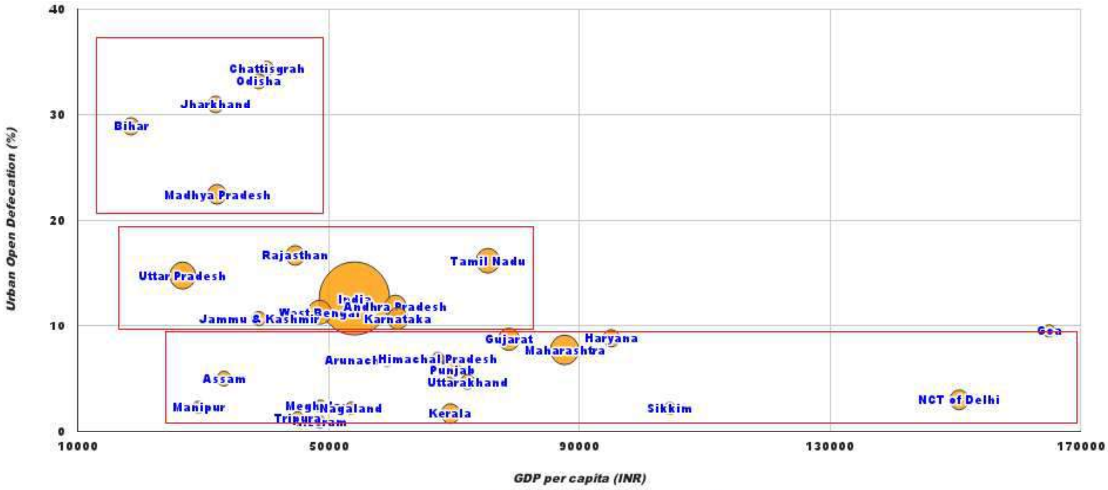
Waste water treatment Capacity 10-11% of census Urban Pop → **~ 70% Statutory Town urban pop in 2011**



MDG/SDG	Service ladder	Progressive realization
SDG 6.2	Safely managed sanitation	Private improved facility where faecal wastes are safely disposed on site or transported and treated off-site; plus a handwashing facility with soap and water
MDG continuity	Basic sanitation	Improved facility which separates excreta from human contact (private)
	Shared sanitation	Improved facility which separates excreta from human contact (shared with other hh)
	Unimproved sanitation	Unimproved facility does not separate excreta from human contact
	No service	Open defecation



STATE DIFFERENCES: URBAN SANITATION



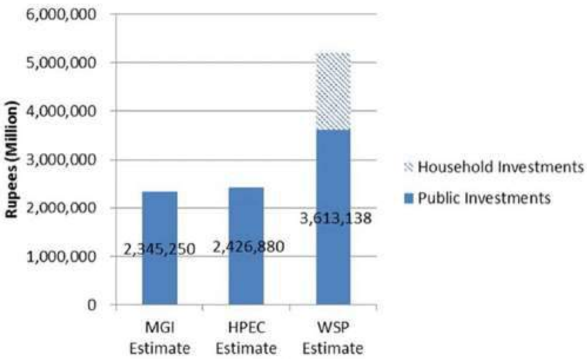
Source: Census of India (2011), Planning Commission (2012)

Urban Open defecation in India, as against per capita State GDP shows three clear clusters

1. Smaller, higher income states, have lower OD; 2. Large sized states have OD similar to India's average : 3. Medium sized lower urbanized states have higher OD

Source: S. Dasgupta, Center for Policy Research, New Delhi

Financing requirements for urban sanitation



The first estimate, based on 2008 prices (US$ 1 = Indian rupees (INR) 44), was prepared by McKinsey Global Institute (MGI).

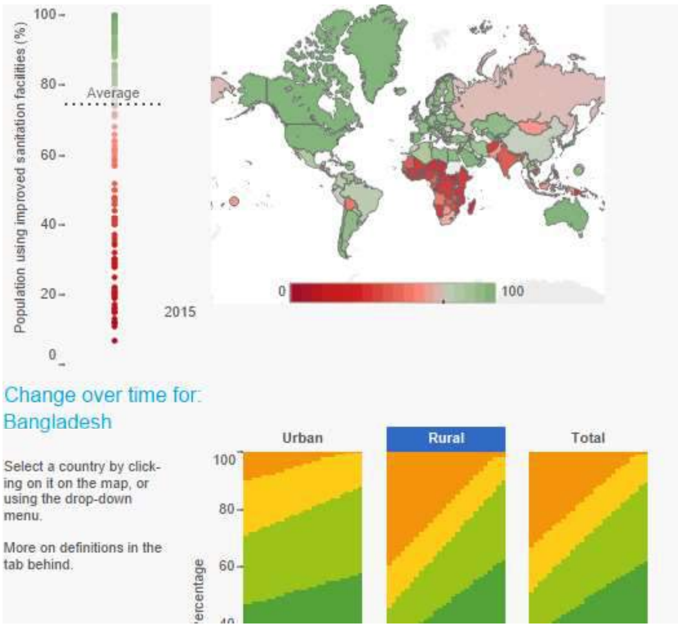
The second estimate was made by the High Powered Expert Committee (HPEC) on Urban Infrastructure, set up by the previous government to estimate investment requirements for the provision of urban infrastructure services over the next two decades, based on 2009 prices.

The third estimate, prepared by WSP, South Asia, differs from others in two central aspects: it takes household investments into account, and it assumes a mix of different sanitation systems rather than sewerage only.

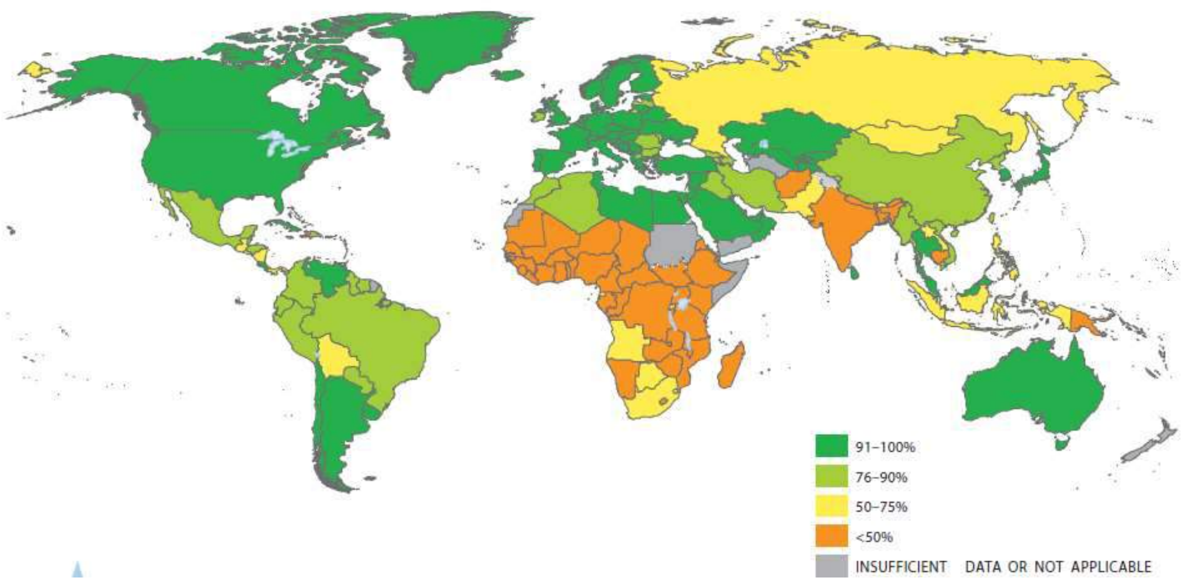
EXPLORE GLOBAL SANITATION PROGRESS

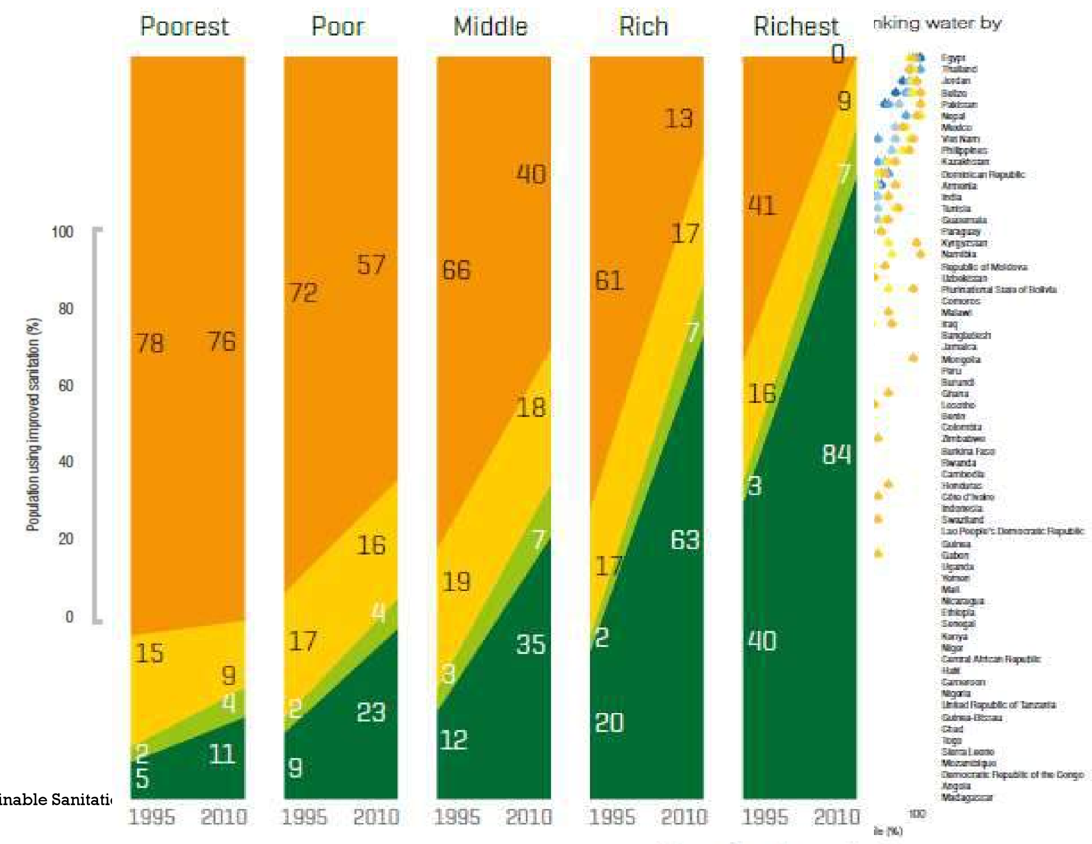
Use this interactive tool from the World Health Organisation to analyse progress on water and sanitation for different countries between 1990-2015.

[Interactive Progress on Sanitation and Drinking Water 2015 Dashboard]



In 47 countries, areas or territories, less than half the population uses improved sanitation in 2015





NATIONAL: CHANGES IN SOCIAL STRUCTURE, HOUSING CONSOLIDATION

- Housing consolidation and improvements in HH access to piped water supply

As share of total housing (NSS)	1983	1993	2002	2008-09	*2011 (census)*
Permanent	57.6%	73.8%	87.7%	91.7%	*84.3%*
Semi-permanent (roof quality)	25.9%	17.9%	9.0&	6.2%	*11.6%*

- Changes in social structure including
  - Family composition – nuclear families
  - Social Equity and dignity demands –
    - gender equity and voice within HH, increased workforce participation
    - Manual scavenging Act, caste based mobilization, etc

ORGANISED FSM CENTRAL TO IMPROVED SANITATION

- **Current scenario no more ac**

Image Source: UMC 2014

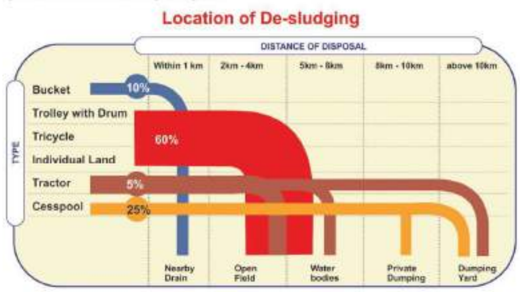
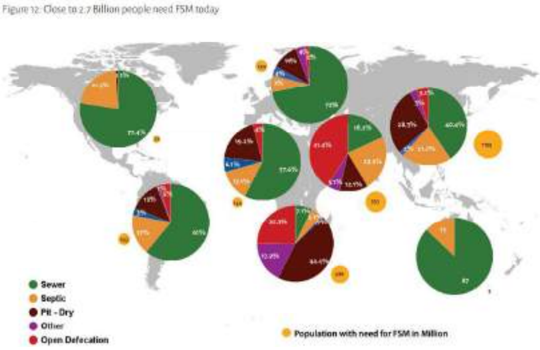


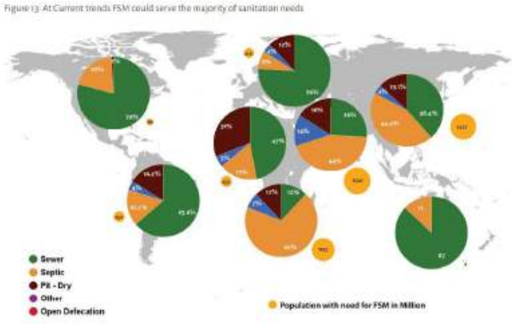
Image Sources: SCI-FI 2014

Image Sources: Injeti Srinivas 2014

INTERNATIONAL: FSM IS GROWING AND IS HERE TO STAY

- High ***dependency*** on OSS currently
- Future ***increase in dependency*** – from 2.7 billion upto 4.9 billion persons by 2030!
- High ***Vulnerabilities*** – occupational and human health and the environment
- ***Advantages over sewerage systems*** – costs, time requirements of construction, nature of cities, climate benefits, private service opportunity etc.





Source: Cairns-Smith, Hill and Nazarenko 2014

CHALLENGES
OR
WHY IS SANITATION STILL AN ISSUE IN THE 21ST CENTURY?

- Roads, airports, flyovers, Mars missions .... everything works but sanitation?

Source: http://breakoutwear.co.uk/blog/?p=3449

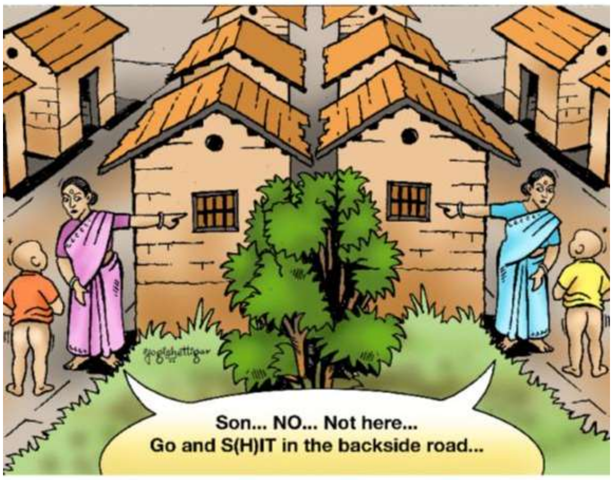
Source: http://www.apagemedia.com/gallery/category/92

CHALLENGE

- Speed
- Cities are not able to cope with the pace of urbanization with regard to
  - Reforms
  - Institutions
  - Skill development
  - Asset creation and maintenance

CHALLENGE

- Sanitation requires not only sound technical solutions but highly depends on
  - good governance
  - social and local political contexts
  - wide ranging awareness in all stakeholders
  - inclusiveness

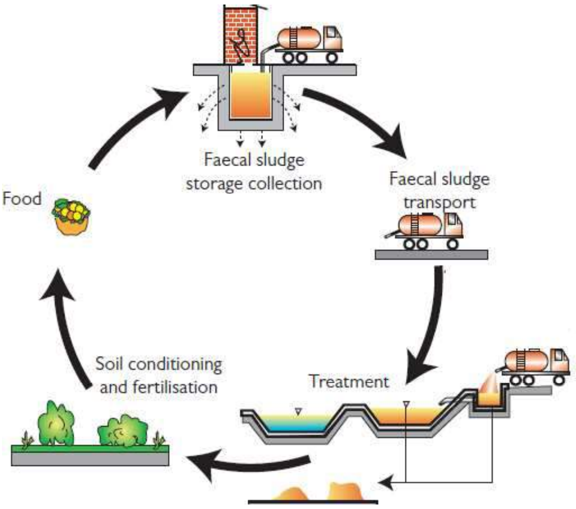


CHALLENGE

- Solutions of the west can not be replicated due to
- Lack of money
- Lack of water
- Lack of energy
- Lack of reuse orientation

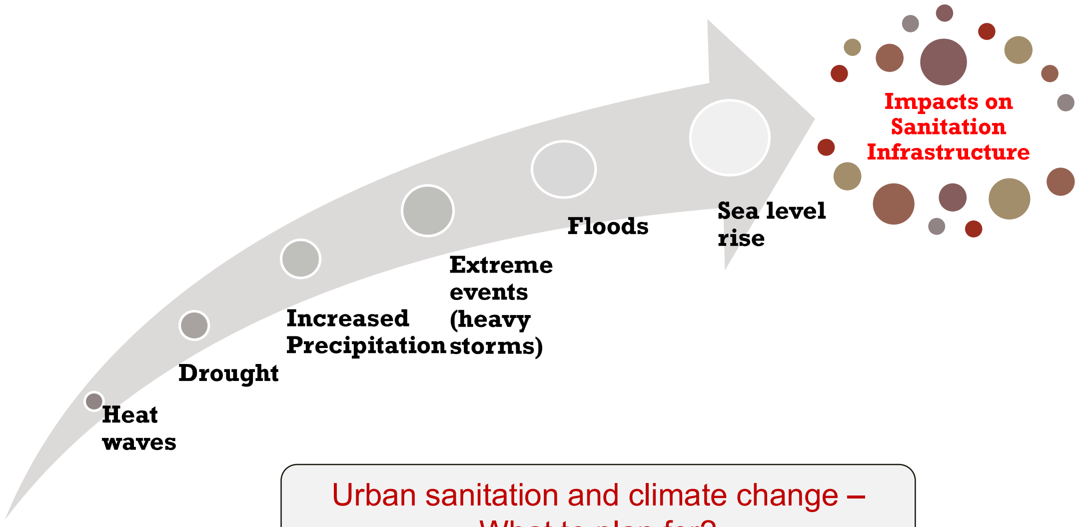
CHALLENGE

- The big question : What then????
- Few good examples
- The famous "leap frogging" requires
  - vision,
  - political will
  - courage as well as
  - capable institutions



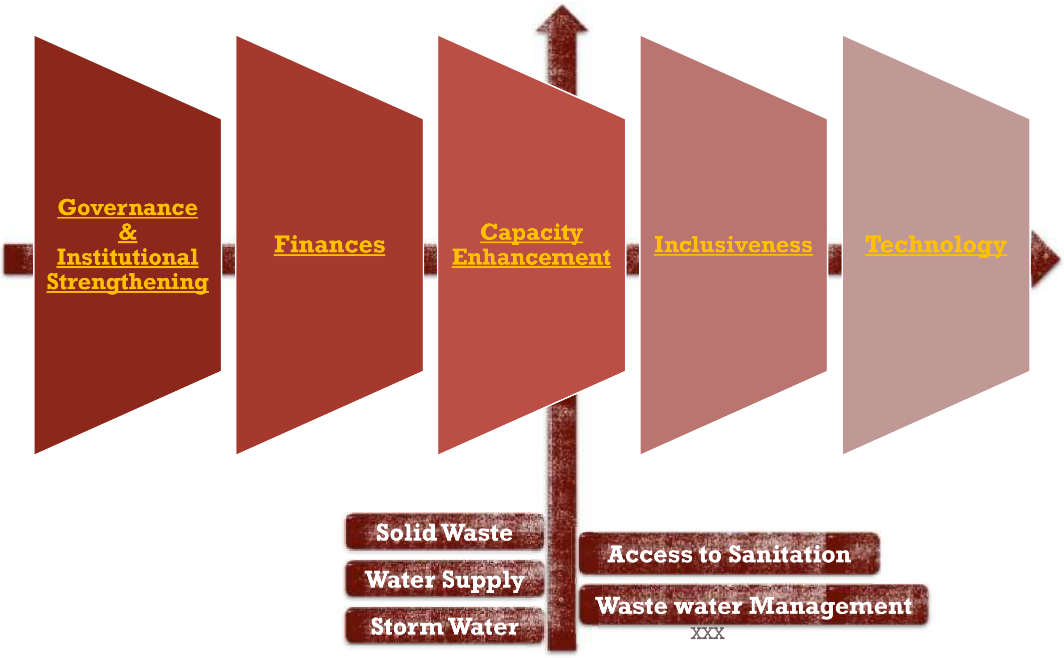
Success factors are often missing

Challenge No 5 : Global warming



Urban sanitation and climate change – What to plan for?

5 Strategic dimensions of good City Sanitation Plan (CSPs)



Thank you

Prof. Pratap Raval
pmr.civil@coep.ac.in

SANITATION CAPACITY BUILDING PLATFORM

Non-Technical Aspects

Mr. Dhawal Patil
M.Sc. Hydro Science and Engineering
General Manager - Operations

CONTENTS

- Stakeholders
- Enabling environment
- Institutional and political aspects
- Economic aspects
- Financial aspects

STAKEHOLDERS & ENABLING ENVIRONMENT

STAKEHOLDERS

Key stakeholders

- The community
- The municipality
- The utility
- Sector NGOs
- CBOs

Secondary stakeholders

- Private sector
- Sector specialists/experts
- Universities
- Donors
- Funding institutions

ENABLING ENVIRONMENT

An ‘enabling environment’ can be seen as the set of interrelated conditions that impact on the potential to bring about sustained and effective change.

INSTITUTIONAL AND POLITICAL ASPECTS

Regulations and standards, Organisation setup, Political aspects, Bureaucracy

REGULATIONS AND STANDARDS

- Developed countries use permit system.
- Quantity – volume of water allowed to be discharged in a day.
- Quality – characteristic of treated effluent allowed to be discharged.
  - Frequency of monitoring is fixed.
  - Standards depend on where the discharge is taking place.

REGULATIONS AND STANDARDS

- Developing countries – permit system does not exist or is not enforced.
- Households and community based sanitation systems are beyond the scope of regulations.
- Growing number of on-site sanitation systems, regulations and standards will be enforced strictly.

ORGANISATIONAL SETUP

Sanitation systems need functional organisational setup of sanitation stakeholders with clearly defined responsibilities.

ORGANISATIONAL SETUP

Public utilities

- Overburdened
- Underfunded
- Sheer volume of work makes the institution look inefficient and obsolete.

Private sector

- Profit focussed
- Efficient
- Can support in running the infrastructure and manage it.

Non profit organizations

- Community focussed
- Human resource

Can support to create awareness.

POLITICAL ASPECTS

A supportive political environment is essential for the successful implementation of a sanitation program.

- Step 1: Defining over arching vision and political will
- Step 2: Articulating broad objectives and taking on challenges
- Step 3: Environmental sanitation, advocacy, mass awareness
- Step 4: Percolation of knowledge

POLITICAL ASPECTS

- Governments tend to sacrifice environmental concerns for other fiscal priorities.
- Political and administrative preferences lean heavily towards large-scale, centralised wastewater and sewerage systems.

BUREAUCRACY

- Responsibilities of different authorities are not clearly defined.
- Three tier: central, regional and local authorities.
- Lack of coordination and communication mechanism.
- Sanitation programs get hindered in terms of execution.

KEY TAKE AWAY POINTS

- Familiarity with the local regulatory framework.
- Political will and support for creating an enabling environment.
- Unclear responsibilities and bureaucratic processes can significantly delay sanitation program.
- In a sanitation program, the roles of the different stakeholders have to be clearly defined.

ECONOMIC ASPECTS

LOCAL SKILLS AND COMMUNITY PARTICIPATION

- Important criteria to select appropriate intervention.
- Community participation is not merely the provision of self-help labour.
- Community participation is important not only in planning and implementing stages, but also during monitoring and evaluation.

AVAILABILITY OF LOCAL MATERIALS AND TOOLS

- Aim to reduce implementation time and costs.
- Expertise is needed to modify standard designs or develop new design.
- While using local resources, there should not be adverse effect on local environment and economy.

AFFORDABLE TECHNOLOGY

- On site or local sanitation systems seems to be less expensive to build and operate.
- Not all on plot facilities are equally affordable to all.
- Pour flush toilets linked to septic tank > Pour flush toilet linked to twin soak pit > Pit latrines
- Designing a suitable and affordable sanitation and environmentally safe system is the key to achieving the targets.

APPROPRIATE SERVICE LEVEL AND WILLINGNESS TO PAY

- The level of service appropriate to the need of the communities.
- Higher satisfaction leads to more willingness to pay.

Should we design storm water drainage system for six month monsoon season or recurring 10 year storm period?

OPERATION AND MAINTENANCE

- OpEx is as important as CapEx while choosing/designing of sanitation system.
- Life cycle cost analysis of sanitation systems.
- Community toilet blocks or IHHL?
- Most crucial part while deciding the technologies for wastewater treatment.

FINANCIAL ASPECTS

Cost benefit analysis, Subsidies and loans

COST-BENEFIT ANALYSIS

- Ideally should be undertaken for all possible sanitation systems.
- Virtually impossible as improved health and user convenience cannot be quantified.
- Evaluation w.r.t. economic costs and financial costs.
- Economic costs necessary for decision makers.
- Financial costs are dependent on policy variables.

SUBSIDIES OR LOAN?

- Is direct subsidy going to make sanitation affordable?
- Discounts on some key components of sanitation system?
- Should not reduce sense of ownership and responsibilities.

- Will beneficiaries avail loan facility?
- Setting the interest rate and loan repayment term is crucial.
- Control is needed to ensure proper utilisation of loan.

KEY TAKE AWAY POINTS

- Financial costs are only relevant for individual stakeholders (e.g. households).
- Accounting for economic costs allows user to compare alternative system or technology options.
- Subsidies and loans may help the poor pay the investment costs of sanitation infrastructure but at the expense of ownership and maintenance.

SANITATION CAPACITY BUILDING PROGRAM

Decentralised Liquid Waste Management System

Mr. Dhawal Patil
M.Sc. Hydro Science and Engineering
General Manager - Operations

DECENTRALIZED SYSTEMS

Shift in paradigm, Limitations of centralised systems, Features and Constraints of Decentralised Systems

SHIFT IN PARADIGM

- Water borne sanitation system - densely populated areas of industrialised countries.
- In developing countries - urgent need for affordable and sustainable infrastructure.
- There is a need in shift of approach.

LIMITATIONS OF CENTRALISED SYSTEMS

- Increases risk in event of system failure.
- Poor reachability in peri urban areas and informal settlements.
- Complex and require professional and skilled operators.
- O&M to be financed by the local government.
- Reduces wastewater reuse opportunities.

LIMITATIONS OF CENTRALISED SYSTEMS

Engineering solution based on centralised systems built and maintained by subsidised public agencies are inappropriate to the extraordinary pace and character of the urbanisation process in the developing world.

FEATURES OF DECENTRALISED SYSTEMS

- Reduces risks associated with system failure.
- Allows segregation of waste streams and local reuse.
- Increases responsiveness to local demands – needs.
- Permits tailormade solutions.
- Minimises the freshwater requirements.
- Allows incremental development and investment.

CONSTRAINTS OF DECENTRALISED SYSTEMS

- Capacity to plan, design, implement and operate.
- Appropriate policy framework.
- Coordination between government, private sector and civil society.
- Compatibility with knowledge, skills locally available.
- Number of small investments = BIG investment!

KEY TAKE AWAY POINTS

- In developing countries, decentralised sanitation systems and technologies are often more affordable and sustainable.

- Decentralised solutions are usually more responsive to local needs and conditions.

Decentralised and centralised systems should complement and not exclude each other.

Thank you...

+91 20640 00736 | +91 20245 30061

ecosan@ecosanservices.org

www.ecosanservices.org

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SANITATION CAPACITY BUILDING PLATFORM

Sanitation Systems

Mr. Saurabh Kale
Sr. Project Manager
Ecosan Services Foundation

CONTENTS

- Waste products
- Parameters for characterising wastewater
- Understand your system
- Ecological sanitation
- Resource management
- Planning of sanitation system
- Closing the loop

3 WASTE PRODUCTS

Black water, Grey water, Excreta, Faecal sludge, Domestic wastewater and Stormwater

BLACK WATER

Mixture of

- Urine,
- Faeces,
- Flushing water and
- anal cleansing water or
- dry cleansing material (toilet paper)

GREY WATER

Is generated through,

- Bathing,
- Handwashing,
- Washing utensils and
- Laundry

EXCRETA

Mixture of

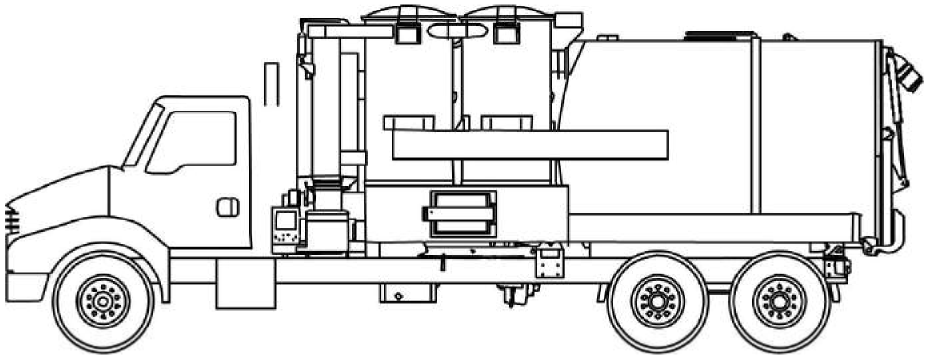
- Urine,
- Faeces and
- Small amount of anal cleansing water

No flushing water!

Source: India Water Portal

FAECAL SLUDGE

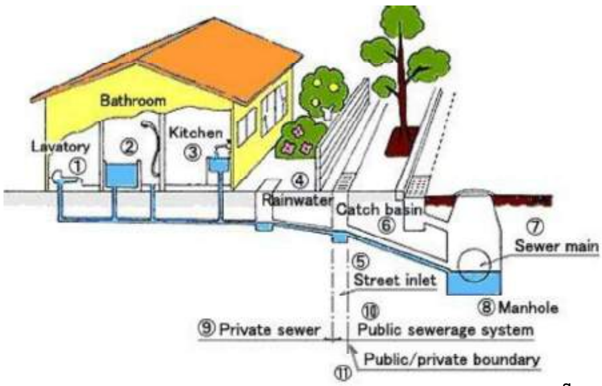
Undigested or partially digested slurry or solid resulting from storage of blackwater or excreta.



Source: Martin Engineering

DOMESTIC WASTEWATER

It includes all kind of liquid waste generated at household level (blackwater and greywater). However it usually does not include storm water.



Source: Eawag, Sandec

STORMWATER

- Runoff from house roofs, paved areas and roads during rainfall event.
- Water from catchment of a stream or river upstream of a community settlement.

Source: Protect Every Drop

10

PARAMETERS TO CHARACTERIZE WASTEWATER

Solids, Organic constituents, Nutrients, Pathogens and other parameters

SOLIDS

- TS: Total Solids & TSS: Total Suspended Solids
- Suspended solids- bigger than 0.2µm
- Settleable and colloidal solids
- 70% organic solids; 30% inorganic solids

Turbidity and organic solids deplete the oxygen in the water body and prevent light from penetrating.

ORGANIC CONSTITUENTS

- BOD: Biochemical Oxygen Demand
  COD: Chemical Oxygen Demand
- Biodegradable organics: proteins, carbohydrates and fats.
- BOD signifies approximate amount of oxygen required to stabilise the organic matter.

Used to size treatment plants, measure efficiency of the processes, evaluate compliance with the discharge standards.

NUTRIENTS

- TN: Total Nitrogen; TP: Total Phosphorus
- Also known as bio stimulants.
- Essential for growth of micro organisms, plants and animals.
- In aquatic environment – growth of undesired aquatic life.
- On land – leads to groundwater pollution

PATHOGENS

- TC (MPN): Total Coliform; FC (MPN): Faecal Coliform
- Communicable diseases can be transmitted.
- Specific monitoring organisms is tested
  - to gauge the plant operation and
  - suitability for reuse.

OTHER PARAMETERS

- Heavy metals
- Acidity/Basicity (pH)
- Alkalinity (Ca & Mg Bicarbonates)
- Electrical Conductivity (EC)
- Temperature

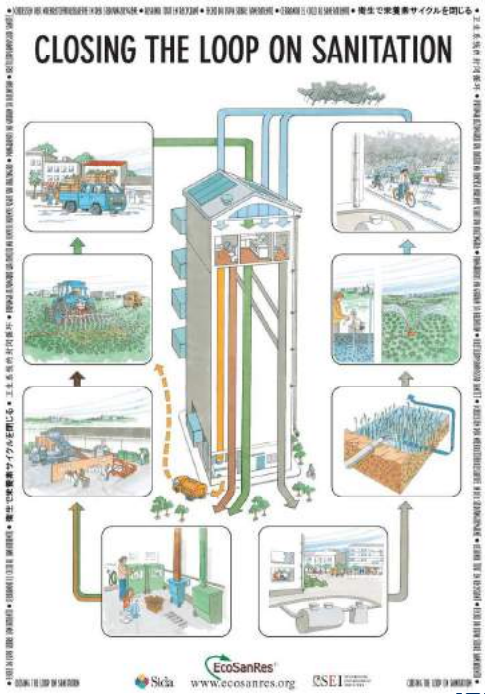
ECOLOGICAL SANITATION

Hygienically safe, economical and closed loop system

ECOLOGICAL SANITATION

- Resource recovery and reuse.
- Minimizing the consumption of non renewable resource.

Hygienically safe, economical and closed loop system!



CHARACTERISTIC COMPARISON

	Total	Grey water	Urine	Faeces
Volume (L/cap.yr)	25,000-100,000	**25,000-100,000**	500	50
Nitrogen (kg/cap.yr)	2.0-4.0	5%	**85%**	10%
Phosphorus (kg/cap.yr)	0.3-0.8	10%	**60%**	30%
Potassium(kg/cap.yr)	1.4-2.0	34%	**54%**	12%
COD (kg/cap.yr)	30	**41%**	12%	**47%**
Faecal coliform (per 100 mL)	-	**10^4-10^6**	0	**10^7-10^9**

POTENTIAL RISKS AND BENEFITS

	Greywater	Urine	Faeces
Chemical contaminants	Fats, oils and toxic substances (org. compounds, chlorides, metals)	Micro contaminants (e.g. hormones & antibiotics)	Micro contaminants (e.g. heavy metals)
Biological contaminants	Pathogens (bacteria, viruses, helminths, protozoa)	Almost sterile (if not cross contaminated by faeces)	Pathogens (bacteria, viruses, helminths, protozoa)
Value	Reuse potential (for irrigation or municipal and non potable domestic use)	Nutrients (N, K and P) Ideal fertilizer	Good soil conditioner but only little nutrients.

SANITATION AND THE NEXUS

SANITATION AND THE NEXUS

22

UNDERSTAND YOUR SYSTEM

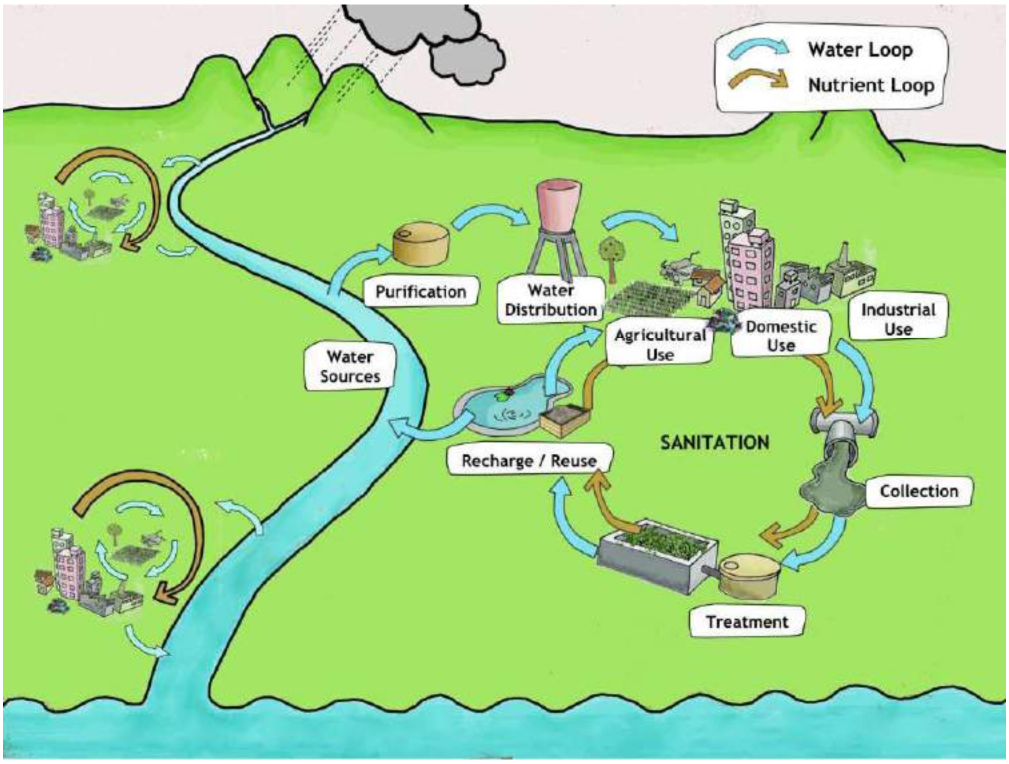
UNDERSTAND YOUR SYSTEM

- Define system boundaries
  - Physical, Political, Social and Economical boundaries
- Identify local water cycle
- Identify local nutrient cycle
- Identify problems, root cause, linkages

25 CLOSING THE LOOP!

Urban water cycle loop

Urban nutrient cycle loop



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ecosan@ecosanservices.org

www.ecosanservices.org

SANITATION CAPACITY BUILDING PLATFORM

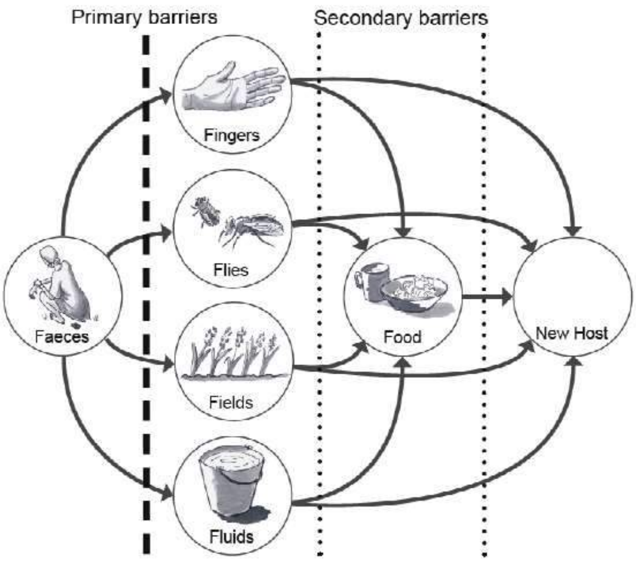
Group Work – Understand Your System

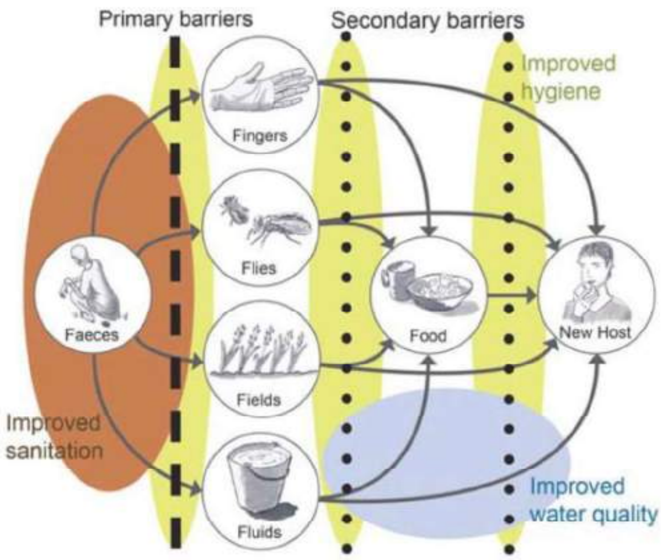
Mr. Saurabh Kale, Sr. Project Manager
Mr. Dhawal Patil, General Manager (Operations)

NATURAL AND BUILT ENVIRONMENT

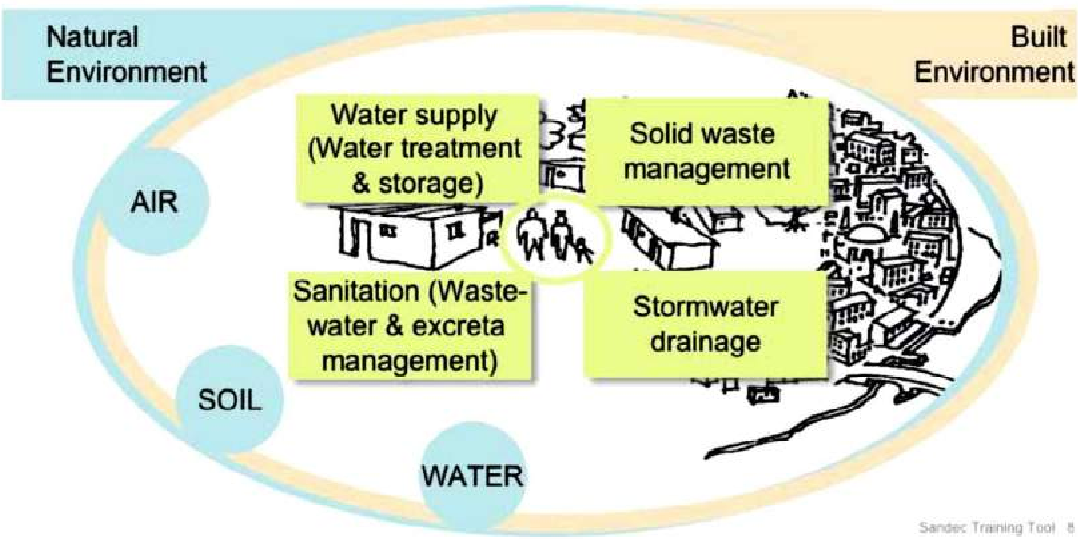
Source: Sandec Training Tool

THE F-DIAGRAM

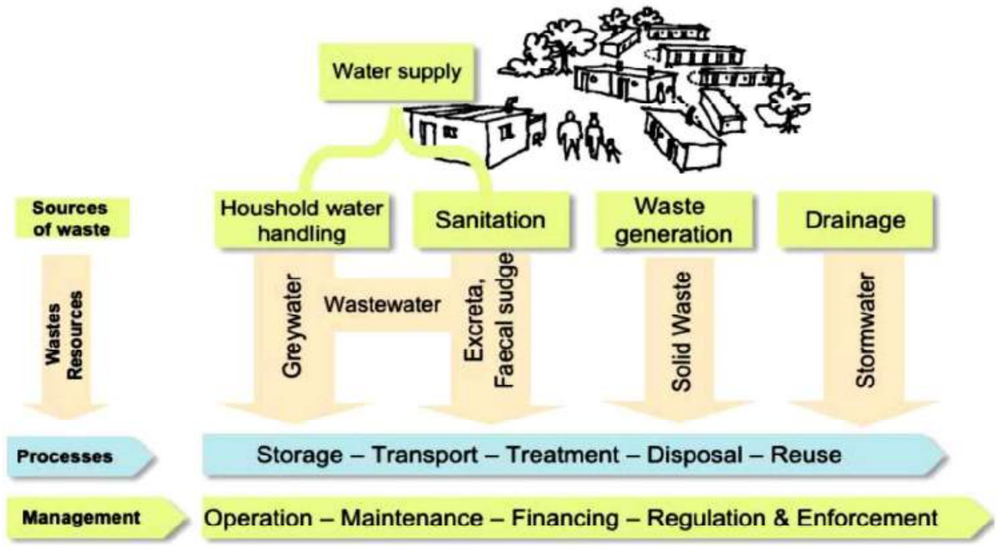




ENVIRONMENTAL SANITATION



WASTE AND RESOURCE FLOWS



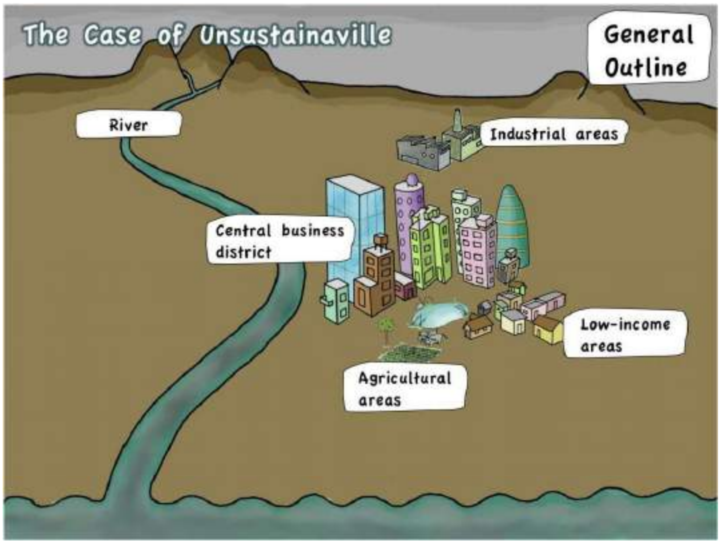
Source: Sandec Training Tool

6 UNDERSTANDING YOUR SYSTEM

OBJECTIVES

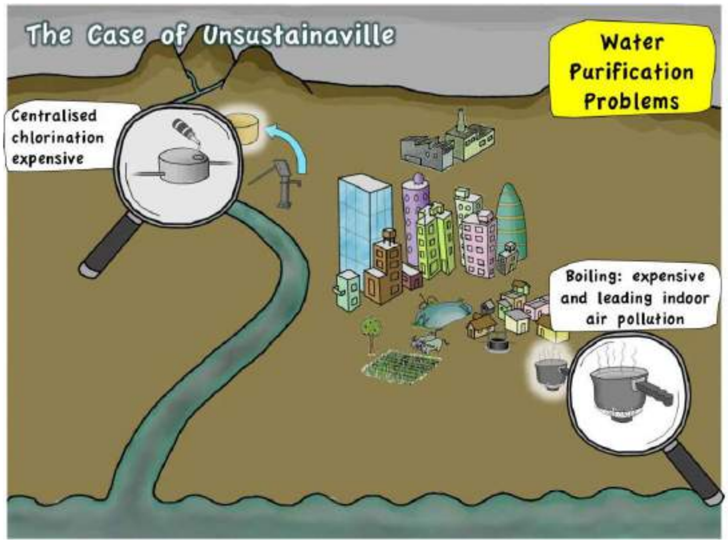
- To get an overview of your local water and nutrient cycle.
- To identify root causes, and how problems are linked.
- To get a deeper understanding of the interrelationships between water resource, sanitation and agriculture.

THE CASE OF UNSUSTAINAVILLE



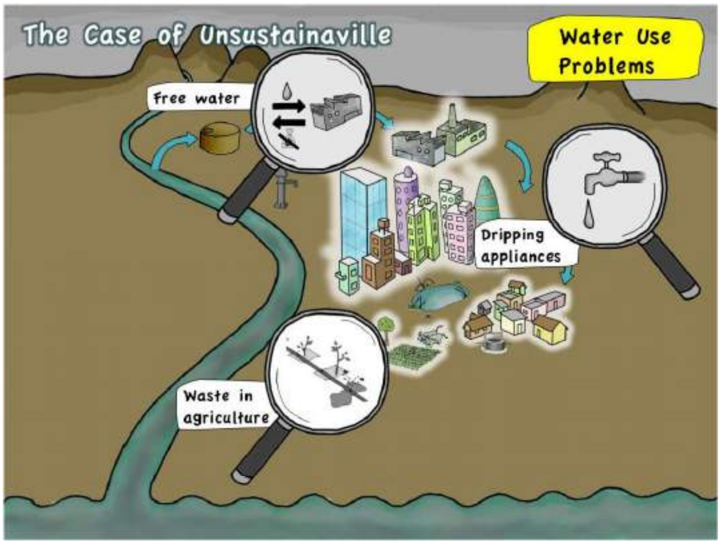
MAPPING WATER SOURCES

WATER PURIFICATION



WATER DISTRIBUTION

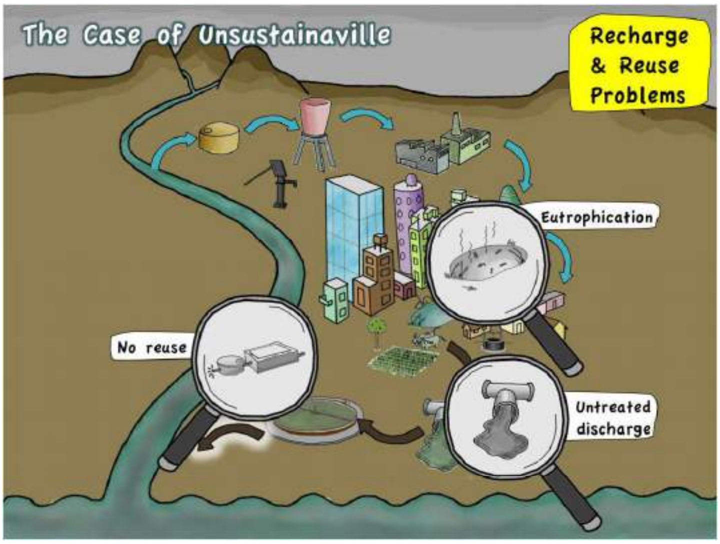
WATER CONSUMPTION



WASTEWATER COLLECTION

WASTEWATER TREATMENT

WASTEWATER REUSE



SOURCE OF FERTILIZER

MAIN PROBLEM AREAS

- Weak political & legal framework
- Overuse & mismanagement of water resources
- Pollution of drinking water sources
- No reuse whatsoever!

CREDITS

- **The complete exercise has been developed through material available on www.sswm.info**
- **The article has been compiled by Katharina Conradin, Michael Kropac, Dorothee Spuhler of seecon International gmbh.**
- **All the pictures belong to seecon International gmbh.**

SCBP

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+91 20640 00736 | +91 20245 30061
ecosan@ecosanservices.org
www.ecosanservices.org

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SANITATION CAPACITY BUILDING PLATFORM

Sanitation Systems and Technologies

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

CONTENTS

- Sanitation and its objectives
- Functional groups
- Sanitation systems
- Emergency sanitation infrastructure

3

SANITATION & ITS OBJECTIVES

Definition and objectives

DEFINITION

- An intervention involving behaviour and facilities aiming at interrupting the disease cycle (faecal-oral disease transmission).
- Safe management of excreta.
- Hardware (toilets & sewers)
- Software (regulations & hygiene promotion)
- Access to basic vs. access to improved

OBJECTIVES

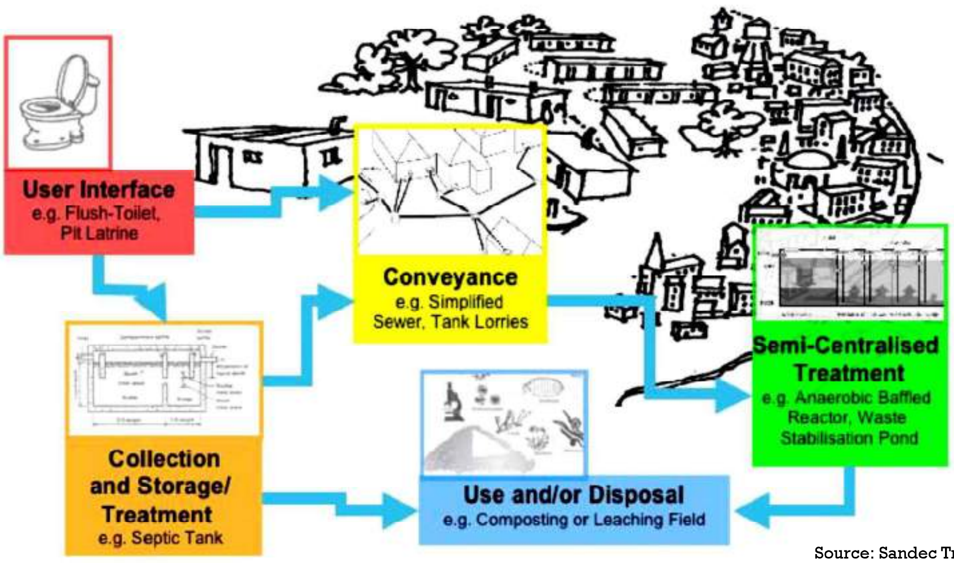
- Protect and promote health
- Protect the environment
- Be simple
- Be affordable
- Be culturally acceptable
- Works for everyone

6 FUNCTIONAL GROUPS

FUNCTIONAL GROUPS

- Technologies which perform the same, or similar function are grouped into “Functional Groups”
- A sanitation system is a combination of technologies through which the products flow.
- Only selected combinations of technologies will lead to functional systems.
- Domestic products mainly run through five different Functional Groups.

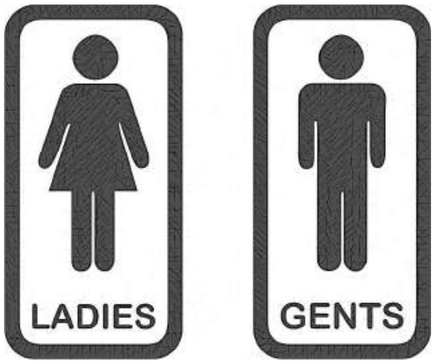
FUNCTIONAL GROUPS



Source: Sandec Training Tool

9

USER INTERFACE

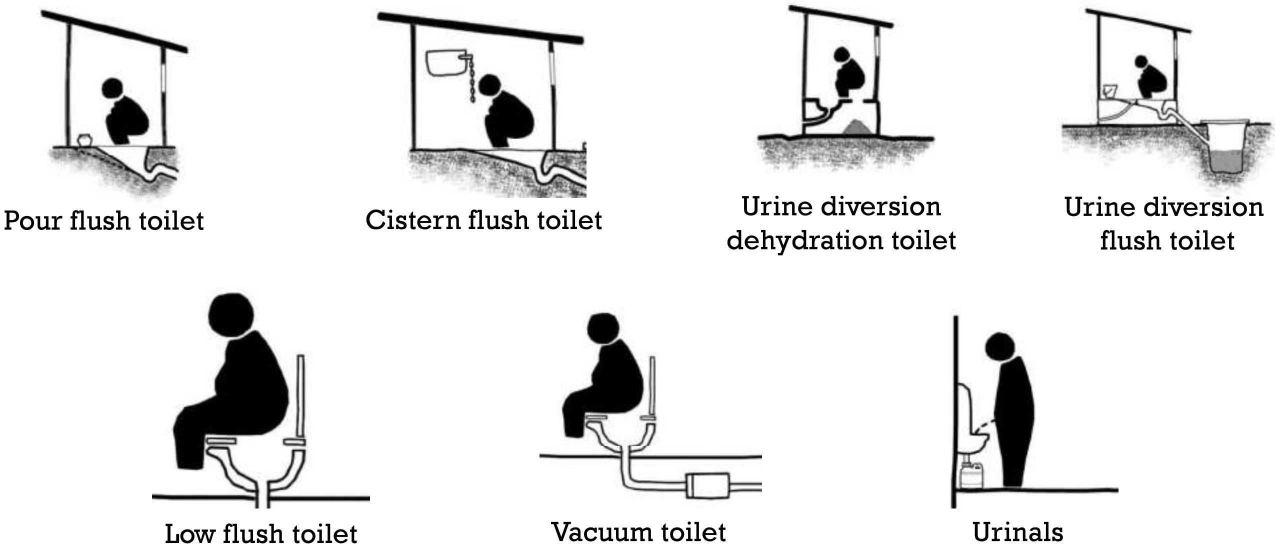


Functional group

USER INTERFACE

- The type of toilet, pedestal, pan or urinal the user comes in contact with.
- It is the place where water is introduced in the system.
- Determines the final composition of the product.
- The choice of user interface is often dependent on the availability of water.

USER INTERFACE

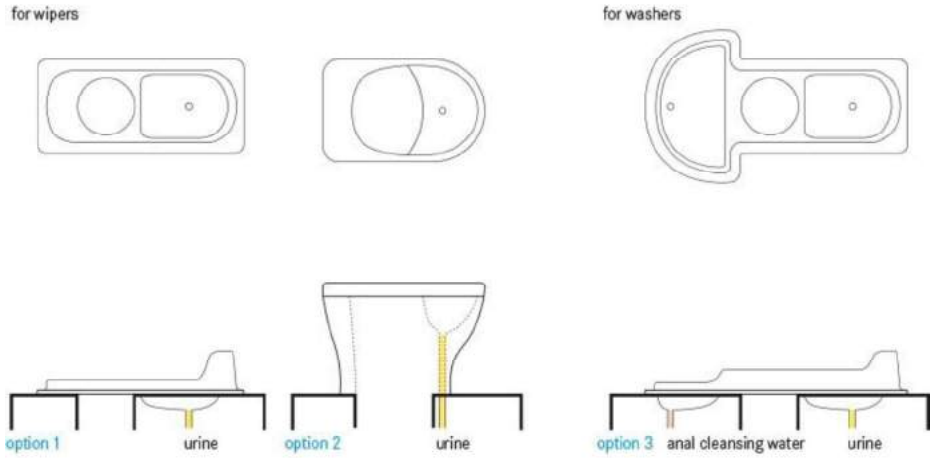


Source: SSWM Tool Box

TECHNICAL AND PHYSICAL CRITERIA

- Availability of space (especially in case of urban poor)
- Ground condition (rock, sandy, loam)
- Groundwater level and contamination (coastal towns and cities having sandy strata)
- Water availability (small towns and emerging cities)
- Climate (temperature, rainfall, sunlight)

URINE DIVERSION DEHYDRATION TOILET

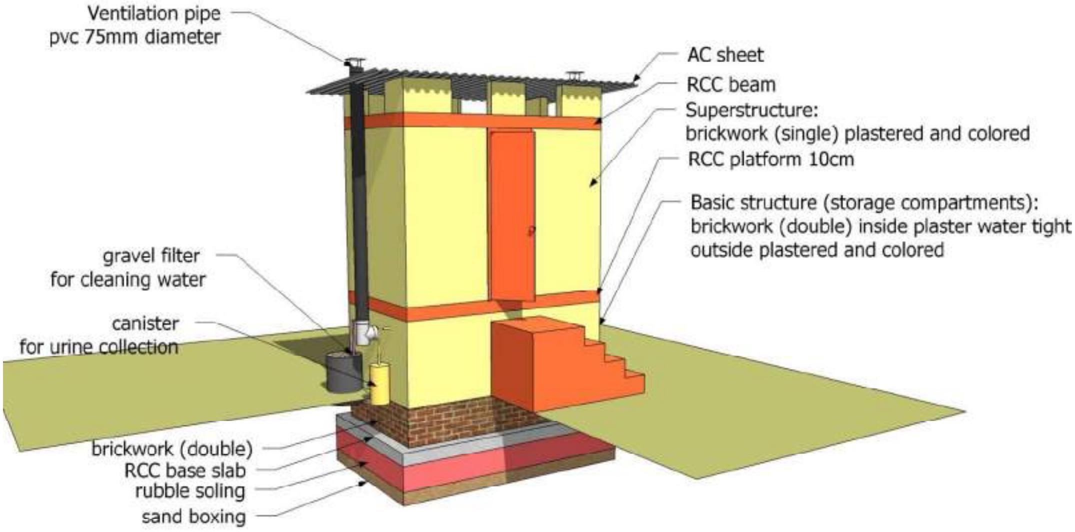


Source: Tilley et al. 2014

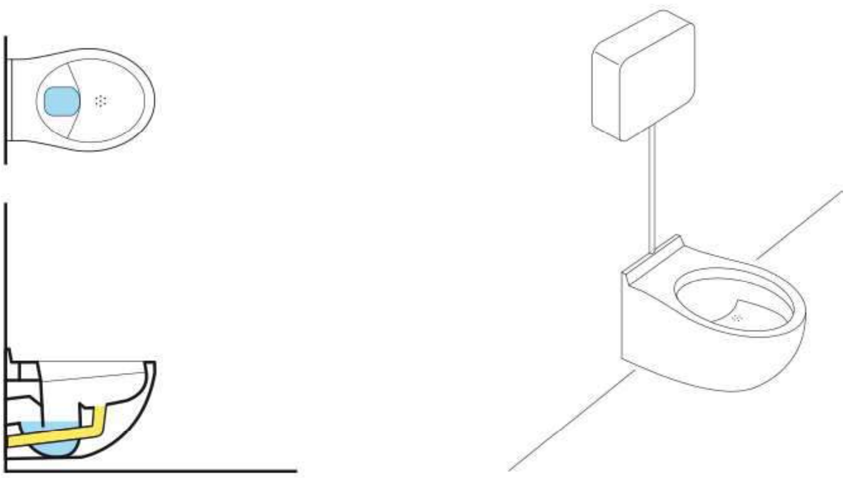
URINE DIVERSION DEHYDRATION TOILET

Source: Waffler (2010); UNESCO-IHE (n.y.)

URINE DIVERSION DEHYDRATION TOILET



URINE DIVERSION FLUSH TOILET



Source: Tilley et al. 2014

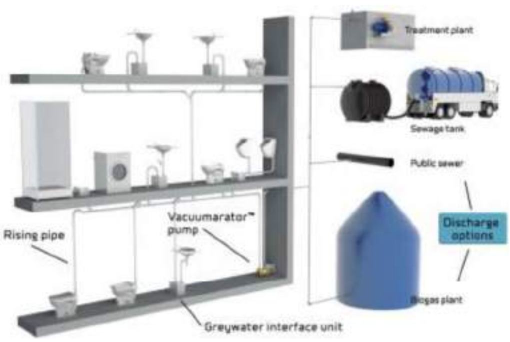
URINE DIVERSION FLUSH TOILET



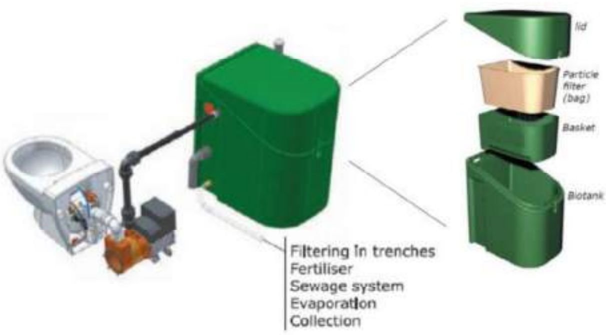

Source: dubbletten.nu; gustavsberg.com; stman.se; rroevac.de

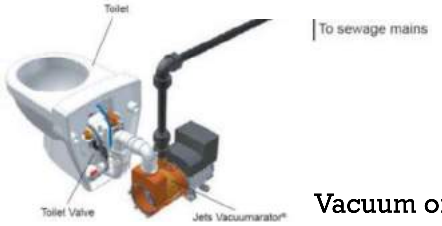
VACUUM TOILET

Vacuum toilet with biotank



Constant vacuum system

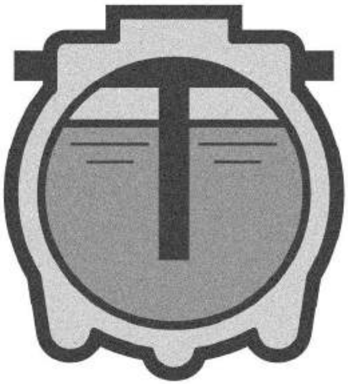




Vacuum on demand system

Source: Jets Group (2005 & 2009)

COLLECTION & STORAGE/ TREATMENT

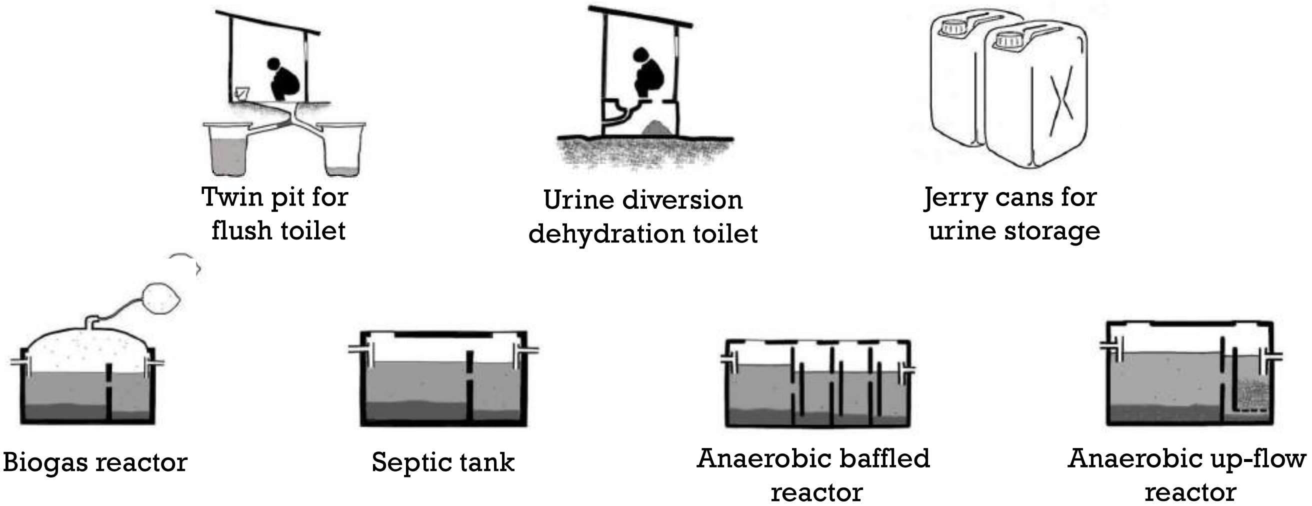


Functional group

COLLECTION & STORAGE/TREATMENT

- The ways of collecting and storing products generated at the user interface.
- Storage often also performs some level of treatment.
- The units are connected to soakaway zone or conveyance system for discharge of liquid.
- The units have to be regularly emptied for solids.

COLLECTION & STORAGE/TREATMENT

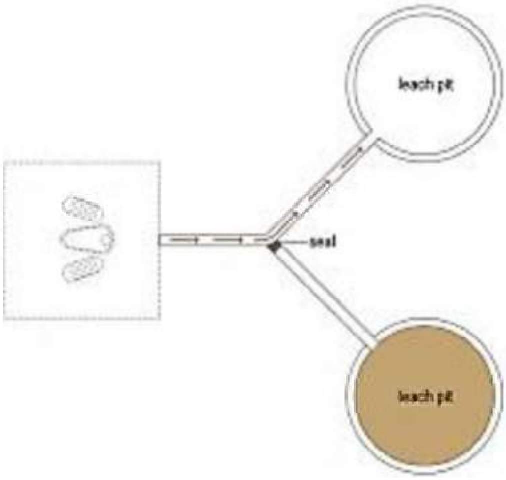


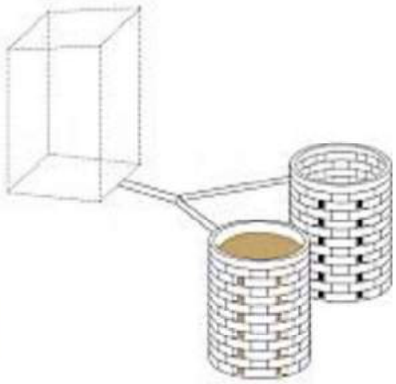
Source: SSWM Tool Box

TECHNICAL AND PHYSICAL CRITERIA

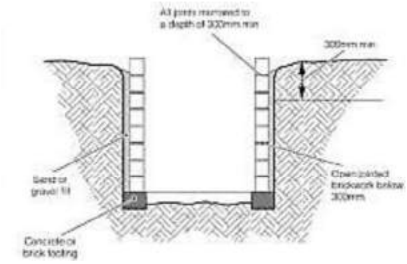
- **Ground condition**
  - Soil and strata (percolation and cost of construction)
- **Groundwater level and contamination**
  - Cross contamination (pathogens)
- **Climate**
  - Temperature (degree of treatment) and rainfall (percolation rate)

TWIN PIT FOR POUR FLUSH TOILET



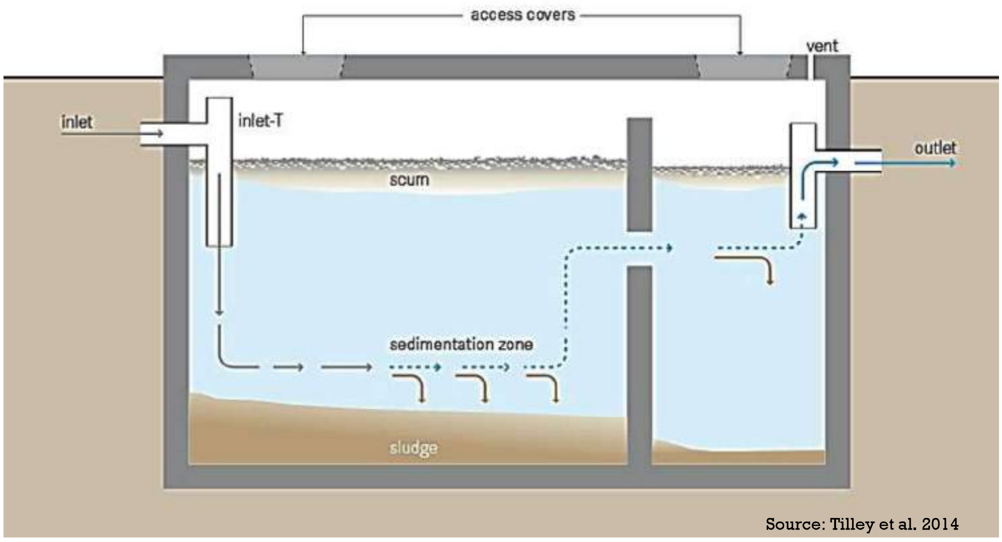


Source: Tilley et al. 2014



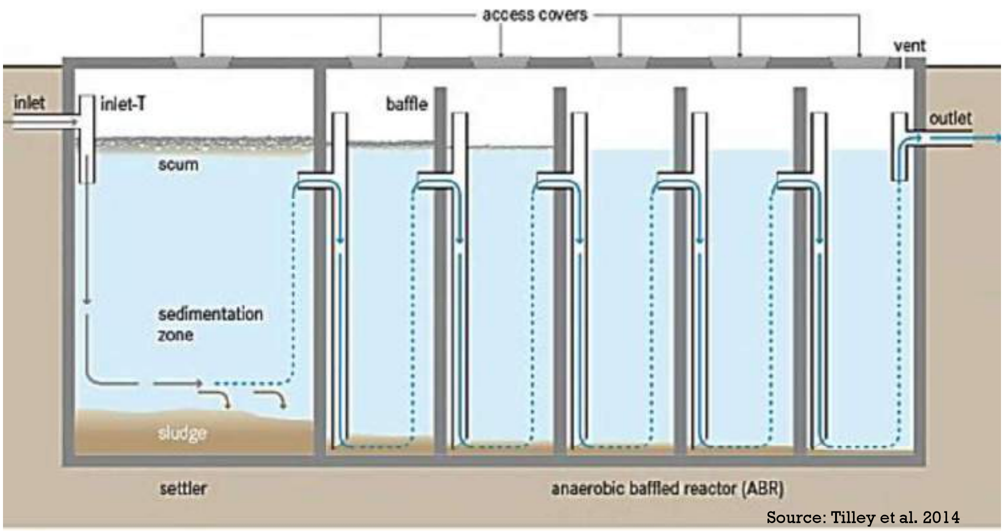
Source: D. Friedman

SEPTIC TANK



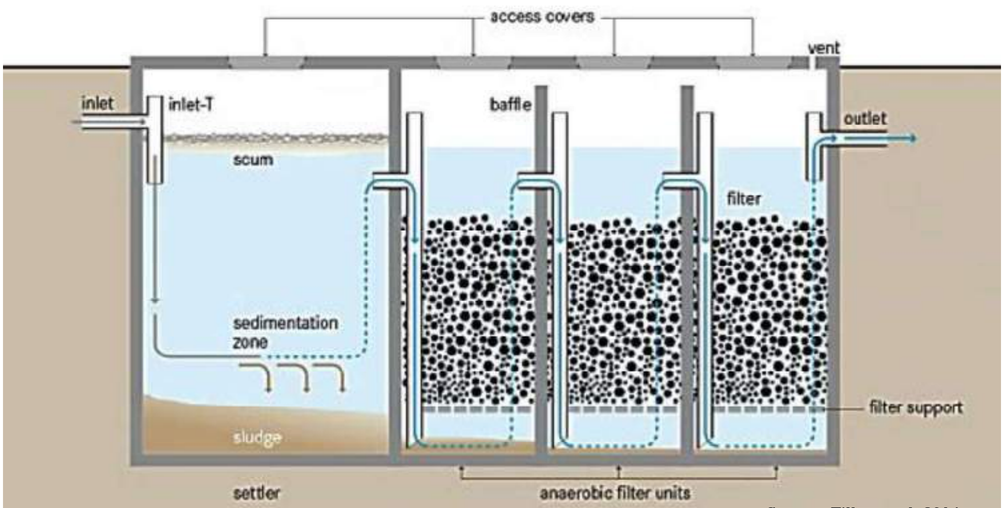
Source: Tilley et al. 2014

ANAEROBIC BAFFLED REACTOR



Source: Tilley et al. 2014

ANAEROBIC UP-FLOW FILTER



Source: Tilley et al. 2014

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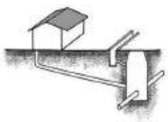
CONVEYANCE

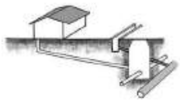
Functional group

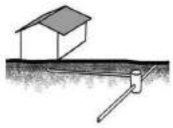
CONVEYANCE

- The way in which products are moved from one process to another.
- Products may need to be moved in various ways to reach the required process.
- The longest and most important gap lies between user interface and treatment stage.

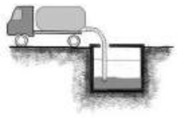
CONVEYANCE

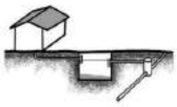

Conventional sewers

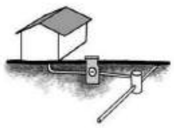

Separate sewers

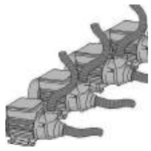

Simplified sewers

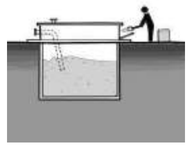

Human powered Emptying & transport


Motorised Emptying & transport


Small bore sewers


Vacuum sewers


Pumping stations

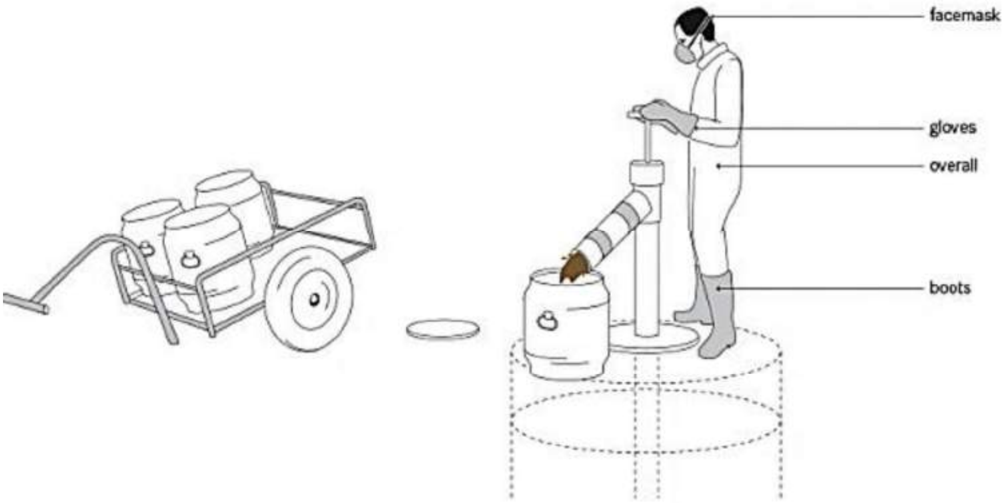

Transfer stations

Source: SSWM Tool Box

TECHNICAL AND PHYSICAL CRITERIA

- **Water availability**
  - Centralized, decentralized and choice of conveyance
- **Ground condition**
  - Rocky and high water table increases cost of construction
- **Groundwater level and contamination**
  - Choice of conveyance

HUMAN POWERED EMPTYING

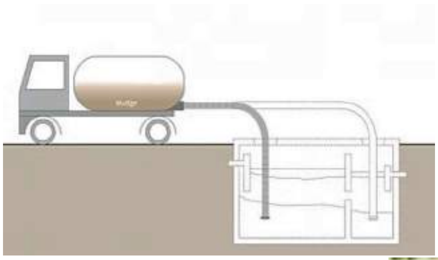


Source: Tilley et al. 2014

GULPER

Source: IaW (2007)

MOTORISED EMPTYING



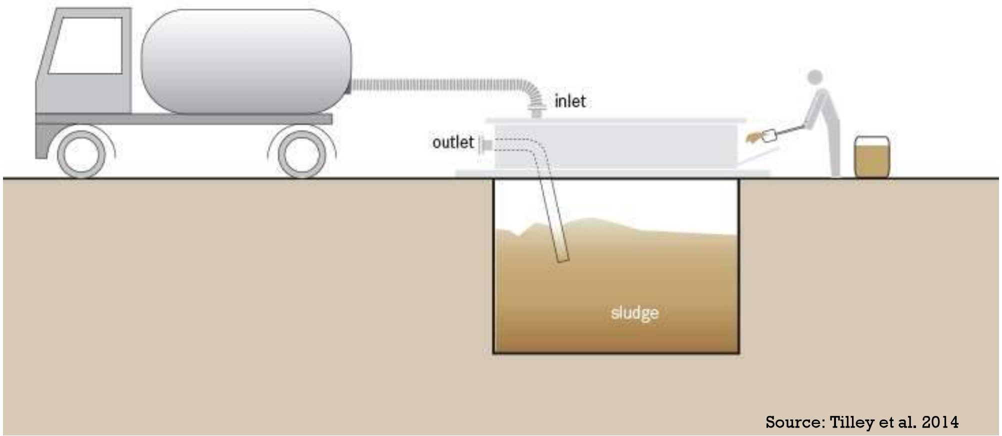
Source: Tilley et al. 2014

Source: KAMAVIDA

Source: KAMAVIDA

Source: Strauss et al. 2002

TRANSFER STATION



Source: Tilley et al. 2014

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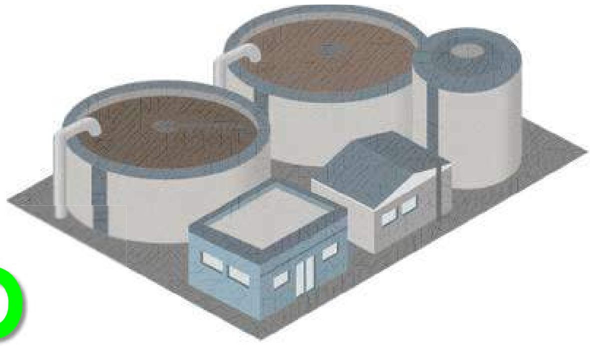
SEMI-CENTRALISED TREATMENT

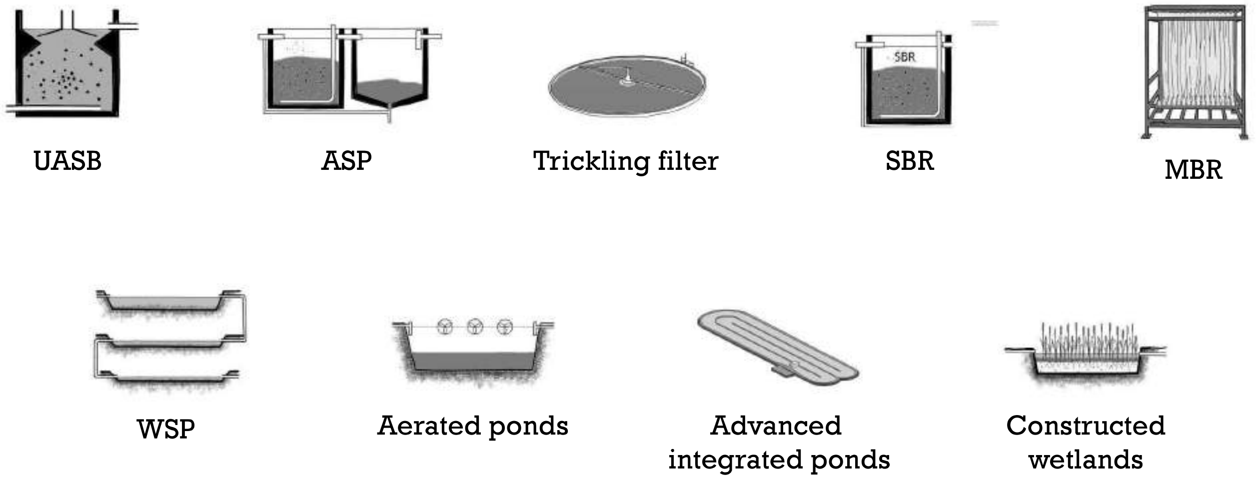


Functional group

SEMI-CENTRALISED TREATMENT

- Are larger in size.
- Require a greater inflow.
- More skilled operation.
- WSP, Aerated lagoons, ASP, SBR, MBBR, FBR, UASB, Anaerobic treatment, Constructed wetlands etc.

SEMI-CENTRALISED TREATMENT

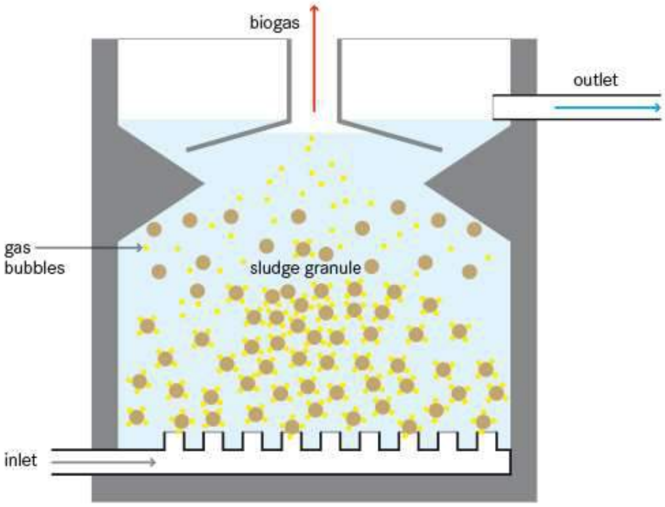


Source: SSWM Tool Box

TECHNICAL AND PHYSICAL CRITERIA

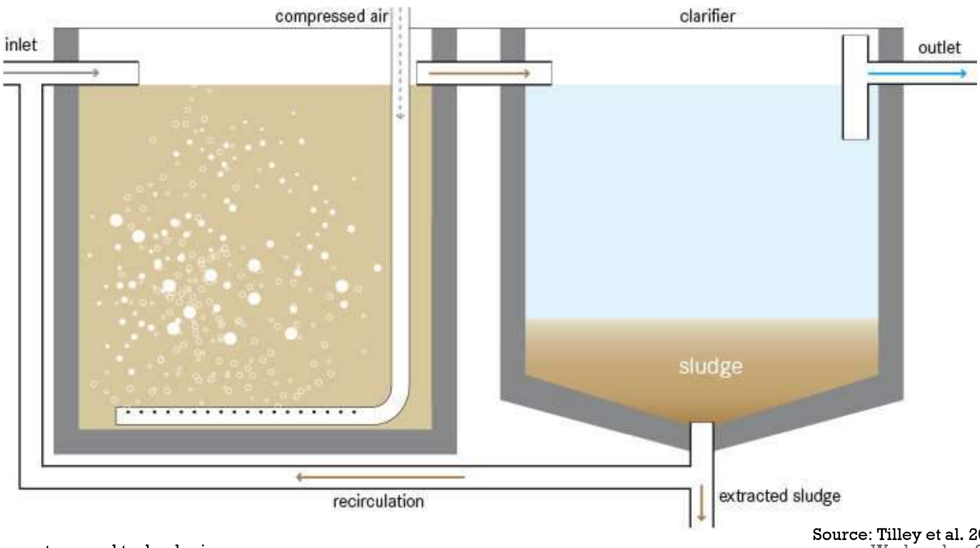
- Availability of space and other resources (Choice of technology)
- Climate (Temperature affects rate of reactions)
- Ground condition (Flood prone area)
- Groundwater level and contamination (Cross contamination from tanks underground)

UASB REACTOR



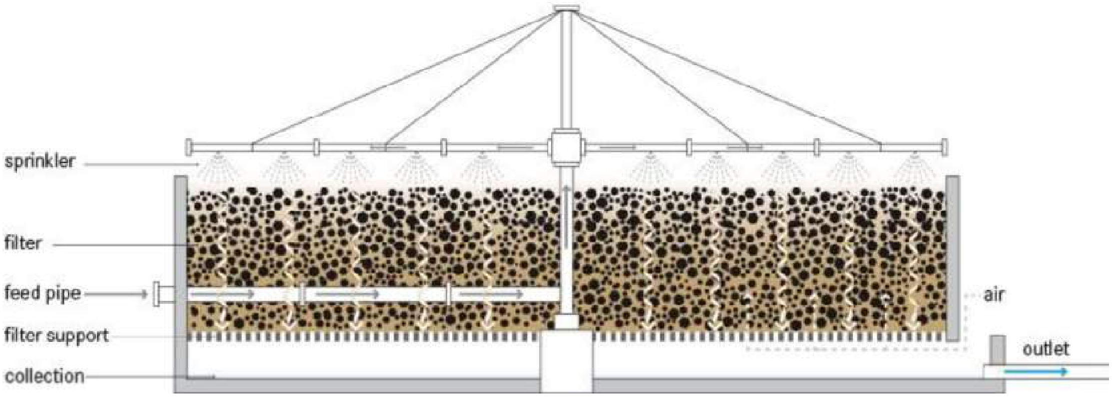
Source: Tilley et al. 2008

ASP TREATMENT



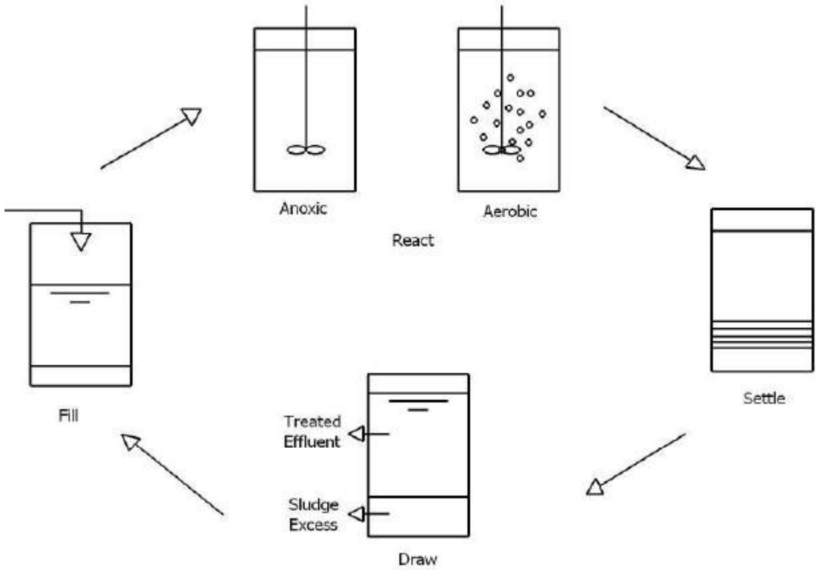
Source: Tilley et al. 2014

TRICKLING FILTER

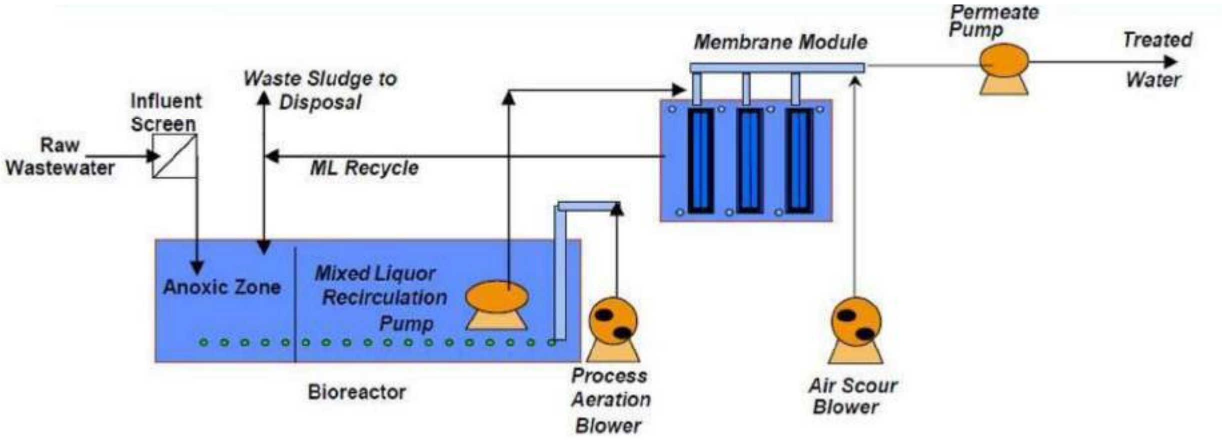


Source: Tilley et al. 2014

SBR

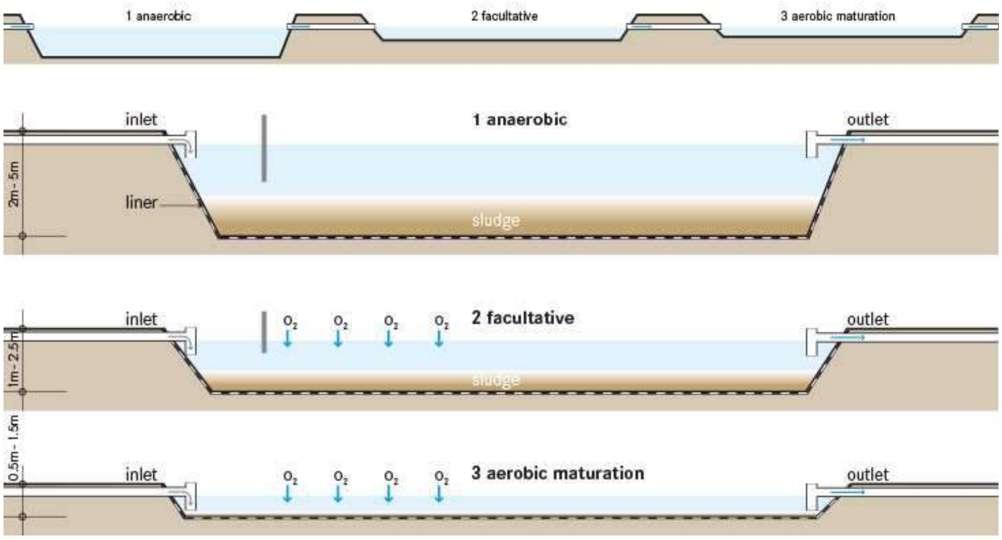


MBR



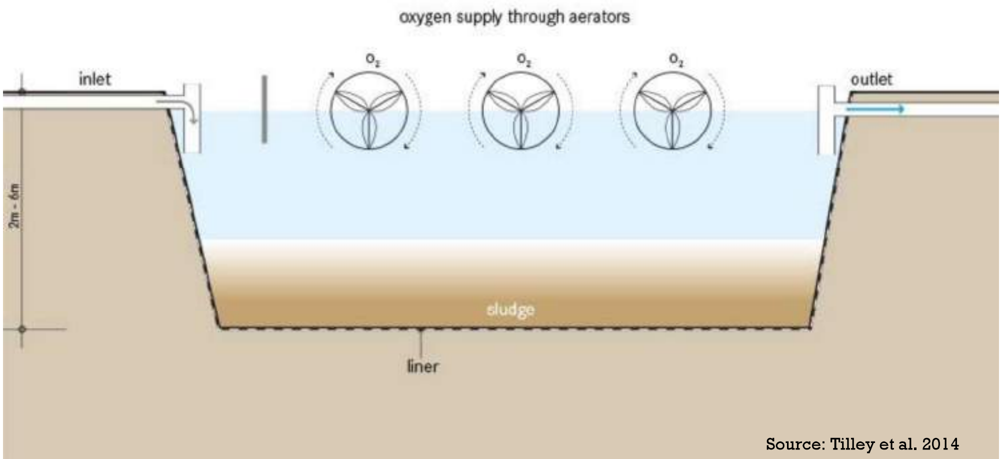
Source: Fitzgerald 2008

WSP TREATMENT



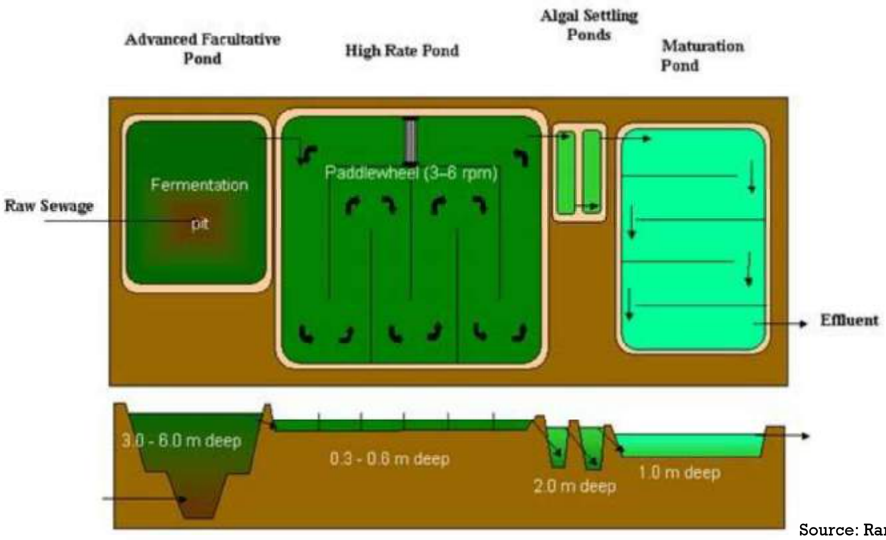
Source: Tilley et al. 2014

AERATED POND TREATMENT



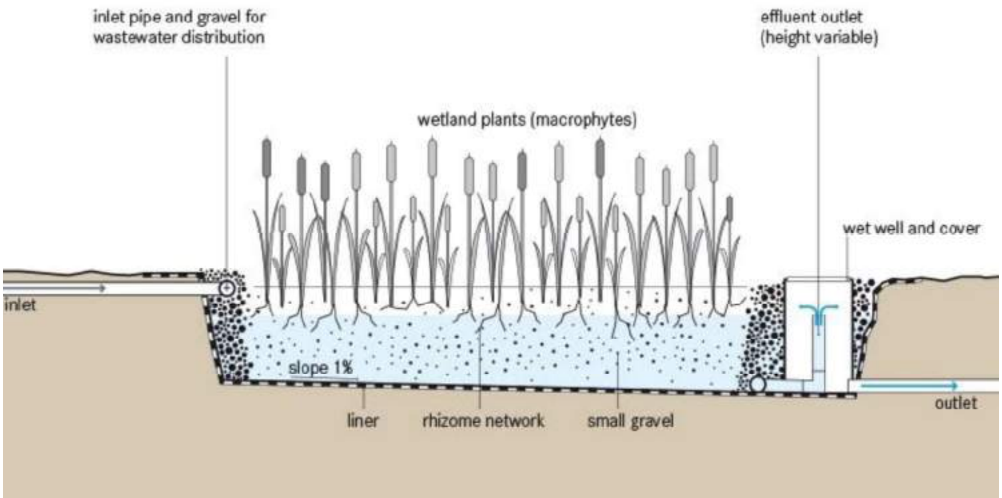
Source: Tilley et al. 2014

ADVANCED INTEGRATED PONDS



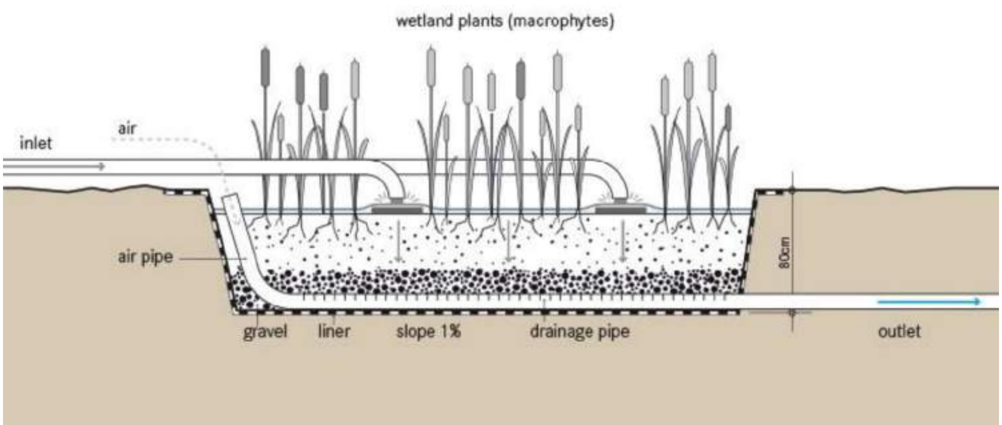
Source: Ramadan et al. (n.y.)

CONSTRUCTED WETLANDS (HORIZONTAL FLOW)



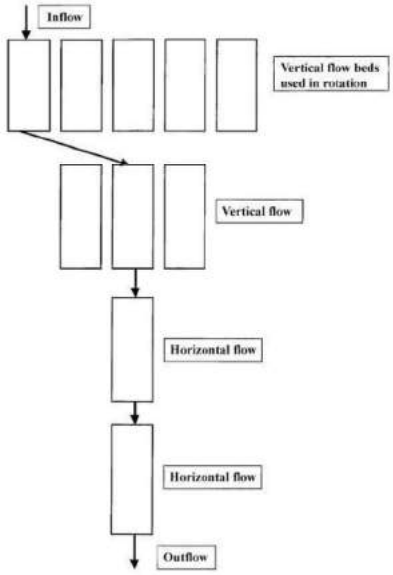
Source: Tilley et al. 2014

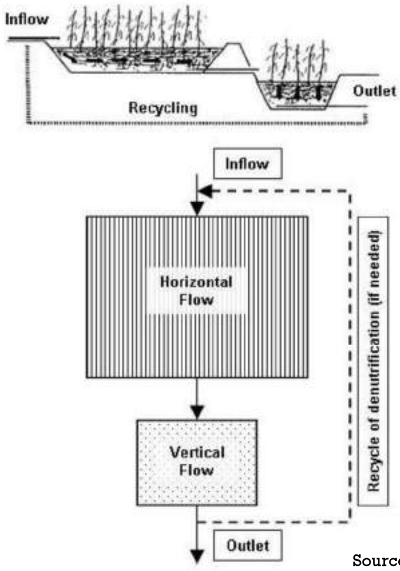
CONSTRUCTED WETLANDS (VERTICAL FLOW)



Source: Tilley et al. 2014

HYBRID CONSTRUCTED WETLANDS





Source: Vymazal 2005

50 USE AND/OR DISPOSAL

Functional group

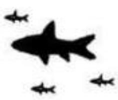
USE AND/OR DISPOSAL

- The ways in which products are ultimately returned to the soil, either as harmless substances or useful resources.
- Products can also be re-introduced into the system as new products.
- Products - Dehydrated faeces, Sterilized urine, Treated wastewater, Treated sludge

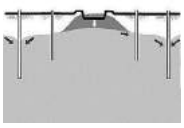
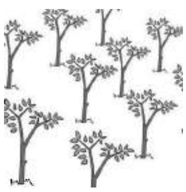
USE AND/OR DISPOSAL

- Agriculture
- Aquaculture
- Recharge or disposal
- Energy products from sludge



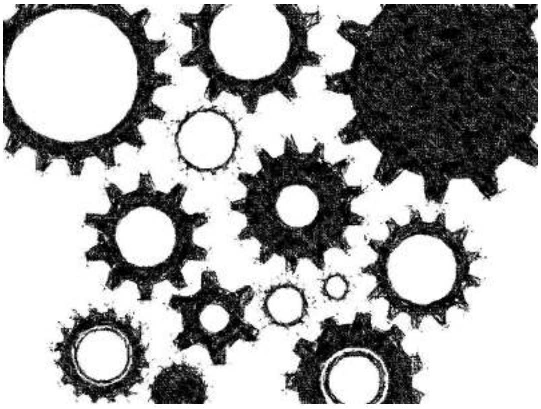




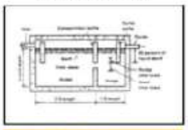
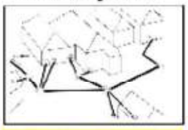
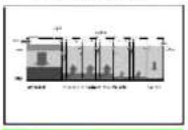
Source: SSWM Tool Box

SANITATION SYSTEM



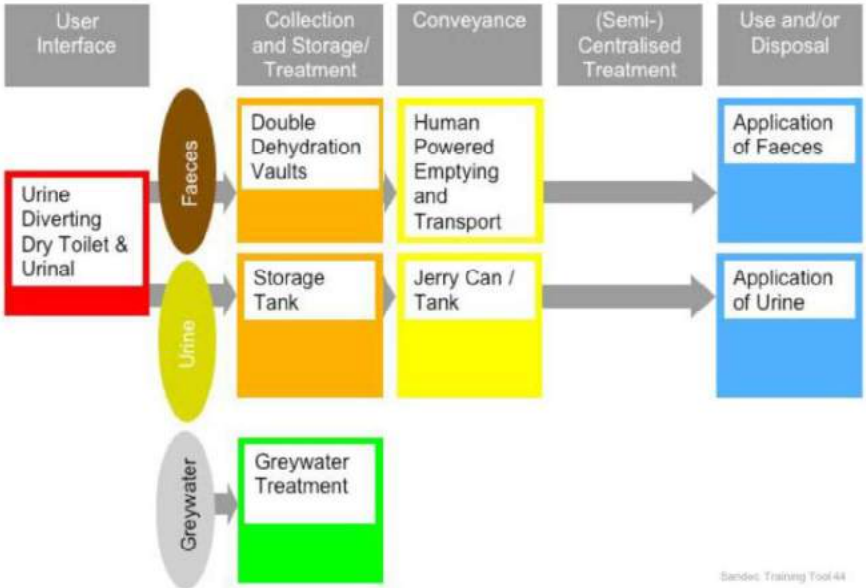
Only selected combinations of technologies will lead to functional systems!

SANITATION VALUE CHAIN

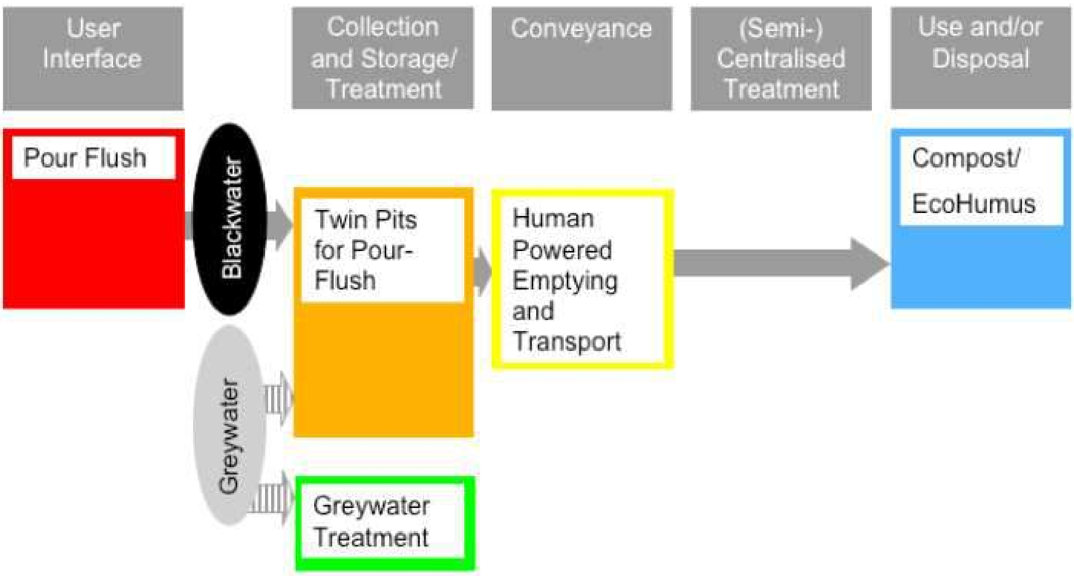
User Interface	Collection and Storage/ Treatment	Conveyance	(Semi-) Centralised Treatment	Use and/or Disposal
				
• Dry Toilet • Urine Diverting Dry Toilet • Urinal • Pour-Flush Toilet • Flush Toilet • Urine Diverting Flush Toilet	• Single Pit • Single VIP • Dehydration Vaults • Septic Tank • Composting Chamber • Anaerobic Baffled Reactor • Anaerobic Filter etc.	• Human-Powered Emptying and Transport • Motorized Emptying and Transport • Simplified Sewers • Small-Bore Sewer • Conventional Gravity Sewer • Jerry Can/Tank etc.	• Anaerobic Baffled Reactor • Anaerobic Filter • Trickling Filter • Waste Stabilisation Ponds • Activated Sludge • Constructed Wetland • Co-composting etc.	• Application of Urine • Application of Dehydr. Faeces • Compost • Irrigation • Aquaculture • Soak Pit • Leach Field • Land Application • Surface Disposal etc.

Source: Sandec Training Tool

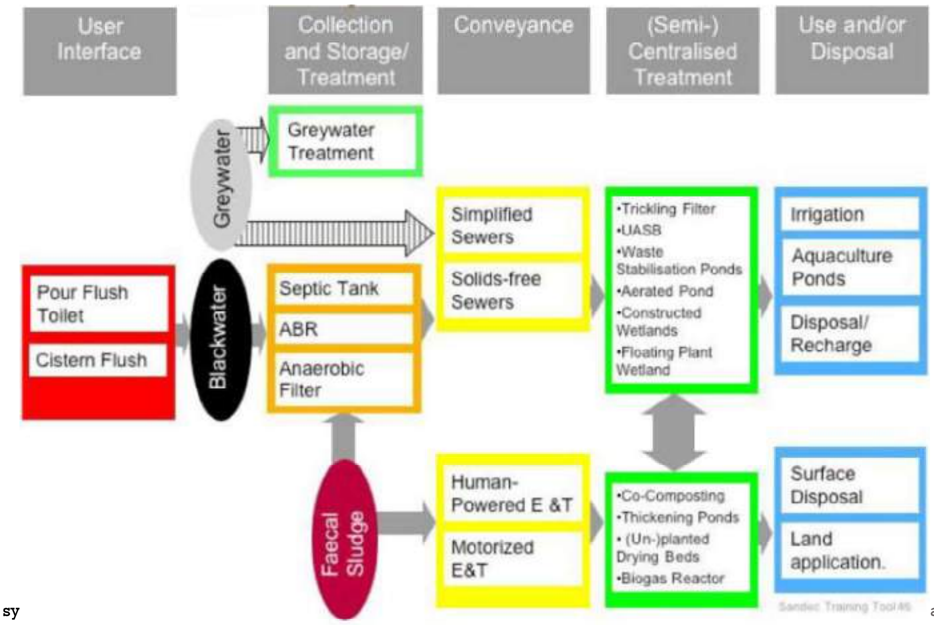
CASE 1
WATERLESS SYSTEM WITH URINE DIVERSION



CASE 2
WATER BASED, ALTERNATING DOUBLE PIT



CASE 3
WATER BASED, SMALL BORE SYSTEM



Thank you...

+91 20640 00736 | +91 20245 30061

ecosan@ecosanservices.org

www.ecosanservices.org

Ecosan Services Foundation

SANITATION CAPACITY BUILDING PLATFORM

Control Parameters

Wastewater Treatment Processes

Prof. Dr. P. A. Sadgir,
College of Engineering, Pune

Sewage or Wastewater **is the used water or liquid waste of a community, which includes**

- **human and household waste**
- **street washings**
- **industrial waste**
- **ground and storm water**

Waste water Classifation

- **Sewage**- All domestic, commercial waste water
- **Sullage**- waste water from kitchen, bathroom, wash basin, other than W.C.
- **Industrial Waste water-** water from industrial processes
- **Ground water infiltration**
- **Storm water**

Characteristics of waste water

- Physical-
- Chemical
- Biological-

Physical Characteristics of waste water

- Color,
- Odor,
- Temperature,
- Dissolved Oxygen
- Solids
- Biodegradable,
- non biodegradable,
- settle able,
- suspended,
- volatile, fixed,
- dissolved etc

Chemical –Characteristics of waste water

- pH,
- Biochemical Oxygen Demand,
- Chemical Oxygen Demand,
- Total Organic Carbon,
- Nitrogen, Ammonia
- Phosphorus,
- Sulphates,
- Heavy metals like Iron, Chromium
- fats,
- Oils & grease,
- pesticides,
- detergents,
- toxic element

Biological- Characteristics of waste water

- Viruses,
- Fungi,
- Algae,
- Protozoa,
- Rotifer,
- Ciliates,

- Bacteria
- (aerobic, anaerobic, facultative),
- Pshychrophylic Bacteria
  0-5 degrees C
- Mesophilic bacteria
  20- 40 degrees C
- Thermophilic bacteria
  40-60 degrees C

The pH

The hydrogen ion concentration expressed as pH, is a valuable parameter in the operation of biological units. The pH of the fresh sewage is slightly more than the water supplied to the community.

However, decomposition of organic matter may lower the pH, while the presence of industrial wastewater may produce extreme fluctuations.

Generally the pH of raw sewage is in the range 5.5 to 8.0.

Temperature:

The normal temperature of sewage is slightly higher then water temperature.

Temperature above normal indicate inclusion of hot industrial wastewaters in sewage

Colour:

Fresh sewage is light grey in colour. While the old sewage is dark grey in colour.

At a temperature of above 20^0c, sewage will change from fresh to old in 2 ~ 6 hours.

Odour:

Fresh domestic sewage has a slightly soapy or oil odour.

Stale sewage has a pronounced odour of Hydrogen Sulphide (H_2S).

Solids:-

Solids in sewage may be suspended or in solution solids are a measure of the strength of sewage.

SOLIDS

TOTAL SOLIDS:-

Include both suspended and dissolved solids.

It is measured by evaporating a known volume of sample and the weighting the residue.

Results are expressed in mg/l

SUSPENDED SOLIDS:-

These are solids which are pertained on a pre-weighed glass fiber filter of 0.45 103-105^{0}C

DISSOLVED SOLID:-

Filtrate which has passed thought 0.45µ filter is evaporated in chine dish.

The residue gives the dissolved solids.

SETTLEABLE SOLIDS:-

It is the fraction of the solids that will settle in an imhoff cone in 30-60 minutes.

These are expressed as mg/l.

VOLATILE SUSPENDED SOLIDS

They give a rough measure of the organic content or in some instances of the concentration of BIOLOGICAL SOLIDS such as bacteria.

The determination is made by ignition of residues on 0.45μ filter in a Muffle furnace at 550^0C.

The residues following the ignition is called non-volatile solids or ash and is rough measure of the mineral content of the waste water.

(Note:- Most of the inorganic and mineral content do not volatilize at 550^0C and are quiet resistant)

COD (Chemical Oxygen Demand)

It describes how much oxygen is required to oxidise all organic and inorganic matter.

It is expressed in mg/L

It is the amount of oxygen required to oxidize organic matter chemically (biodegradable and non-biodegradable) by using a strong chemical oxidizing agent. ($K_2Cr_2O_7$) in an acidic medium. For a single waste water sample the value of COD will always be greater then BOD.

The oxidant ($K_2Cr_2O_7$) remaining is found out to find $K_2C_{r2}O_7$ considered COD and BOD can be interrelated.

BOD(Biochemical Oxygen Demand)

Is always a fraction of COD.

It denotes the amount of oxygen required by the microorganisms to decompose organic matter

Bacteria placed in contact with organic matter will utilize it as food source.

In the utilization of the organic material it will eventually be oxidized to stable and products such as CO_2 and H_2O.

"The amount of oxygen required by the bacteria to oxidize the organic matter present in sewage to stable end products is known as biochemical oxygen demand."

Nitrogen

The principal nitrogen compounds in domestic sewage are proteins, amines, amino acids, and urea.

Ammonia nitrogen in sewage results from the bacterial decomposition of these organic constituents.

Nitrogen being an essential component of biological protoplasm, its concentration is important for proper functioning of biological treatment systems and disposal on land.

Generally, the domestic sewage contains sufficient nitrogen, to take care of the needs of the biological treatment.

For industrial wastewater if sufficient nitrogen is not present it is required to be added externally. Generally nitrogen content in the untreated sewage is observed to be in the range of 20 to 50 mg/L measured as TKN.

Phosphorus

Phosphorus is contributing to domestic sewage from food residues containing phosphorus and their breakdown products.

The use of increased quantities of synthetic detergents adds substantially to the phosphorus content of sewage.

Phosphorus is also an essential nutrient for the biological processes.

The concentration of phosphorus in domestic sewage is generally adequate to support aerobic biological wastewater treatment. However, it will be matter of concerned when the treated effluent is to be reused.

The concentration of PO_4 in raw sewage is generally observed in the range of 5 to 10 mg/L.

Sr. No.	Item	Values in sewage gm per capita per day
1	BOD_5	45-54
2	COD	1.6 to 1.9 BOD_5
3	Total organic Carbon	0.5 to 1.0 $BOD_{5\ (soluble)}$
4	Total Solids	170-220
5	Suspended Solids	70-145
6	Grit	5-15
7	Alkalinity, as $CaCO_3$	20-30
8	Chlorides	4-8
9	Nitrogen, total as N	6-12
	Organic Nitrogen	0.4*Total N
	Free Ammonia	0.62 to Total N
	Nitrate & Nitrate Nitrogen	Absent
10	Phosphorus, Total, as P	0.8-4.0
	Organic phosphorus	0.3* Total P
	Inorganic	0.7*Total P
11	Potassium, as K_2O	2.0-6.0

Typical Composition of Raw Domestic Wastewater

	Weak	Medium	Strong
Solids, total (TS), mg/L	350	720	1200
Total dissolved (TDS), mg/L	250	500	850
Total suspended (TSS), mg/L	100	220	350
Settleable solids, mg/L	5	10	20
BOD_5, mg/L	110	220	400
TOC, mg/L	80	160	290
COD, mg/L	250	500	1000
Nitrogen (total as N), mg/L	20	40	85
Organic, mg/L	8	14	35
Free ammonia, mg/L	12	25	50
Nitrites + nitrates, mg/L	0	0	0
Phosphorus (total as P), mg/L	4	8	15
Organic, mg/L	1	3	5
Inorganic, mg/L	3	5	10
Chlorides, mg/L	30	50	100
Sulfate, mg/L	20	30	50
Alkalinity, mg/L as $CaCO_3$	50	100	200
Grease, mg/L	50	100	150
Total coliform, no/100 mL	$10^6 \sim 10^7$	$10^7 \sim 10^8$	$10^7 \sim 10^9$

How is Wastewater Treated to Remove Pollutants?

Physics, Chemistry, Microbiology, mathematics and Engineering are all involved in purifying wastewater so that it can be safely returned to the environment.

Standards for discharge of sewage and industrial effluents in surface

Water source (rivers, lakes, reservoirs,

Sr. No.	CHARACTERISTI C OFTHE EFFLUENTS	DISCHARGE INTO SURFACE WATER SOURCES AS PER IS 4764-1973.	TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENT DISCHARGE INTO INLAND SURFACE WATERS AS PER IS 2490- 1974.	TOLERANCE LIMITS FOR DISCHARGE INTOPUBLIC SEWERS AS PER IS 3306-1974
1	B O D $_5$	20 mg/lit	30 mg/lit	500 mg/lit
2	C O D	250 mg/lit	250 mg/lit	
3	pH value	5.5 - 9	5.5 - 9	5.5 - 9
4	Total Suspended solids	30 mg/lit	100 mg/lit	600 mg/lit
5	Ammonia & Nitrogen	50 mg/lit	50 mg/lit	50 mg/lit
6	Oil & grease	Nil	10 mg/lit	100 mg/lit
7	Temp.	40 °c	40 °c	45 °c

Physical treatment

Screening	Removal floating matter
Comminuting	Cutting , grinding of coarse matter
Flow equalization	Equalization of flow
Mixing	Mixing of chemicals, gases
Flocculation	Promotion of flock formation & gravity sedimentation
Sedimentation	Separation of settle able solids
Floatation	Removal of very fine, particle
Filtration	Removal of very fine residue
Micro screening	Same as above with microorganism

Treatment of waste water

- Preliminary
- Primary
- Secondary
- Tertiary

- Centralized Treatment or Off site treatment
- Decentralized treatment or Onsite treatment

- Physical Treatment
- Biological Treatment
- Chemical Treatment

- Conventional Treatment
- Low cost treatment

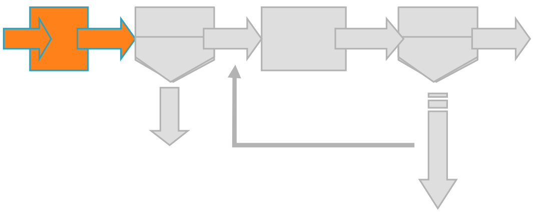
- Aerobic Treatment
- Anaerobic treatment

Biological Treatment

- **Biological** plants are more commonly used to treat domestic or combined domestic and industrial wastewater from a municipality.
- They use basically the same processes that would occur naturally in the receiving water, but give them a place to happen under controlled conditions, so that the cleansing reactions are completed before the water is discharged into the environment.

Biological treatment

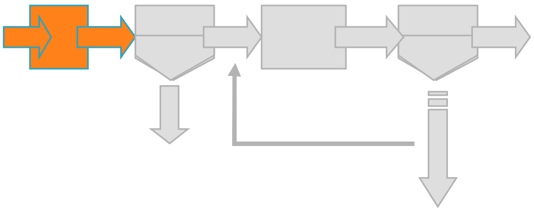
Aerobic	**Anaerobic**
Activated sludge Process	Stabilization pond
Trickling filter	Digester
Septic Tank	U A S B Reactor
Oxidation pond	Anaerobic filter
Aerated lagoon	
Oxidation ditch	
Rotating biological contactor	



Wastewater Treatment

Preliminary Operations

- To remove materials that will interfere with subsequent treatment processes.
  - Materials : sticks, logs, shoes, dead animals, etc.
- Grit is removed.
  - It will cause undue wear on piping and pumping system.

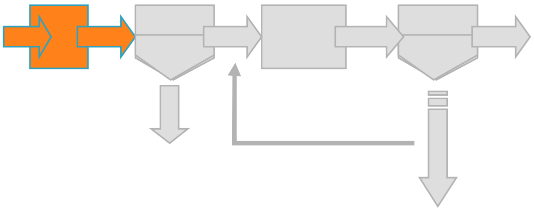


Wastewater Treatment

Preliminary Operations

Bar Racks

- Foreign objects can create serious problems for equipment at a treatment plant.
- Possible problems are clogging pumps or smaller piping within the plant.
- Bar racks can be cleaned either mechanically or manually
- The bar spacing : 0.5cm – 3 or 4 cm

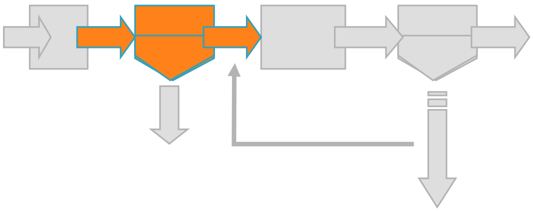


Wastewater Treatment

Preliminary Operations

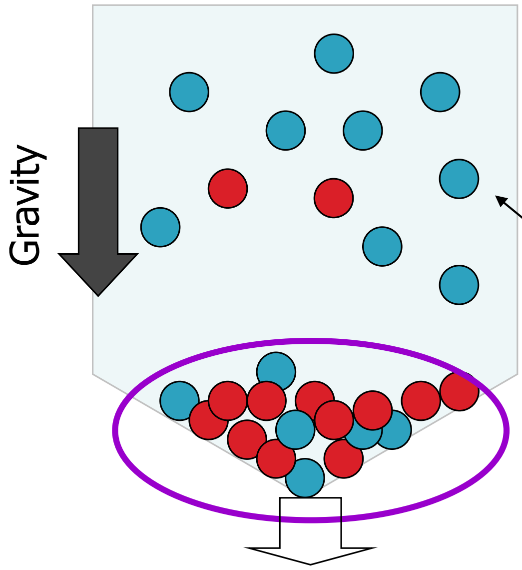
Grit Removal

- Grit
  - Composed primarily of sand, cinders, and gravel
  - It cause excessive wear in pipes and pumps
  - It accumulates in downstream tanks where flow velocities are insufficient to keep it in suspension. As grit accumulates, it reduces the effective tank volumes and thus treatment effectiveness
- Grit removal
  - By gravity settling (the high specific gravity of grit)
  - Grit chambers are relatively small



Wastewater Treatment

Primary Sedimentation

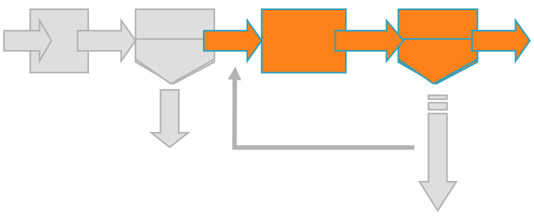


Sedimentation is the gravity setting, and thus removal, of materials more dense than a suspending fluid.

Organic matter, grit, clay, sand, and bacteria

In primary sedimentation –
Remove about 1/3 BOD_5 and 2/3 SS

Collected in sludge hoppers and removed

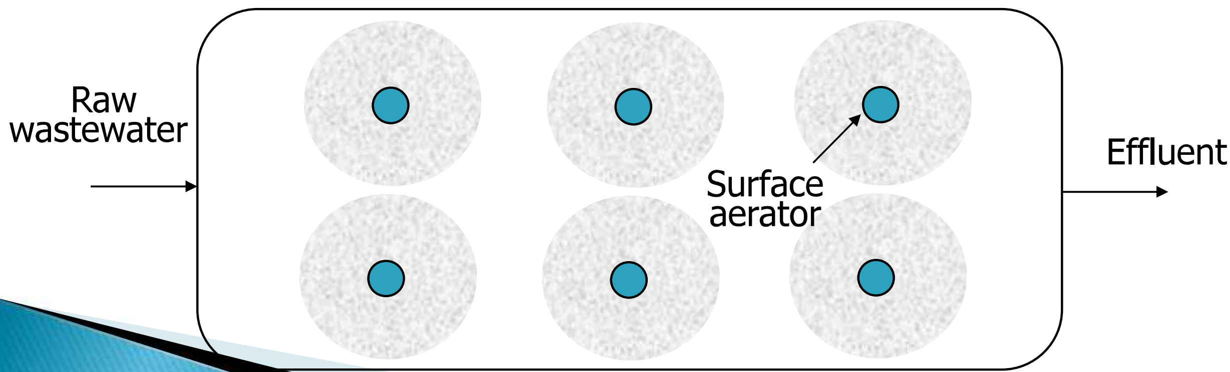


Wastewater Treatment

Secondary Treatment

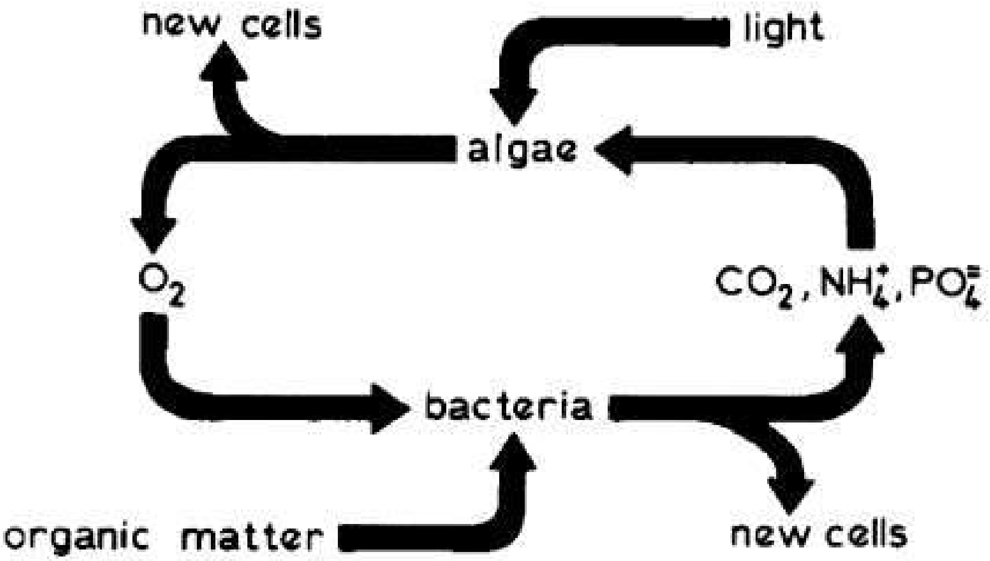
Aerated lagoon

- Suspended growth system
- Completely mixed mode
- Contact time limited to hydraulic retention time due to no recycle of sludge
- Limited effluent quality



Principle of Aerobic Process

- Oxidation Pond



Bacterial and algal symbiosis

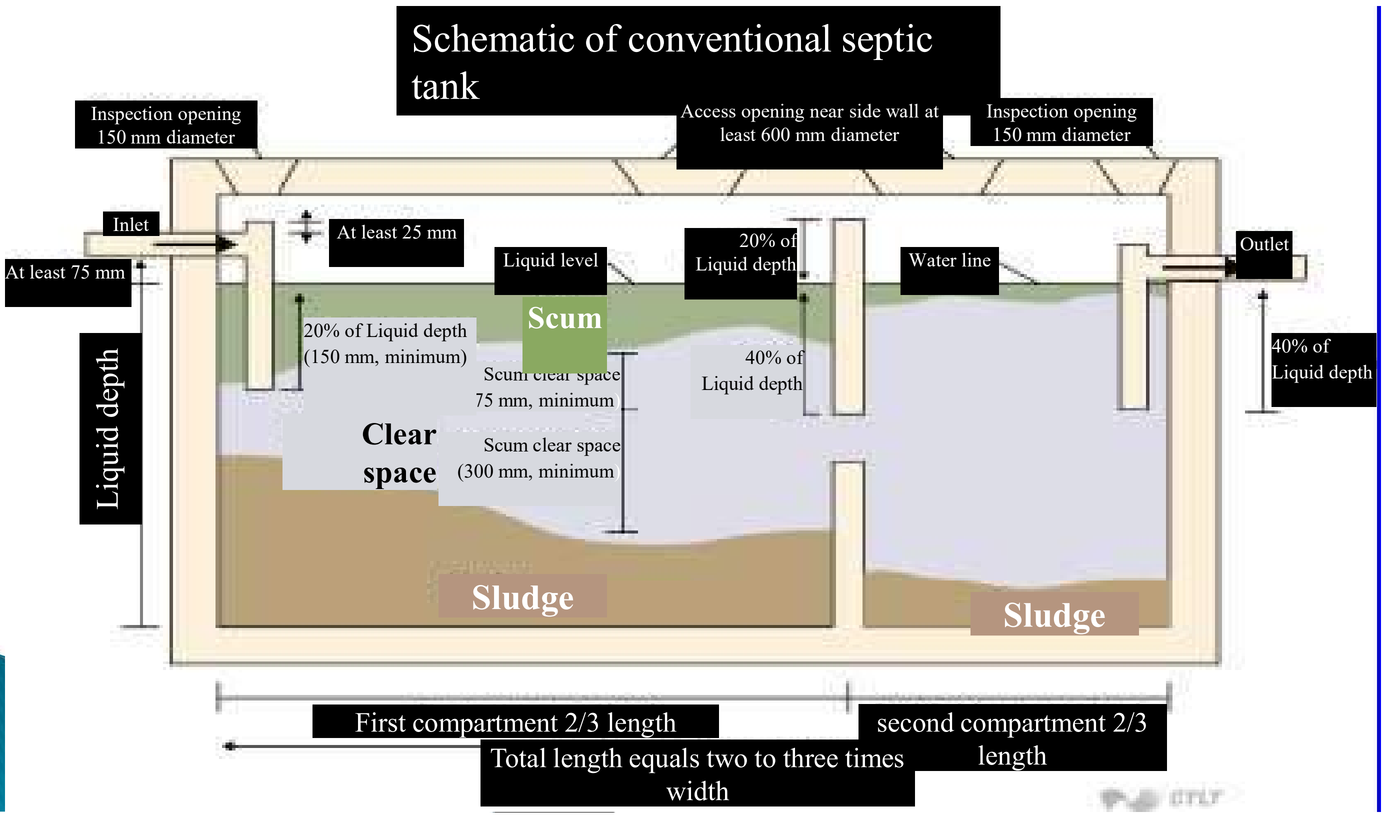
Advantages

- Low cost
- Suitable in hot countries like India
- Simplicity of construction
- Excellent pathogen removal
- Ability to treat a variety of wastes
- Toleration of organic and hydraulic shock loads
- Low maintenance requirements
- Low sludge production
- Reliability of operation
- Simple land reclamation

Limitations

- Extensive land area requirement
- Assimilative capacity of certain industrial waste is poor.
- Encroachment on pond site in urban area

The Septic Tank



Recommended Sizes of Septic Tank Up to 20 Users

No of users	Length (m)	Breadth (m)	Liquid Depth with Cleaning interval 2 yrs.	Liquid Depth with Cleaning interval 3 yrs.
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PLATFORM

Anaerobic Baffle Reactor (ABR) and Constructed Wetlands (CW)

Ms. Radhika Boargaonkar
Project Manager
Ecosan Services Foundation

ecosan SERVICES FOUNDATION

CONTENTS

- **Control parameters**
- **Dimensioning parameters**
  - Hydraulic load
  - Organic load
  - Sludge volume
- **Design fundamentals**
  - Anaerobic baffled reactor
  - Constructed wetland
- **Design flaws**

1

CONTROL PARAMETERS

Sludge volume, Sludge retention time

CONTROL PARAMETERS

- Volume
- Solids
- Fat, grease and oils
- Turbidity, colour and odour
- COD and BOD
- Nitrogen
- Phosphorus
- Temperature and pH
- Volatile fatty acids
- Dissolved oxygen
- Pathogens

2

DIMENSIONING PARAMETER: HYDRAULIC LOAD

Daily flow, Peak flow, Up-flow velocity, Hydraulic retention time, Hydraulic conductivity of filter media

HYDRAULIC LOAD

- Volume of wastewater to be applied per volume of reactor
- Dimension: (m^3/d) of load per m^3 volume of reactor
- Determines velocity of water in the reactor
- Critical parameter if organic loading rate is less

HYDRAULIC LOAD

Design parameters to be considered while dimensioning of the system;

- Daily flow (m^3/d)
- Peak flow (m^3/h)
- Up flow velocity (m/h)
- Hydraulic retention time (h)
- Hydraulic conductivity of filter media (m/d)

DAILY FLOW AT HOUSEHOLD LEVEL

- Difficult to determine on field;
  - Water consumption of different activities
  - Per capita water consumed
  - Capacity of overhead/underground tanks and pumping frequency
  - Water meter/ tanker loads

DAILY FLOW AT COMMUNITY LEVEL

- According to CPHEEO manual;
  - 80-85% of the per capita water consumption is converted into wastewater
  - Safety factor needs to be considered for infiltration and exfiltration.

EXAMPLE: DAILY FLOW CALCULATION

Household wastewater calculations

- No. of users: 4
- Water supply: 135 lpcd
- Wastewater generation: 80%
- **Total wastewater generation= 432 L/d ~ 0.4 m^3/d**

Community Toilet Block

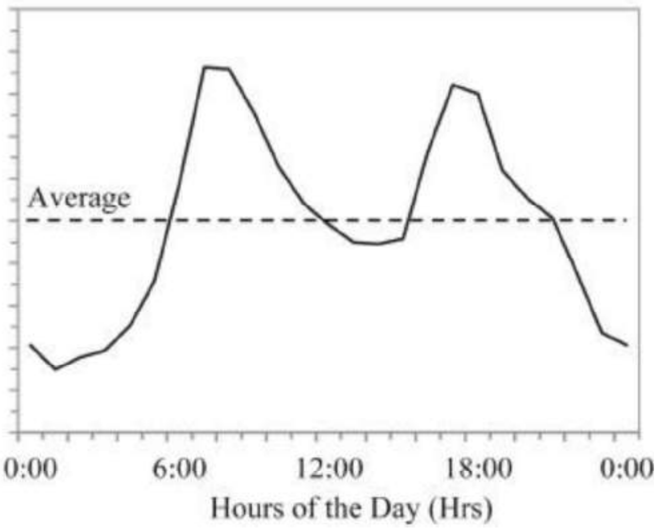
- No. of seats: 6
- No. of families per seat: 4 (family size: 5)
- No. of uses per person: 2
- Water per use: 10 L
- **Total wastewater(black) generation= 2400 L/d ~ 2.4 m^3/d**

PEAK FLOW

- Peak hours: The duration for which most water is consumed
- Peak flow: Flow of wastewater generated during peak hours

Peak hour flow rate = $\text{Total daily flow}\left[\frac{m^3}{d}\right] \Big/ \text{Peak hours}\left[\frac{h}{d}\right]$

DIURNAL CURVE



- Wastewater generation rate changes every hour of the day
- DTS should be capable of handling the highest flow rate of the day

EXAMPLE: PEAK FLOW CALCULATION

Community toilet block

- Peak hours: 3-6 h/d
- Peak flow = $2.4\,[\frac{m^3}{d}] / 6\,[\frac{h}{d}]$

  $= 0.4\ m^3/h$

Entity	Peak hours (h)
Residential housing	8 – 10
Public toilet	12 – 16
Community toilet	4 – 6
Commercial complex	4 – 6
Factories	2 – 4

UP FLOW VELOCITY

- Velocity of water in the reactor in upward direction

Up flow velocity = $\textit{Peak flow}\,[\frac{m^3}{h}] / \textit{Area of each chamber}\,[m^2]$

- Up flow velocity < settling velocity
- Variation affects the treatment performance
- Higher up flow velocity = flush out of sludge
- Lower up flow velocity = larger reactor volumes

HYDRAULIC RETENTION TIME

- Duration for which the batch of liquid resides in the reactor

Hydraulic retention time = $\text{Volume of the rector } [m^3] / \text{Daily flow } [\frac{m^3}{d}]$

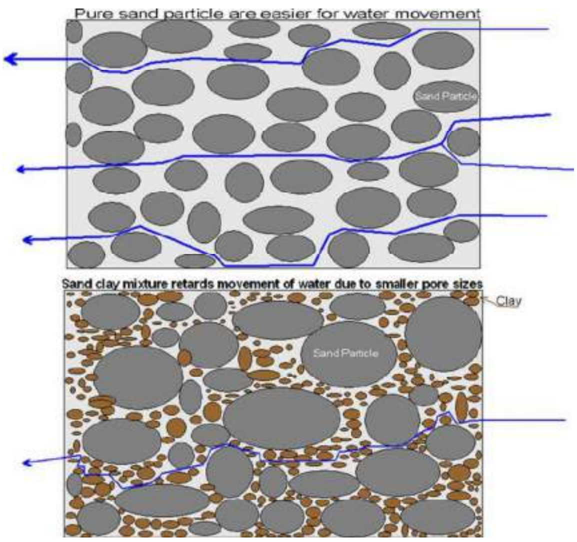
- Relation between volume of water treated in a day to volume of the reactor
- Applicable to both sludge and wastewater

IMPORTANCE OF HRT

- HRT directly proportional to treatment performance
- Higher HRT = Higher reactor volume = Higher costs
- Lower HRT = Low treatment efficiency

HYDRAULIC CONDUCTIVITY

- Velocity at which liquid travels through the filter media.
- Hydraulic conductivity inversely proportional to HRT.
- Higher HC = Lower treatment efficiency
- Lower HC = Chances of clogging



B ORGANIC LOAD

Units, Organic loading rate, Wastewater strength, Composition of wastewater

ORGANIC LOAD

- Important dimensioning parameter for wastewater of higher strength (dairy, animal husbandry etc)
- Organic load: Mass per time (kg/d)
- **Load [kg/d] = Concentration [mg/L]x Daily flow [m^3/d] / 1000**

Example:

- Daily flow = 2.4 m^3/d
- BOD_5 = 3000 mg/L
- Organic load = 7.2 kg/d

ORGANIC LOAD RATE (OLR)

- Permitted OLR varies for each module of DTS.

	Baffled reactor	Anaerobic filter	Anaerobic pond
BOD_5 (kg/m^3*d)	6.00	4.00	0.3-1.2
BOD5 removal	85%	85%	70%
Temperature	30 °C	30 °C	30 °C

- For a given system, the organic load handling capacity depends on the reactor temperature.
- Higher OLR = Poisoning; Lower OLR = insufficient bacteria

WASTEWATER STRENGTH

- Strength is measured in terms of BOD, COD and SS.
- In domestic wastewater,
  - the BOD is determined by dissolved solids (50%), settleable solids (33%) and non settleable solids (17%)
  - COD/BOD ratio is equal to or less than two.
- BOD contribution per person = 40-65 g/cap*d

COMPOSITION OF DOMESTIC WASTEWATER

Parameter	Unit	Low strength	Medium strength	High strength
Total Solids (TS)	mg/L	390	720	1230
Total Dissolved Solids (TDS)	mg/L	270	500	860
Total Suspended Solids (TSS)	mg/L	120	210	400
Biological Oxygen Demand(bod)	mg/L	110	190	300
Chemical Oxygen Demand (COD)	mg/L	250	430	800
Total Nitrogen (TN)	mg/L	20	40	70
Total Phosphorus (TP)	mg/L	4	7	12
Oil and Grease	mg/L	50	90	100
Total Coliforms	no. / 100 mL	106-108	107-109	107-1010
Faecal Coliforms	no. / 100 mL	103-105	104-106	105-108

CALCULATIONS

	A	B	C	D	E	F	G
1	**Wastewater production per capita**						
2	user	BOD_5 per user	water consump. per user	COD / BOD_5 ratio	daily flow of wastewater	BOD_5 concentr.	COD concentr.
3	given	given	given	given	calcul.	calculated	approx.
4	number	g/day	litres/day	mg/l / mg/l	m^3/day	mg/l	mg/l
5	**80**	**55**	**165**	**1,90**	13,20	333	633
6	*range =>*	*40 - 65*	*50-300*				

C

SLUDGE VOLUME

Importance of estimating sludge volume, Sludge retention time

SLUDGE VOLUME

- Estimating sludge volume is required for dimensioning of the reactor.
- Accumulation of the sludge results into decrease in HRT.
- Biological sludge production is directly proportional to BOD removal.
- Aerobic digestion produces more sludge than anaerobic digestion.
- Sludge Retention Time in DTS: 24-36 months.

3

DESIGN FUNDAMENTALS: ANAEROBIC BAFFLED REACTOR

Anaerobic Baffled Reactor (ABR)

Design description, Treatment efficiency, Criteria for design

DESIGN OF ABR

- Underground, closed tank with 4-8 chambers in series.
- Each chamber is designed to handle the hydraulic and organic loading.
- Chambers in series helps to digest complex degradable constituents.
- Active sludge at the bottom of the tank biologically treats the incoming wastewater.

DESIGN OF ABR

- Dimensions of the chambers (width and length) depends on peak flow and up flow velocity.
- Importance of baffle pipes;
  - Direct the flow of wastewater in each chamber.
  - Ensures optimum contact of wastewater and activated sludge.
- Size and number of chambers define the HRT of the system.

TREATMENT EFFICIENCY

- One of the most efficient module of DTS.
- Efficiency is higher for higher organic loads.
- BOD removal: 70-95%; COD removal: 65-90%
- Efficiency is better if COD/BOD < 2
- Efficiency increases with the number of chamber and availability of active sludge.

DESIGN CRITERIA

Up flow velocity

- Up flow velocity should be maintained between 0.9-1.2 m/h
- Crucial parameter in case of higher hydraulic loads.

Organic load

- OLR < 6 kg BOD/m^3*d
- High OLR possible in higher temperature and lower strength of wastewater.

DESIGN CRITERIA

Retention time

- Should not be less than 8 hours.
- Efficiency is better for HRT between 12-24 hours.

Temperature

- Effective when temperature > 25 ^{0}C

Sludge volume

- Inoculation needs to be done during commissioning of the system.

B

DESIGN FUNDAMENTALS: CONSTRUCTED WETLAND

Constructed Wetland (CW)

Design description, Treatment efficiency, Criteria for design

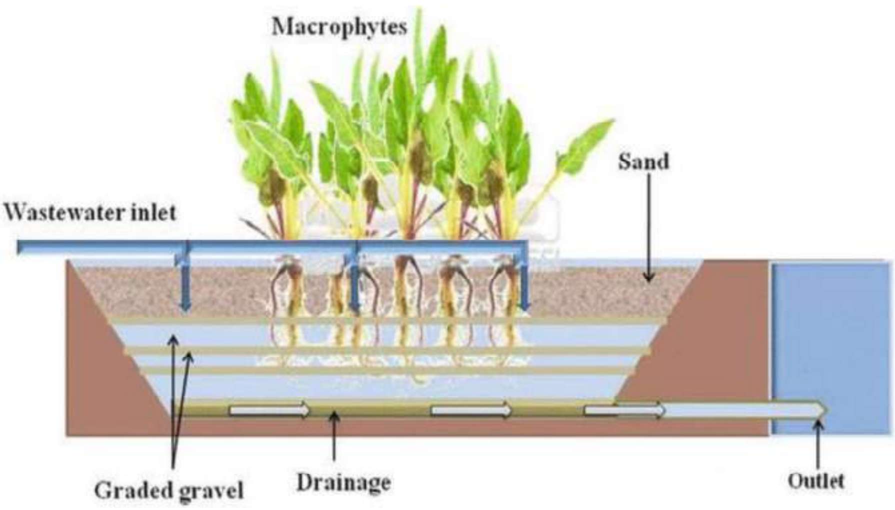
DESIGN OF CW

- Overground, shallow open tanks filled with graded filter material also known as substrate.
- Wastewater flows through the substrate and exists from the drain pipe which also helps to control depth of the water in the wetland.
- Types of constructed wetlands;
  - Horizontal flow
  - Vertical flow

DESIGN OF CW

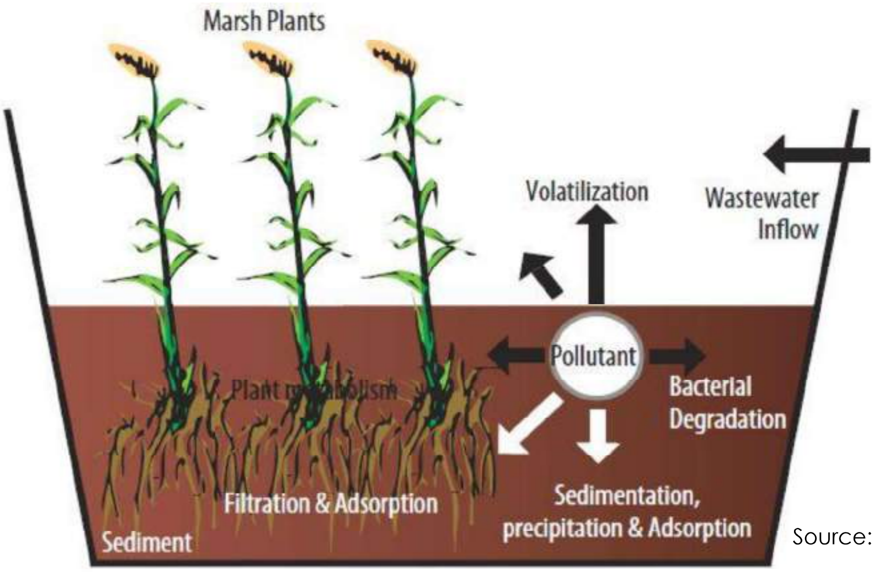
- Substrate: civil aggregates planted with wetland or aquatic species.
- Microbes gets attached to the substrate and are responsible for removal of soluble organic constituents.
- Incoming wastewater gets aerobic, anoxic and anaerobic treatment.
- Oxygen required for aerobic treatment is provided by atmospheric diffusion or by vegetation roots.

CONSTRUCTED WETLANDS



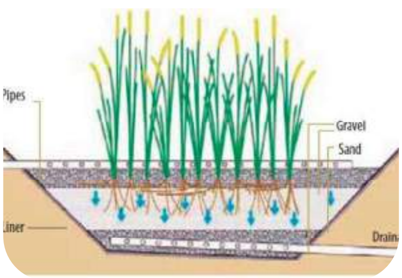
Major Components –
Basin = Substrate = Vegetation = Liner = Inlet/Outlet arrangement system.

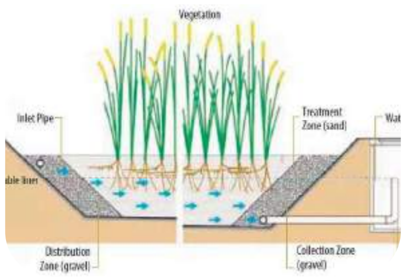
POLLUTANT REMOVAL MECHANISM

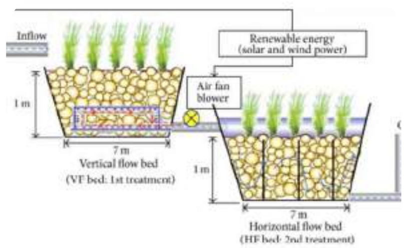


Source: CW Manual, 2008

CW – TYPES

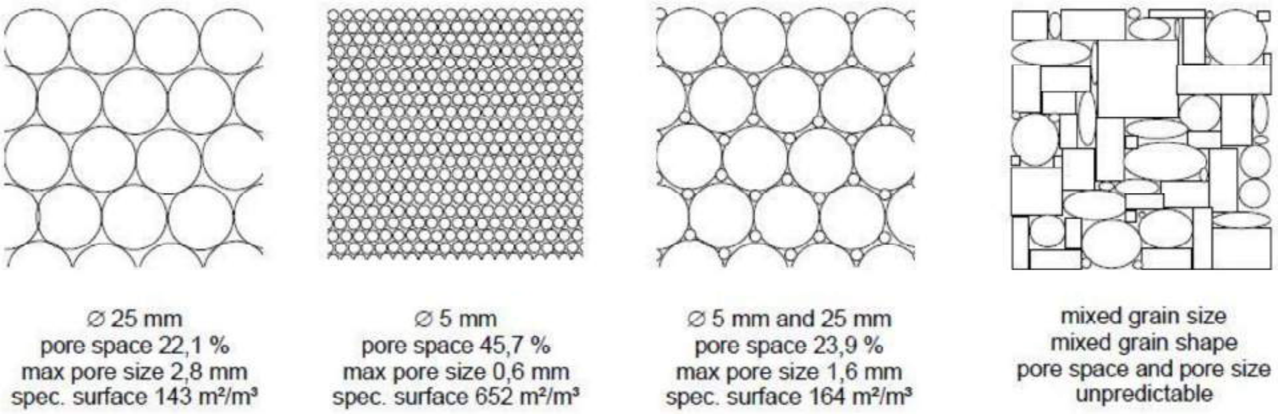






Vertical Flow **Horizontal Flow** **Hybrid**

INFLUENCE OF GRAIN SIZE AND SHAPE ON WETLAND PROPERTIES



Source: Ludwing Sasse, 1998

TREATMENT EFFICIENCY

- Well designed and operated CW provides BOD removal of 50-70%.
- Pre treatment of wastewater is must for treating it with CW.
- CW is suitable for wastewater with low TSS and BOD.
- In DTS, CW is used to remove odour, colour and increase the DO of the water rather than reducing BOD.

DESIGN CRITERIA

Hydraulic conductivity

- Cross sectional area and hydraulic conductivity of the smallest gravels in the filter determine the conductivity.
- Hydraulic conductivity ~ 200 m/d

Temperature

- High efficiency is achieved at higher temperature.

Organic loading

- OLR < 10 g BOD/m^2*d

DESIGN CRITERIA

Retention time

- Determined by the pore space available in filter media.
- Pore space ~ 30-40% of volume of filter.
- HRT: 2-3 days

Vegetation

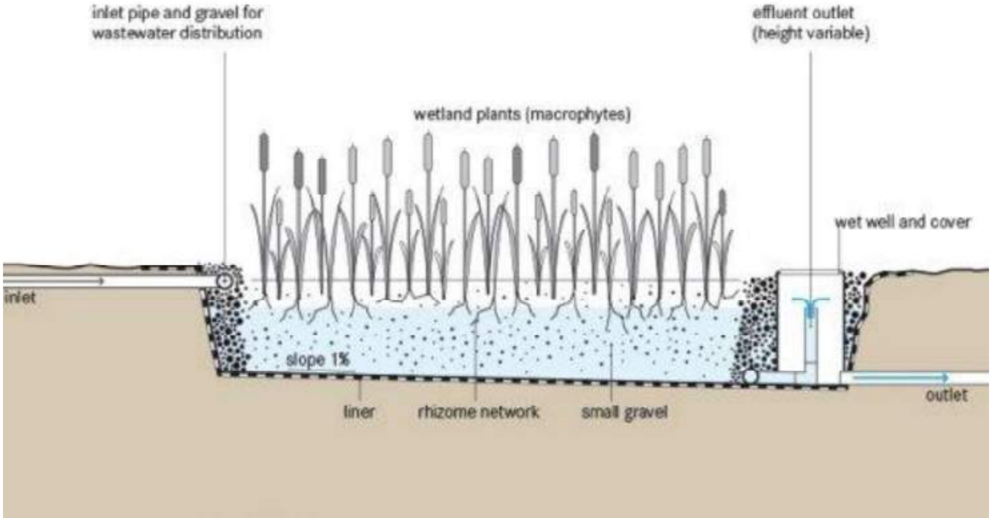
- Facilitate efficient oxygen transfer to the root zone.
- Should have fibrous root system.
- Local species should be used.

DESIGN CRITERIA

Filter media & depth

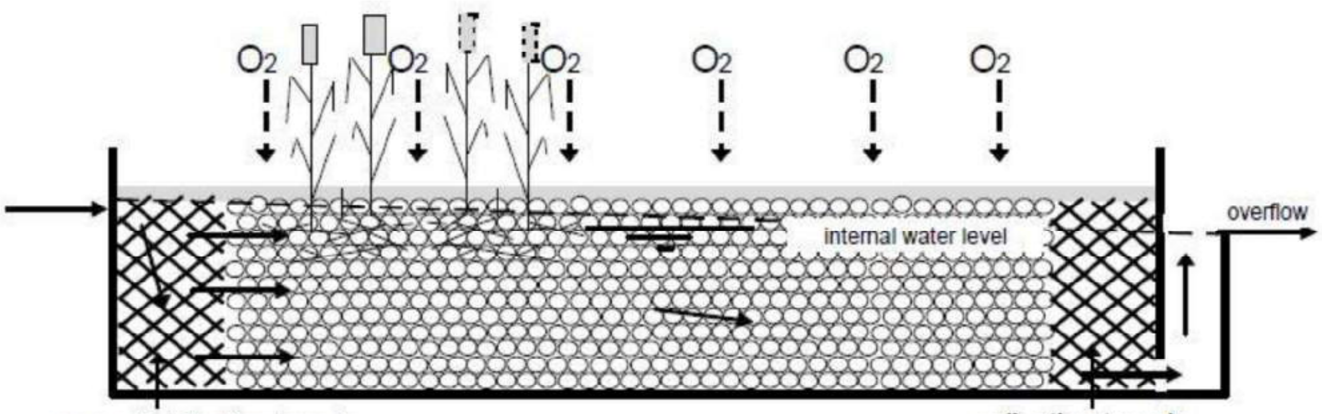
- Evenly distribute the incoming pre treated wastewater.
- Provide surface area for microbial culture to get attached.
- Provide physical filtration for suspended solids.
- Provide good substrate for vegetation to grow.
- Depth: 0.6 - 0.9 m

HF CONSTRUCTED WETLAND



Source: Tilley et al. 2014

HF CONSTRUCTED WETLAND - PRINCIPAL



Source: Ludwing Sasse, 1998

SIZING OF THE WETLAND

KICKUTH'S EQUATION

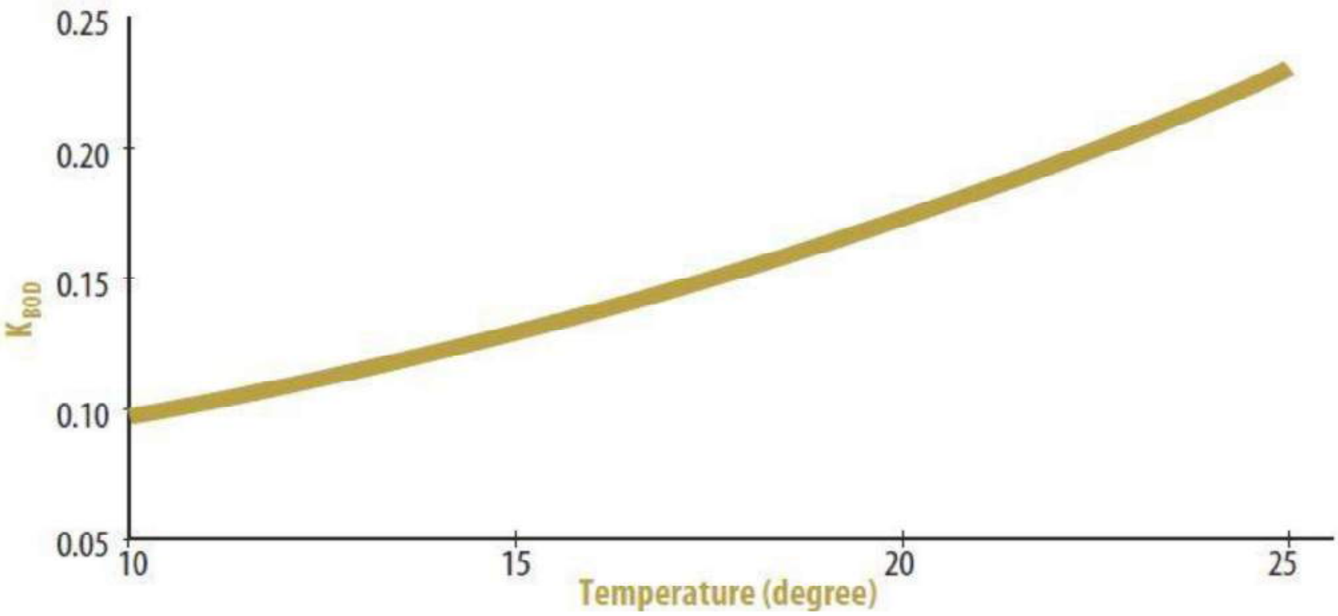
$$A_h = \frac{Q_d (\ln C_i - \ln C_e)}{K_{BOD}}$$

- A_h = Surface area of bed (m^2)
- Q_d = average daily flow rate of sewage (m^3/d)
- C_i = influent BOD_5 concentration (mg/l)
- C_e = effluent BOD_5 concentration (mg/l)
- K_{BOD} = rate constant (m/d)

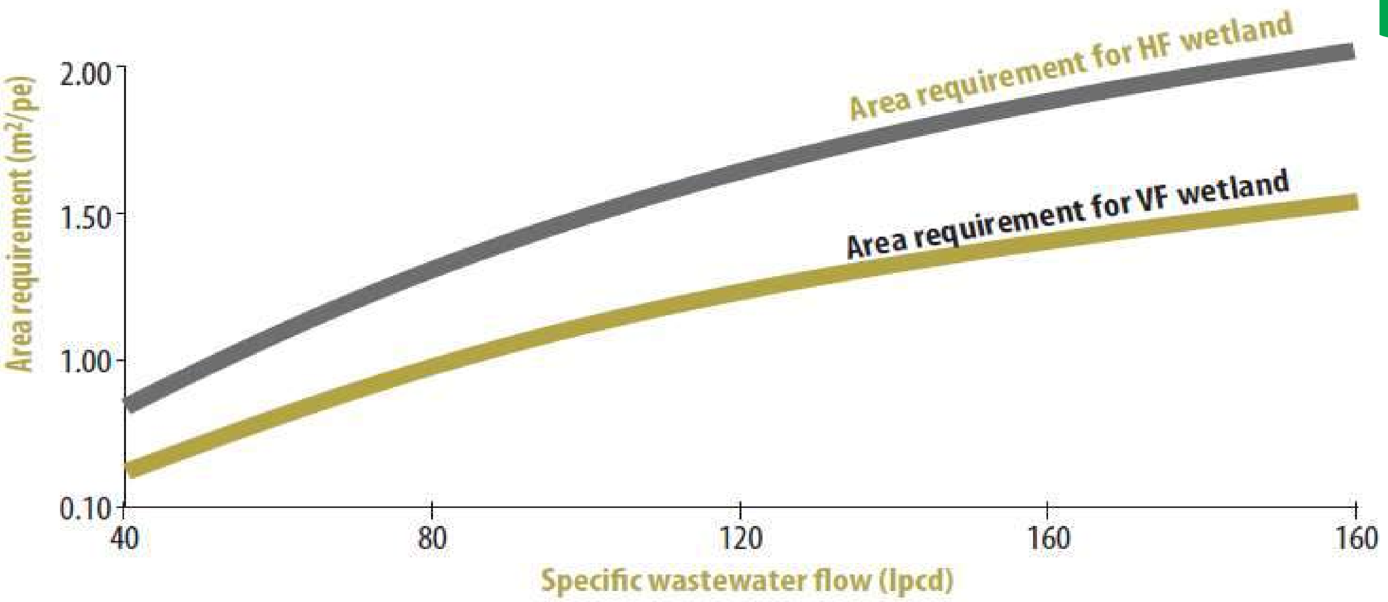
K_{BOD} is determined from the expression $K_T dn$, where,

- K_T = $K_{20} (1.06)^{(T-20)}$
- K_{20} = rate constant at 20 °C (d^{-1})
- T = operational temperature of system (°C)
- d = depth of water column (m)
- n = porosity of the substrate medium (percentage expressed as fraction)

K_{BOD} is temperature dependent and the BOD degradation rate generally increases about 10 % per °C. Thus, the reaction rate constant for BOD degradation is expected to be higher during summer than winter. It has also been reported that the K_{BOD} increases with the age of the system.



K_{BOD} for HF plotted against Temperature for substrate depth 40 cm and porosity 40%



Specific area requirement per PE for HF and VF wetland for different specific wastewater discharges

HF CONSTRUCTED WETLAND

Problem Statement

Calculate the sizing of a constructed wetland for a population of 400 with specific wastewater flow of 80 litres per person per day.

- BOD5 Contribution – 40 g BOD5/pe.day
- BOD5 concentration = 40 x 1000/80 = 500 mg/l
- 30% BOD5 is removed by the primary treatment unit, then the influent BOD5 concentration to the wetland (Ci) = 350 mg/l
- Effluent BOD5 concentration (Ce) = 30 mg/l
- KBOD = 0.15 m/d for HF wetland

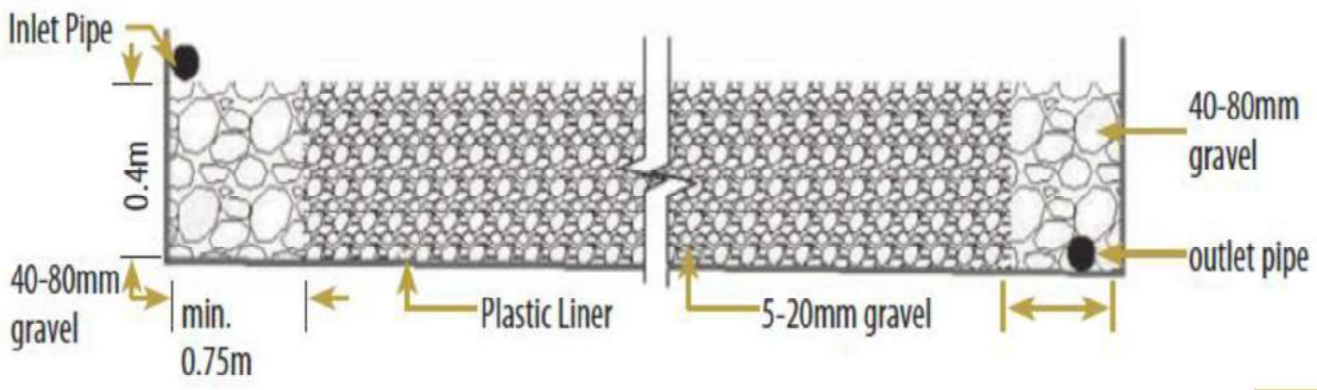
BED CROSS-SECTION AREA

$A_c = Q_s / K_f (dH/ds)$

- A_c = Cross sectional area of the bed (m^2)
- Q_s = average flow (m^3/s)
- K_f = hydraulic conductivity of the fully developed bed (m/s)
- dH/ds = slope of bottom of the bed (m/m)

For graded gravels a value of K_f of 1×10^{-3} to 3×10^{-3} m/s is normally chosen. In most cases, dH/ds of 1% is used.

MEDIA SELECTION

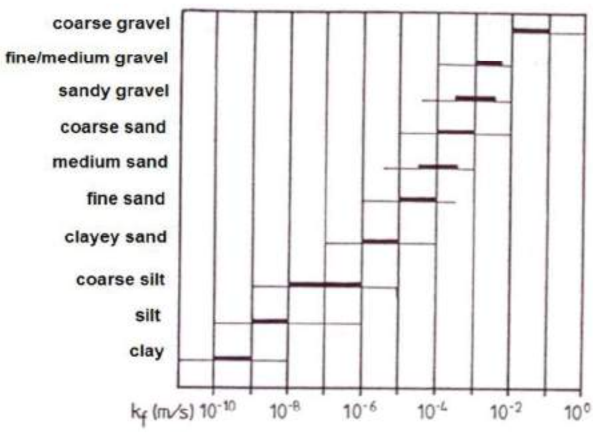


Substrate arrangement in a HF wetland

Source: CW Manual, 2008

GIVEN PARAMETER

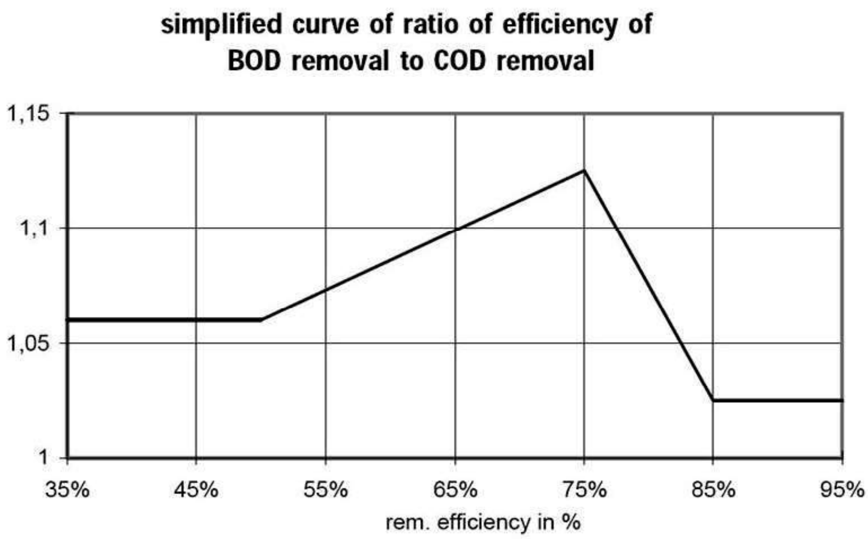
- Daily wastewater flow (m3/d) - As per calculation
- BODin and CODin (mg/L) - Based on BODout and CODout of ABR or AF
- Minimum annual temperature - As per data collection
- Hydraulic conductivity of filter material – usually 4.3*10-3 m/sec for fine gravel



DESIGN PARAMETER (ASSUMPTIONS)

Hydraulic load limit	100 l/m^2
Organic load limit	10 g BOD/ m^2
Voids of Gravel	35% – 45%
Size of Gravel	5-7mm, 10-12mm, 50-70mm, diameter of gravel
Slope	1%
Height of Filter	50 - 60cm
Construction	Swivel at inlet and outlet cross section to adjest water level

FACTOR EFFICIENCY RATIO OF BOD REMOVAL TO COD REMOVAL



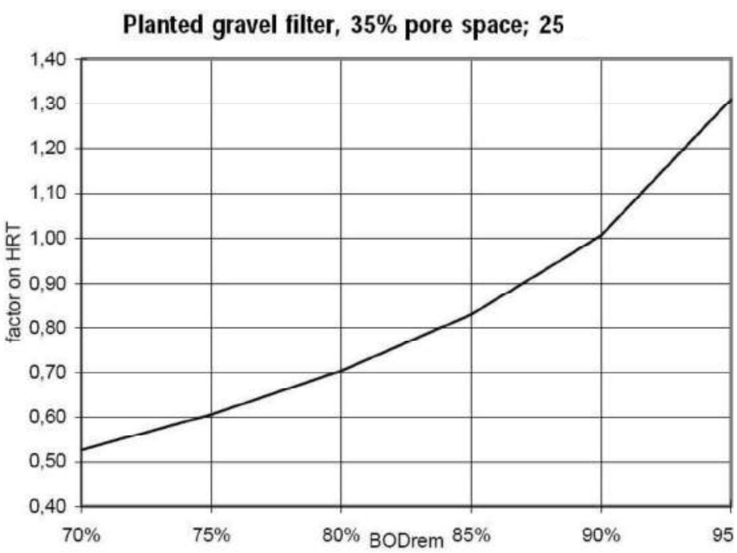
Removal < 0.5:
factor = *1.06*

Removal < 0.75:
factor = $(BOD_{rem}-0.5)*0.065/0.25+1.06$

Removal < 0.85:
factor = $1.125-(BOD_{rem}-0.75)*0.1/0.1$

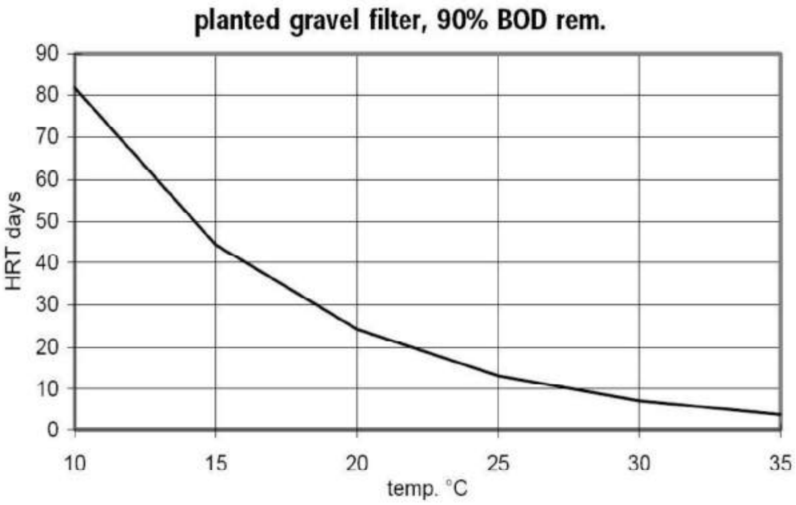
Removal ≥ 0.85:
factor = *1.025*

FACTOR HRT – BOD REMOVAL.



BOD_{rem}< 40%:
factor = BOD_{rem} * 0.22/0.4
BOD_{rem}< 75%:
factor =[((BOD_{rem}-0.4) *31)/35] +0.22
BOD_{rem}< 80%:
factor = [((BOD_{rem}-0.75) *9.5)/5] +0.605
BOD_{rem}< 85%:
factor = [((BOD_{rem}-0.8) *12.5)/5] +0.7
BOD_{rem}< 90%:
factor = [((BOD_{rem}-0.85) *17.5]/5] +0.825
BOD_{rem} ≥ 90%:
factor = [((BOD_{rem}-0.9) *30)/5]+1

FACTOR HRT – TEMPERATURE



temp < 15°C:
factor = 82-[(temp-10) *37]/5
temp < 20°C:
factor = 45-[(temp-15) *31]/5
temp < 25°C:
factor = 24-[(temp-20) *11]/5
temp < 30°C:
factor = 13-[(temp-25) *6]/5
temp ≥ 30°C:
factor = 7






4 DESIGN FLAWS

Estimating peak flows, higher organic loads, sludge accumulation rate, hydraulic retention time, temperature, selection of filter media

DESIGN FLAWS

Underestimation of peak flow

- Treatment efficiency at peak hours will decrease.
- Wash our sludge.

Higher organic loading

- Affects the quality of the final effluent.
- Increases the sludge production rate.

DESIGN FLAWS

Underestimation of sludge accumulation rate

- Reduced HRT.
- Affects the efficiency of the system.

Wrong assumption of HRT

- Lower HRT reduces the efficiency of the system.
- Higher HRT increases the size of the system and thereby the cost.

DESIGN FLAWS

Temperature

- Lower temperature reduces the efficiency.
- Especially wetlands should be designed for keeping in mind the winter temperatures.

Filter media

- Lower hydraulic conductivity increases risks of clogging.
- Higher hydraulic conductivity decreases efficiency.

Thank you...

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ecosan@ecosanservices.org

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ECOSAN SERVICES FOUNDATION

SANITATION CAPACITY BUILDING PLATFORM

Treatment of Faecal Sludge and Septage

Mr. Dhawal Patil
General Manager (Operations), ESF
M.Sc. Hydro Science and Engineering, TU Dresden

CONTENTS

- **FS Treatment Objectives**
- **FS treatment Stages**
- **FS treatment Components**
  - Co-treatment in STP
  - Deep row entrenchment
  - Anaerobic Digestion
  - Unplanted drying beds
  - Planted drying beds
  - Geotubes
  - Mechanical dewatering
  - Co composting
  - Sludge incineration
  - Thermal drying and pelletising
- **Disposal of End products**

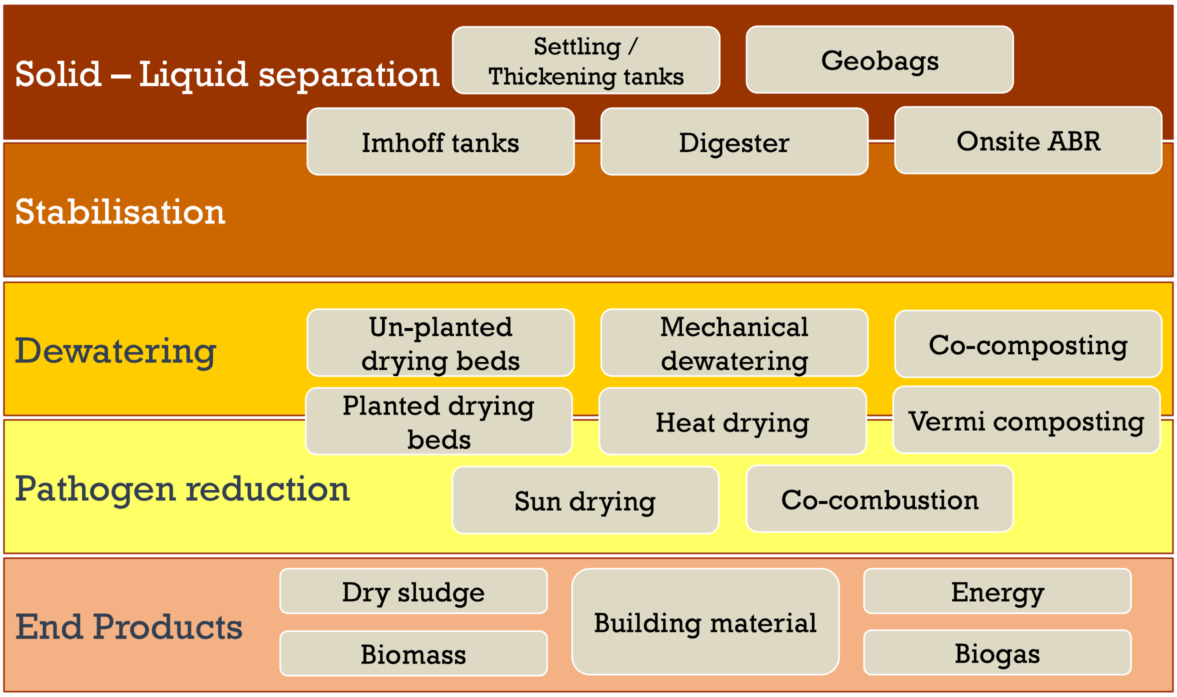
TREATMENT OBJECTIVES

- **Dewatering**
  - More than 90% water content
  - Transporting and treatment
- **Pathogens**
  - Disposal of treatment products
- **Nutrients**
  - End use of treatment products
- **Stabilisation**
  - Controlling oxygen demand

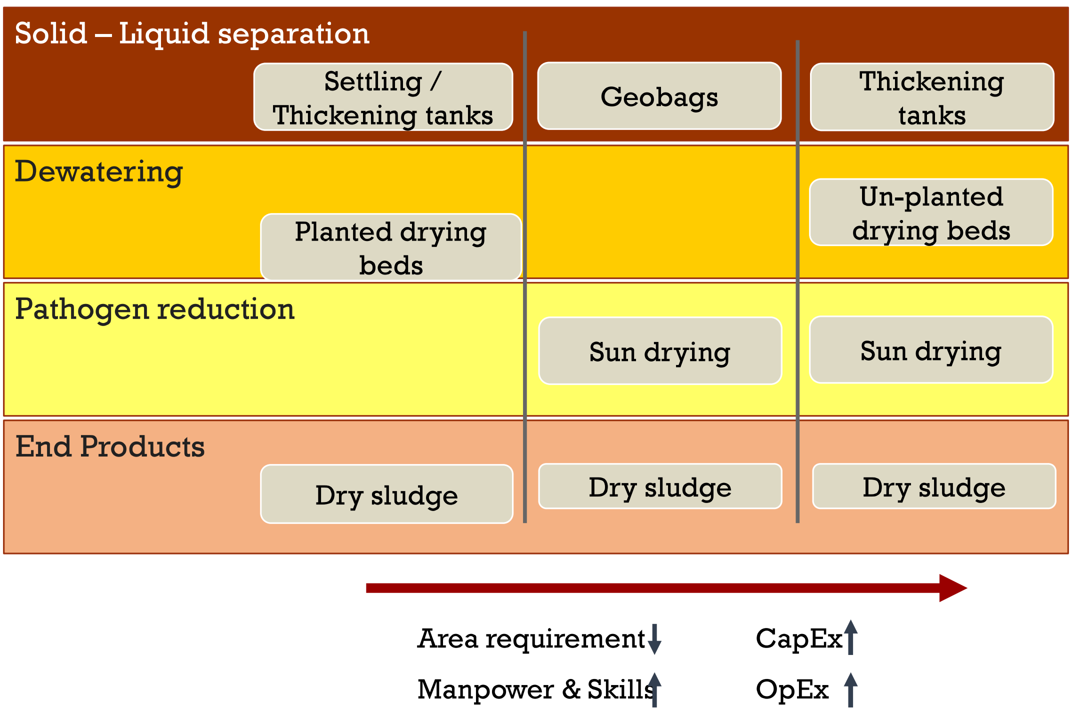
4 FS TREATMENT STAGES

FS Treatment Chain, Feasibility Options

FSS TREATMENT CHAIN



FEASIBLE OPTIONS: < 50,000 POPULATION



FEASIBLE OPTIONS: > 50,000 POPULATION

Solid – Liquid separation		Thickening tanks
Stabilisation	Digester	
Dewatering	Mechanical dewatering	Mechanical dewatering
Pathogen reduction	Heat drying	Co-combustion
End Products	Biogas Dry sludge	Energy Biomass

→

Area requirement ↓ CapEx ↑

Manpower & Skills ↑ OpEx ↑

8 FS TREATMENT COMPONENTS

CO TREATMENT IN STP

- **Limiting factor:** Organic & hydraulic loading
- **Application**
  - At the Manhole Chamber before the inlet of STP
  - At the inlet of Screens of the STP
  - At the Sludge Management Process of the STP

Source: ESF/Dhawal Patil

Source: ESF/Dhawal Patil

Source: Faecal Sludge Management, IWA

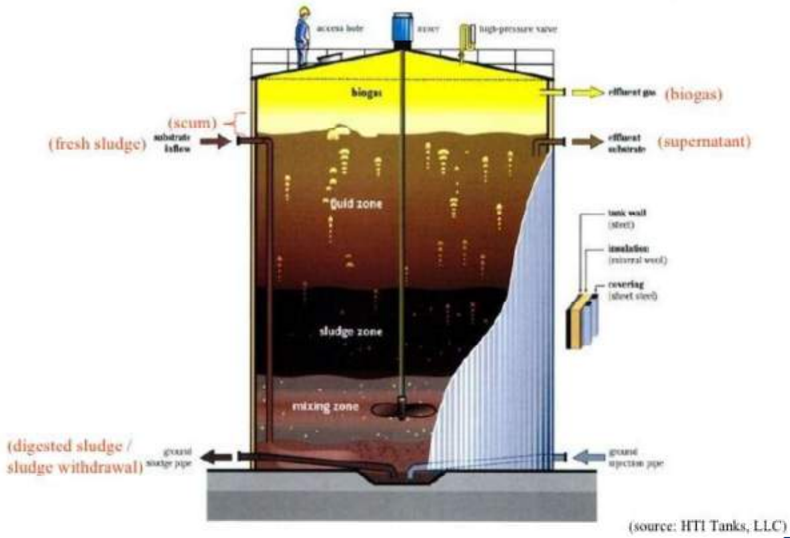
DEEP ROW ENTRENCHMENT

- Deep trenches, filled with sludge and covered with soil.
- **Advantages:** Simple, low cost, limited O&M, no visible or olfactory nuisance.
- **Limiting factor:** Land and groundwater table, legislation.

Source: Faecal Sludge Management, IWA

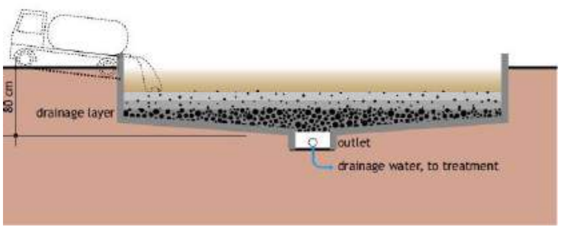
ANAEROBIC DIGESTION

- Organic matter- Biogas (methane and CO_2) and digestate.
- **Advantages:** Production of biogas, reduction of sludge volume and odours.
- **Limiting factor:** High level of skilled operation and monitoring.



(source: HTI Tanks, LLC)

UNPLANTED DRYING BEDS



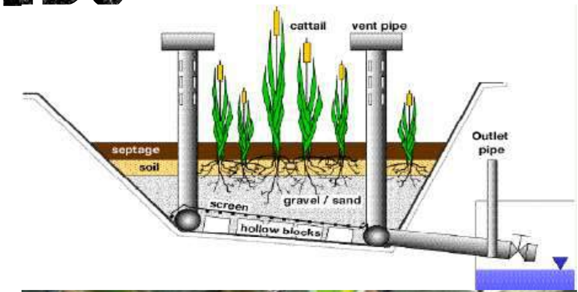
Source: Tilley et al. 2014


Source: Faecal Sludge Management, IWA

- Shallow filters with sand and gravels with under drain to collect filtrate.
- **Application:** Climatic factor and types of sludge
- **Advantages:** Low cost and ease of operation.
- **Limitation:** Large footprint and odour potential

PLANTED DRYING BEDS

- Unplanted drying bed with emergent macrophyte.
- **Application**: Climatic factor
- **Advantages**: Low cost and ease of operation.
- **Limitation**: Large footprint and odour potential



Source: AIT, Thailand

Source: Faecal Sludge Management, IWA

GEOTUBES

- Non woven geotextile is used to create long tubes.
- **Application**: fully digested sludge, increasing efficiency of SDB.
- **Advantages**: Low cost and ease of operation.
- **Limitation**: One time use

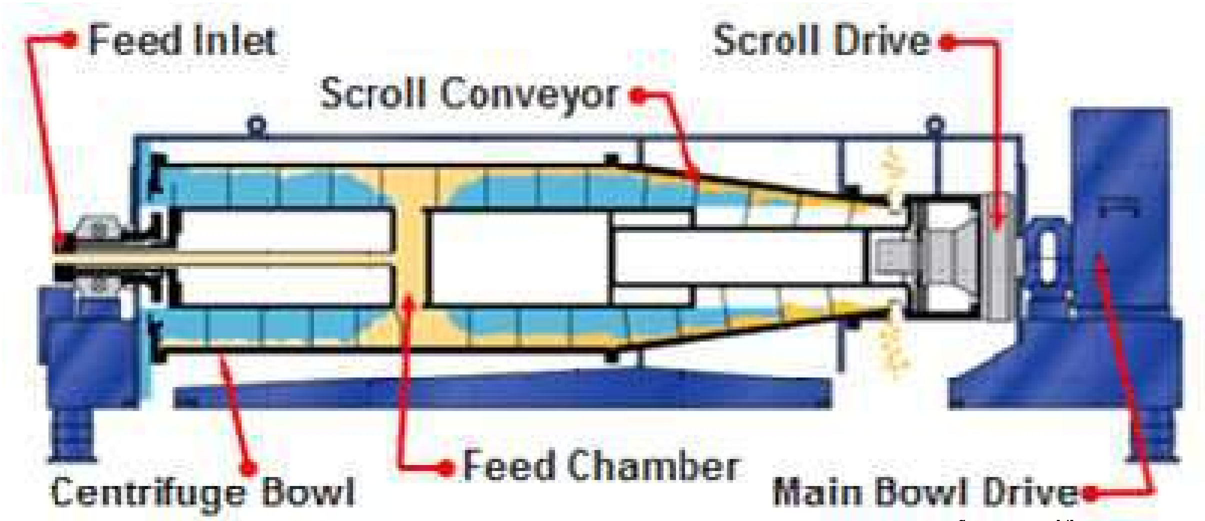
Source: ESF/Dhawal Patil

Source: cementingproductsinc.com

MECHANICAL SLUDGE TREATMENT

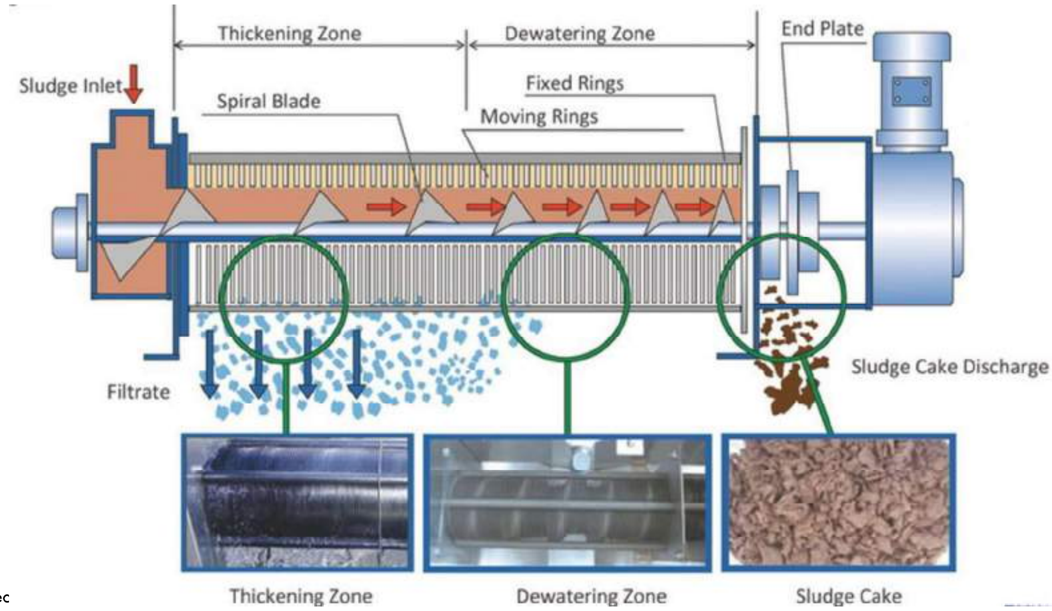
- Belt filter, Centrifuge, Frame filter press and the Screw press.
- Mostly used for sludge generated in STP, transferable to FS and septage.
- Malaysia: centrifugation to dewater FS after screening and addition of flocculants.
- **Advantages:** Compactness, speed of the process.
- **Limiting factors:** investment costs, O&M costs, dependency on electricity.

CENTRIFUGE



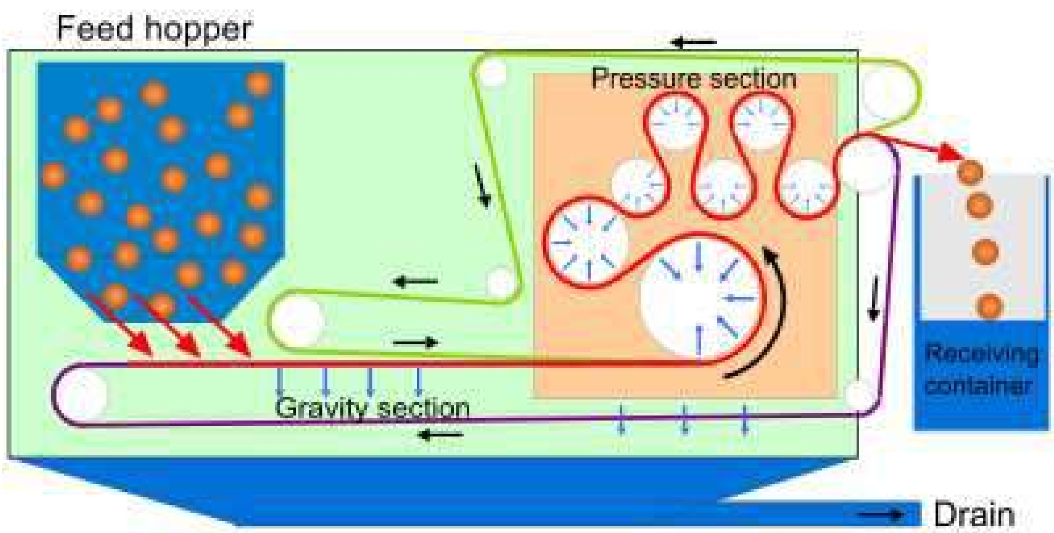
Source: www.hiler-us.com

SCREW PRESS



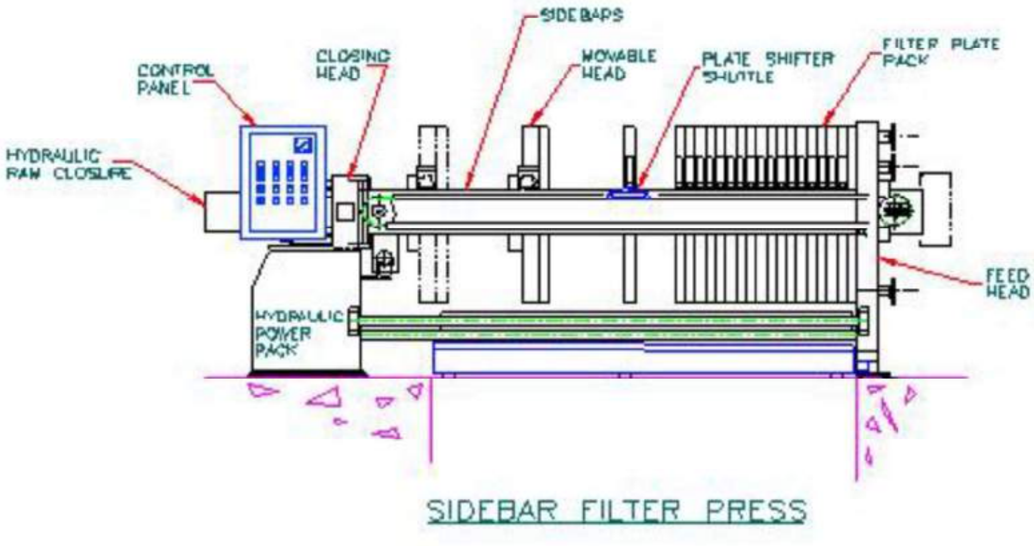
Source: www.ecologixsystems.com

BELT FILTER



Source: wikiwayan, Wikimedia.com

FRAME FILTER PRESS

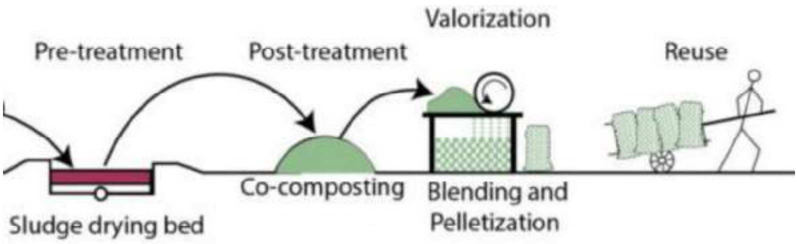


Source: www.ecologixsystems.com

CO COMPOSTING

- C:N Ratio = 20-30:1, Oxygen concentration: 40-60%, Particle diameter < 5 cm
- **Advantages**: Thermophilic condition- Pathogen inactivation
- **Limiting factors**: Technical and managerial skills

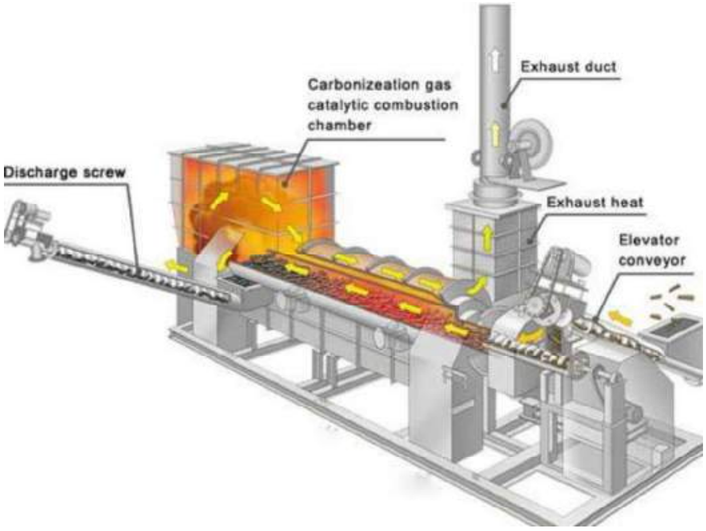
Source: www.iwmi.cgiar.com



Source: www.wateratleeds.com

SLUDGE INCINERATION

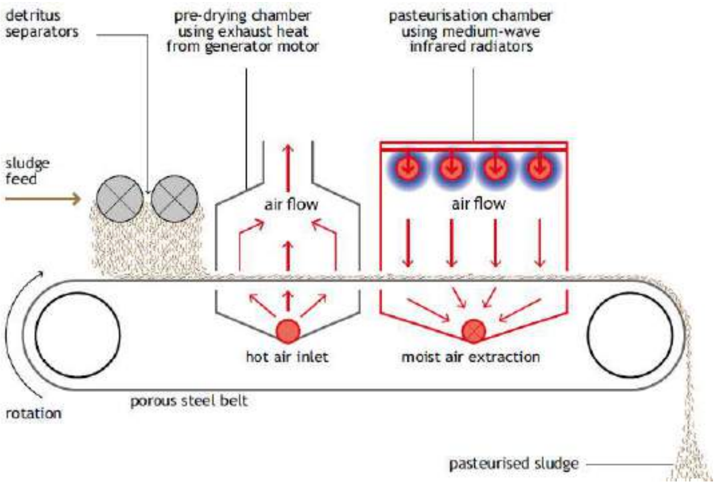
- Burning of sludge at temperature 850-900°C.
- **Advantages:** Volume and pathogen reduction.
- **Limiting factors:** emission of pollutants, high skilled operator and maintenance staff, high capital and O& cost.



Source: www.carbonizationfurnace.com

THERMAL DRYING AND PELLETISING

- Direct (hot air or gas) or indirect thermal driers (hot water or oil).
- Advantages: Reduction in volume and pathogen content.
- Limiting factors: high energy requirements, risk of fire and explosion, high maintenance.



Source: Faecal Sludge Management, IWA

23 END PRODUCTS

END PRODUCTS

Product produced	Treatment / Processing technology
Soil conditioner	Sludge from drying beds, Compost, Pelleting process, Digestate from anaerobic digestion, Residual from Black Soldier Fly
Reclaimed water	Treated liquid FS, Treatment plant effluent
Protein	Black Soldier Fly process
Fodder and plants	Planted drying beds
Fish and plants	Stabilisation ponds or effluent for aquaculture
Building materials	Incorporation of dried sludge
Bio fuels	Biogas from anaerobic digestion, Incineration / co combustion of dried sludge, Pyrolysis of FS, Bio diesel from FS

Thank you...

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REVIEW OF SUSTAINABLE WASTEWATER TREATMENT OPTION – DOSIWAM
A NON MECHANISED SYSTEM

WINTER SCHOOL ON DECENTRALISED LIQUID WASTE MANAGEMENT

18TH FEBRUARY TO 22ND FEBRUARY 2019

AT

COLLEGE OF ENGINEERING, PUNE

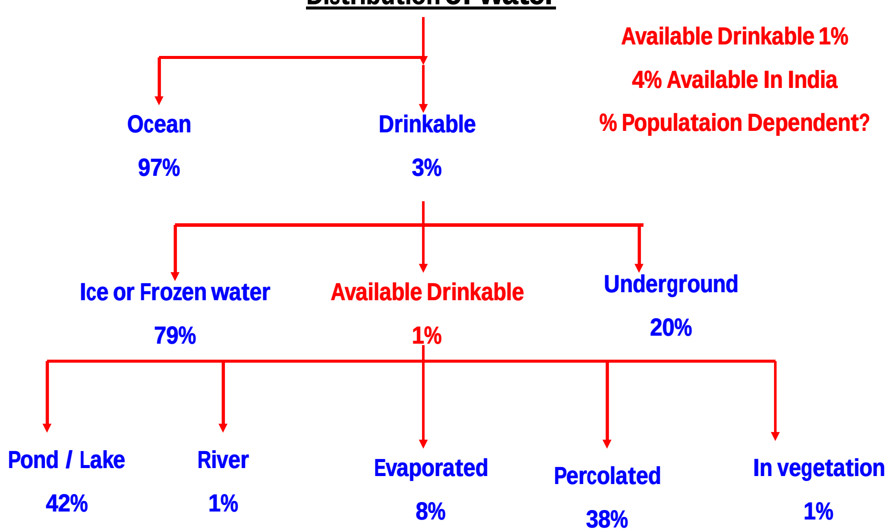
DR. SAMEER SHASTRI

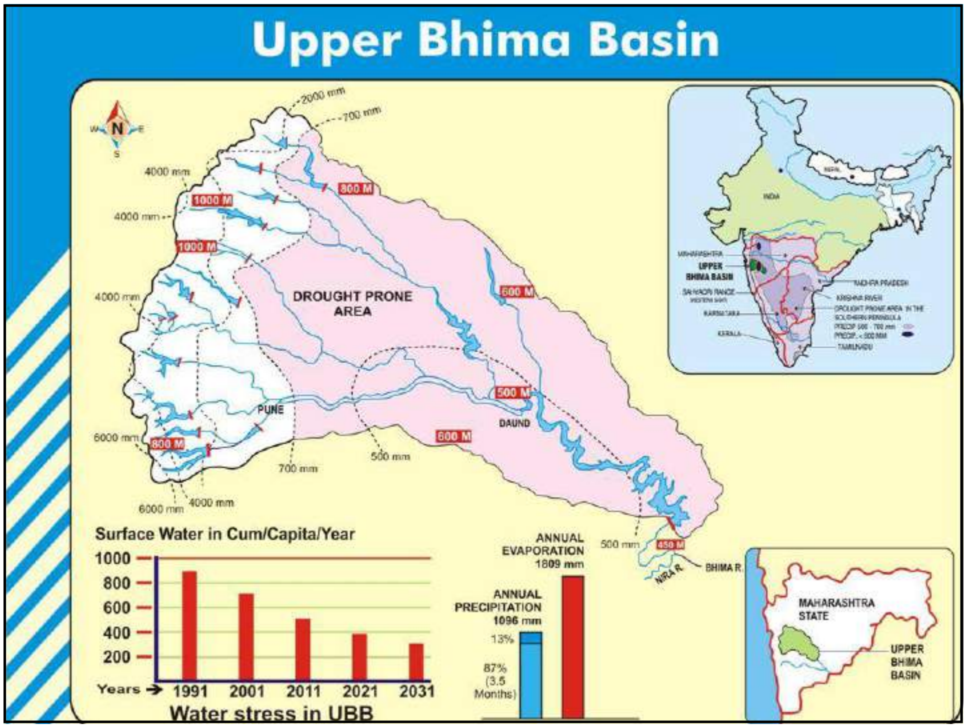
Professor & Head Civil, Sinhgad College of Engineering, Pune

Technical Director, (APPA PATWARDHAN SAFAI Wa PARYAWARAN TANTRANIKETAN, *Founder: LATE DR. S. V. MAPUSKAR, PADMASHREE WINNER 2017)*

DEHUGAON, TAL. HAVELI, DIST. PUNE, MAHARASHTRA, 412 109 INDIA

Distribution of water

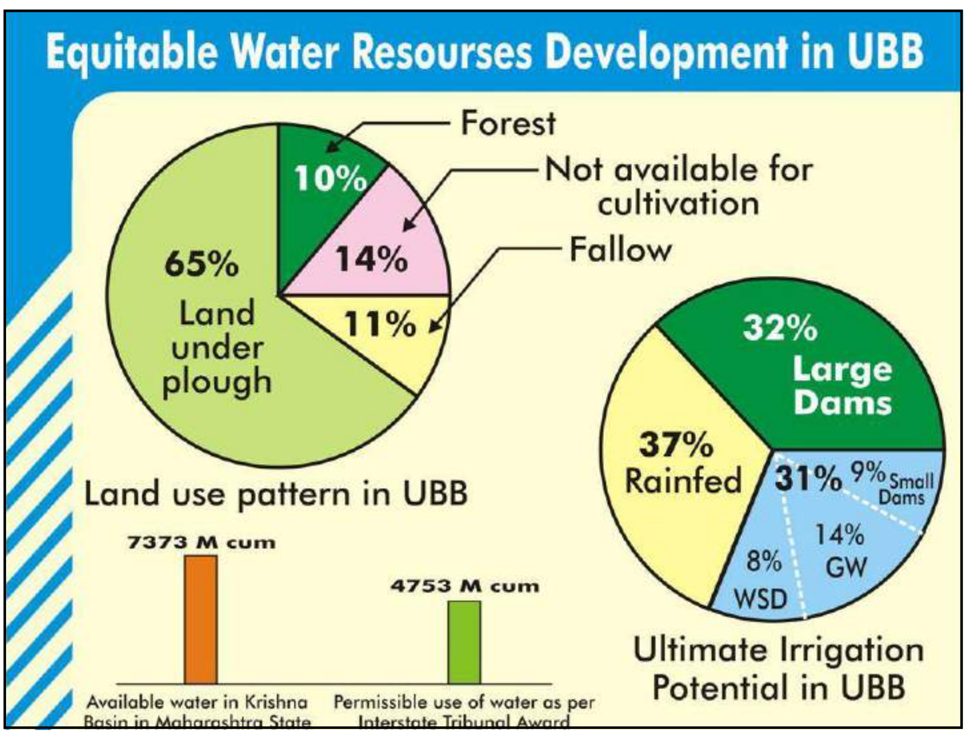




Available and permissible water use in UBB	
Water account in UBB	Qty. Mcum
Average Water available	7373
Permissible use as per IBWDT Award	4753
Av. westward diversion for hydropower by TATA	1200
Live storage of all u/s maj./med./minor dams	2669
Live storage of Ujjani dam	1518

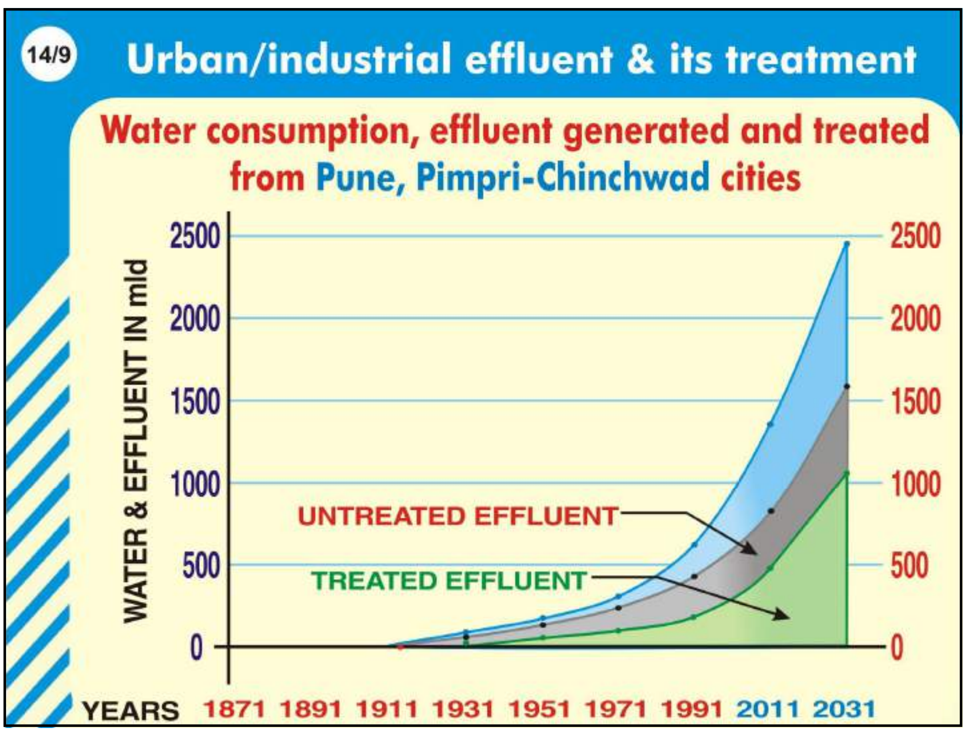
Water Resource Development status in UBB

Khadakwasla dam -	Drought area irrigation & urban water supply	1870
5 dams of TATA	Hydropower by westward diversion	1925
17 Large dams -	Drought area irrigation, Incidental Hydropower, Urban water Supply	1955 to 2012
245 small dams -	Seasonal irrigation	1970 to 2012
Ground Water -	Perennial Irrigation Village water supply	1975 to 2012
Watershed Dev.-	Augmenting GW in rain-fed area	1990 to 2012



Urban-Rural Conflict in UBB

Period ----------- Year	Cumulative Water Stored Mcum	Dams Completed	Urban Use Mcum	Balance For Irrigation Mcum
1871-67	56	Khadakwasla	26	30
1968	294 / 350	Panshet	30	320
1971	241 / 591	Pawana	58	533
1981	591	-	104	487
1991	362 / 953	Warasgaon	292	661
2001	953	-	448	505
2011	64 /1017	Temghar	620	397
2021	1017	-	949	68
2031	1017	-	?	?



Reuse of polluted river water in UBB

Irrigation on polluted river water

1) From 7 weirs on river by private lifts 4000 ha
2) Purandar Lift Irrigation Scheme (PLIS) 5000 ha

UB Basin	9000 ha
Nira Basin	20000 ha
Total	**29000 ha**

Note * Some water from Purandar LIS needs to be released in Khadakwasala. RBC to restore irrigation

TREATED SEWAGE FROM STP + UNTREATED SEWAGE FROM NALLA GETTING MIXED & JOINING RIVER.... UNSUSTAINABLE WASTE WATER MANAGEMENT

FILTHY CONDITIONS OF ALL RIVERS DUE TO UNCONTROLLED DISCHARGE OF LIQUID WASTE & SOLID WASTE / DEBRIS ETC

WATER HYACYNTH GROWING IN POLLUTED RIVER

DECENTRALISED ‘ON SITE’
INTEGRATED WASTE MANAGEMENT
SYSTEM

DOSIWAM

CONCEPT AND TECHNOLOGY DEVELOPED BY PADMASHREE Dr. S. V. MAPUSKAR

DIFFERENT TYPES OF WASTES

DOMESTIC & COMMUNITY

A) HUMAN EXCRETA
B) ANIMAL EXCRETA
C) NONEXCRETAL SOLID WASTE
D) NONEXCRETAL LIQUID WASTE

2. INDUSTRIAL

A HOLISTIC DECISION MAKING PROCESS

IS ESSENTIAL FOR SANITARY PROVISION & SUSTAINABILITY

WHAT IS SUSTAINABILITY?

SANITATION SYSTEM THAT IS SUSTAINABLE

1) PROTECTS AND PROMOTES HUMAN HEALTH,
2) DOES NOT CONTRIBUTE TO ENVIRONMENTAL DEGRADATION OR DEPLETION OF THE RESOURCE BASE,
3) IS TECHNICALLY AND INSTITUTIONALLY APPROPRIATE,
4) ECONOMICALLY VIABLE
5) AND SOCIALLY ACCEPTABLE.

HEALTH ASPECTS

1. RISK OF INFECTION ON USE OF SYSTEM

2. RISK OF EXPOSURE TO HAZARDOUS SUBSTANCES

ENVIRONMENTAL ASPECTS

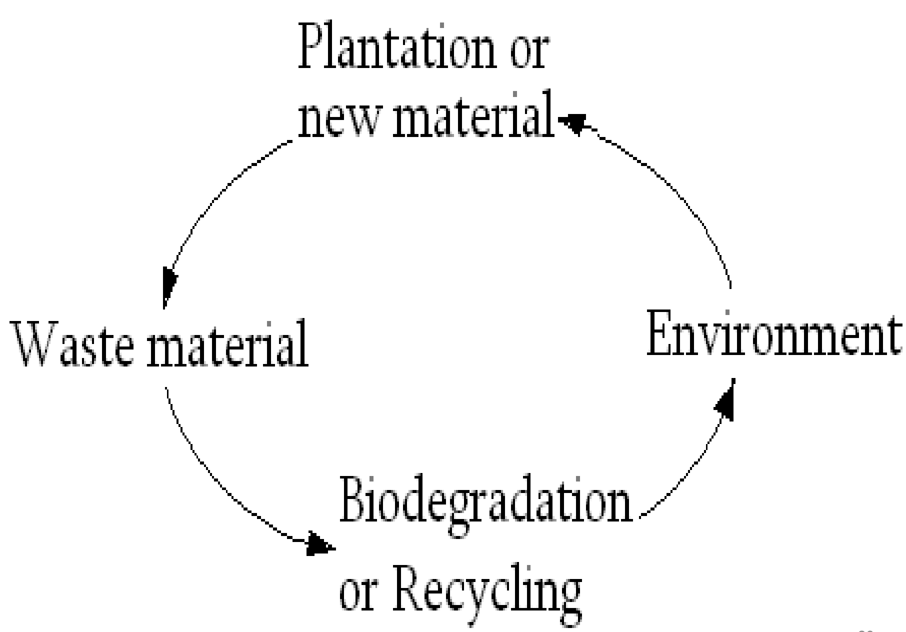
1. USE OF NATURAL RESOURCES FOR FACILITY
2. USE OF LAND FOR FACILITY
3. USE OF ENERGY FOR FACILITY
4. CONSTRUCTION MATERIAL
5. CHEMICALS
6. FRESH WATER
7. DISCHARGE TO WATER BODIES
8. DISCHARGE OF HAZARDOUS SUBSTANCES
9. AIR EMISSIONS
10. CONTRIBUTION TO GLOBAL WARMING
11. ODOUR

IN NATURE NOTHING IS A WASTE.

MATTER ONLY CHANGES FORM.

WASTE IS WEALTH

IMPORTANT CONCEPT
FOR SELECTION OF
APPROPRIATE TECHNOLOGY
FOR MANAGEMENT OF WASTE



Waste generation & natural capacitance

- Waste generation – A problem?
  No – When within natural capacitance
  Yes – Beyond natural capacitance
- Exceeding the natural capacitance
  - High level of developmental activities
    - Industry, Urbanisation, Infrastructure

Low waste & RC & R

- Development within natural capacitance
  - desirable but not always possible
- Remedies
  - Inculcate habits for creation of low qty of waste
  - Resource recovery and recycling
  - Treatment of waste and safe disposal

Appropriate technology

- Choosing a Waste Treatment Technology
  - Appropriate
  - Ecologically friendly
- Conventional and Ecotechnologies
  - Shall be seen as complimentary
  - The conv also adopt biological treatment
  - Waste water is part of water resource
  - Shall be considered with fresh water

Appropriate technology

- Appropriate Technology
  - End of pipe is not appropriate
  - Reduce waste
  - For water scarce cities treating WW to convert it into usable form is appropriate
  - Need to rethink water as a carrier
  - High Urbanisation need conv technology due to essentiality of piped carriage
  - Explore possibility to reduce load while conveying

Appropriate technology

- Implement multiple locations of STPs
  - Why trouble habitants of a single location
  - Segregate black and grey water at house
- **Use most ecofriendly technology say ponds to start till land is in abundance**
- Bioremediation, Green bridge, other cultures, wetlands etc are important and shall be used at appropriate places

Appropriate technology

- In Nutshell
  - First choice is waste reduction
  - Second is Ecotechnologies
  - Third is conventional but appropriate:
  - Power generation from waste attracts carbon credit; advantages – Anaerobic
  - WW treatment to high degree at a cost less than fresh water production go for recovery of water

IN INDIA,
NATURAL BIODEGRADATION PROCESS
SUITABLE FOR ORGANIC WASTE

RECYCLING DESIRABLE FOR THE
NONORGANIC WASTE

All biodegradation methods for
various waste materials are based on
aerobic or anaerobic biodigestive processes.

These can be used in a complementary way.

If end products are returned to nature
in ecofriendly manner, nature reciprocates.

SEWAGE – GENERATION & MANAGEMENT

1. In conventional system excreta and grey water combined and transported for offsite treatment, thus diluting 10% excretal waste to 100% sewage, increasing treatment needs, which are costly & inadequate
2. Untreated component results in pollution & disease transmission.
3. Treating excreta and grey water separately preferably on site reduces costs and simplifies the process.

Concept of DOSIWAM

Decentralised On Site Integrated WAste Management)

For management

- **Waste, without mixing, can be brought together in single process**
- **End products to be brought together for energy recovery and reuse & recycling**
- **Processes can be complementary.**
- **'On Site' management preferable**

OBJECTIVES FOR THE PROJECT

1. COMPREHENSIVE MANAGEMENT OF ALL WASTES IN TOTALITY
2. HYGIENICALLY ORIENTED PROCESS
3. AS LOW COST AS POSSIBLE
4. ENERGY RECOVERY
5. RECYCLING & REUSE OF END PRODUCTS

IN DOSIWAM,

every grain of solid and every drop of liquid
is treated hygienically
by bio-digestive processes & natural aeration
and end products are returned to the soil
in horticulture or agriculture
in an ecologically sustainab

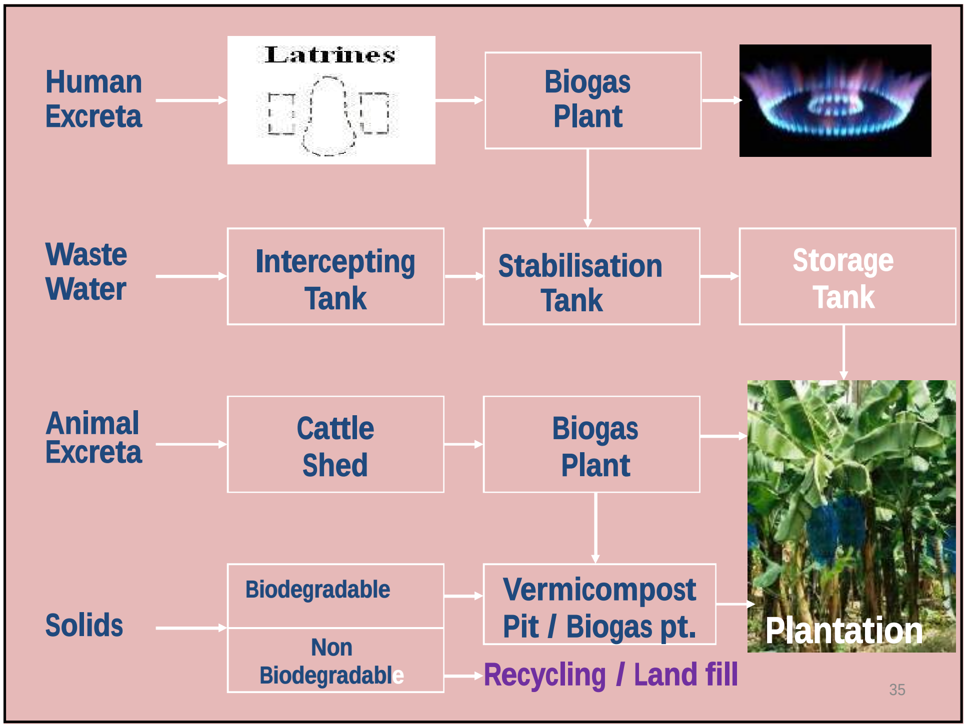
END PRODUCTS FROM DOSIWAM

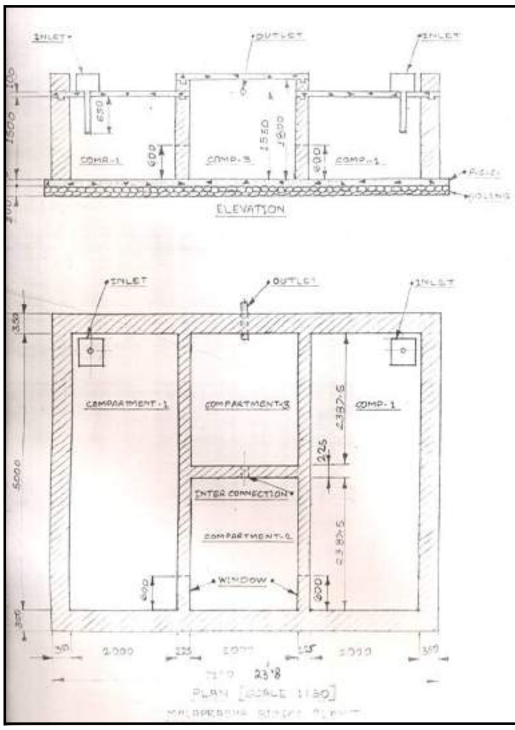
1. Biogas - use -as energy source
2. Fertilizer - use -agriculture / horticulture
3. Stabilized - use - agriculture / horticulture
   Clean water

FLOW PATTERN IN DOSIWAM

All the latrines are connected to biogas plant.

2. Effluent from biogas plant is combined with all the grey water from various places.
3. This water is taken to stabilization tank via intercepting tank.
4. Stabilized water is stored in stabilized water storage tank and onwards for irrigation.
5. Solid waste is segregated.
6. Wet waste is vermicomposted and returned to soil as manure. Dry waste goes for recycling

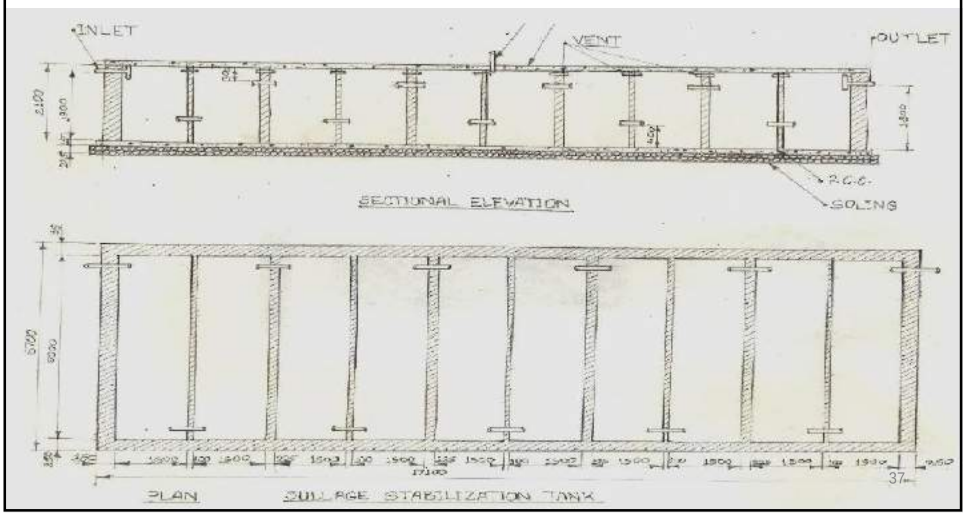


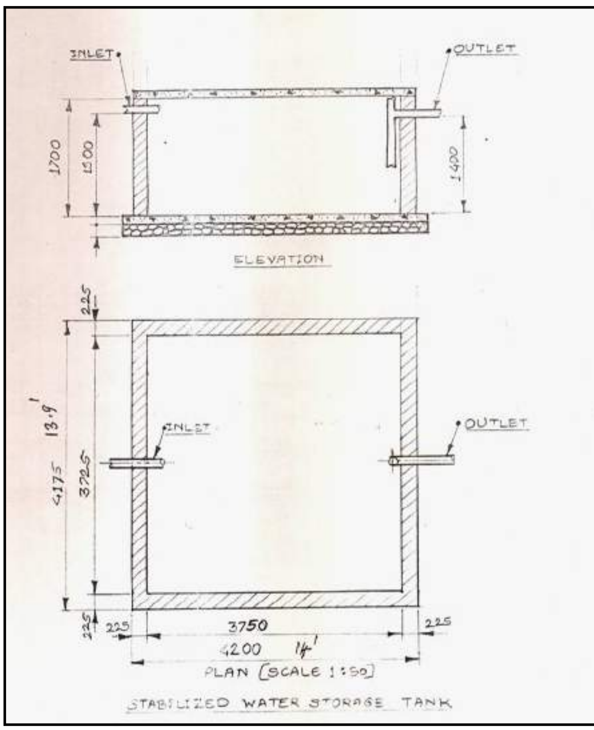


DOSIWAM

If only human nightsoil is to be used -

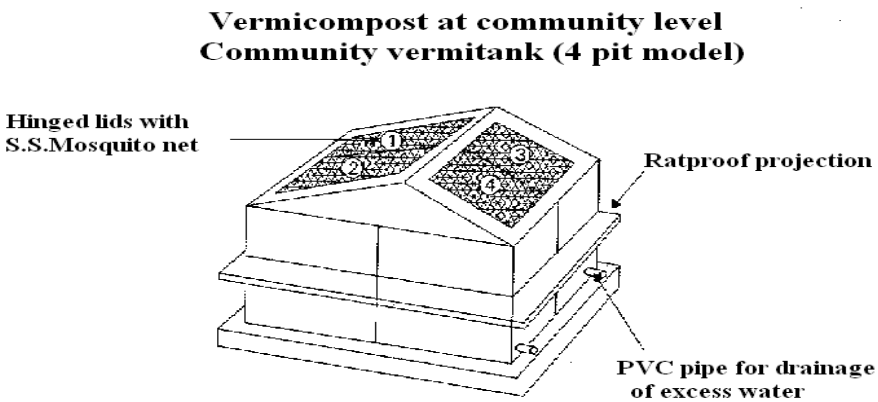
MALAPRABHA BIOGAS PLANT





DOSIWAM STABILIZED WATER STORAGE TANK

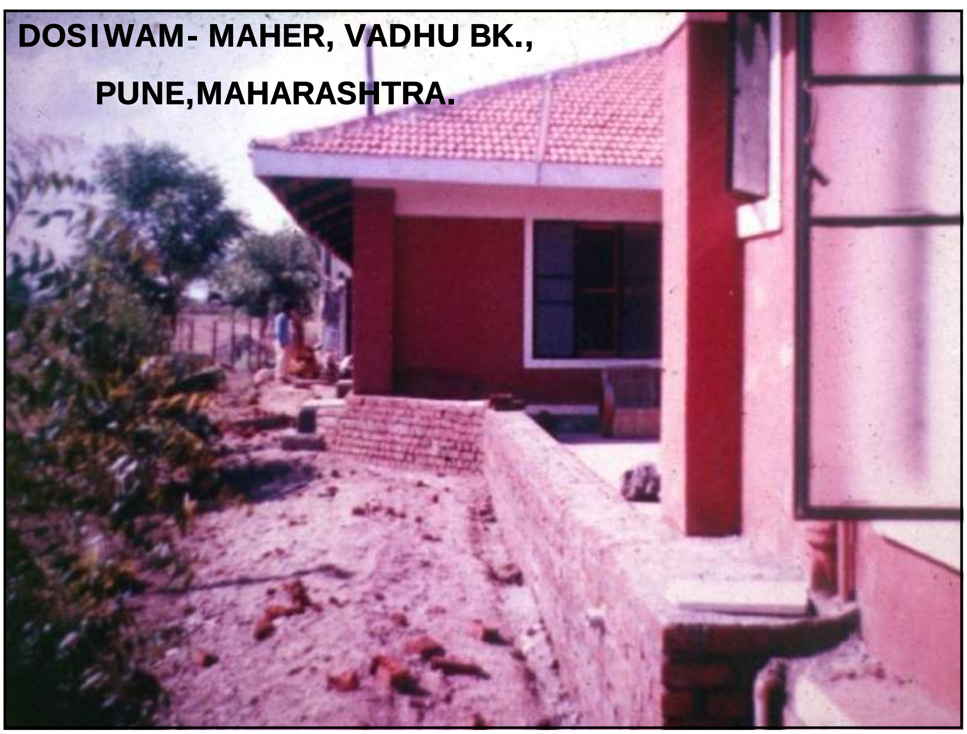
DOSIWAM – VERMI TANK



DOSIWAM- MAHER,VADHU BK.,

PUNE, MAHARASHTRA.

DOSIWAM- MAHER,VADHU BK.,
PUNE, MAHARASHTRA.



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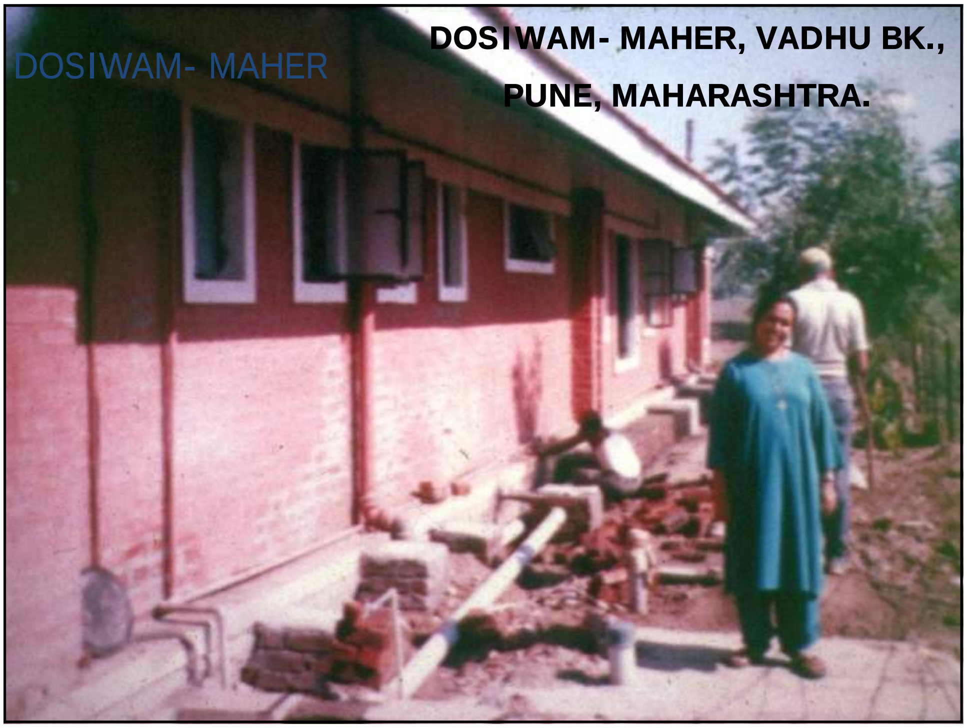
DOSIWAM- MAHER
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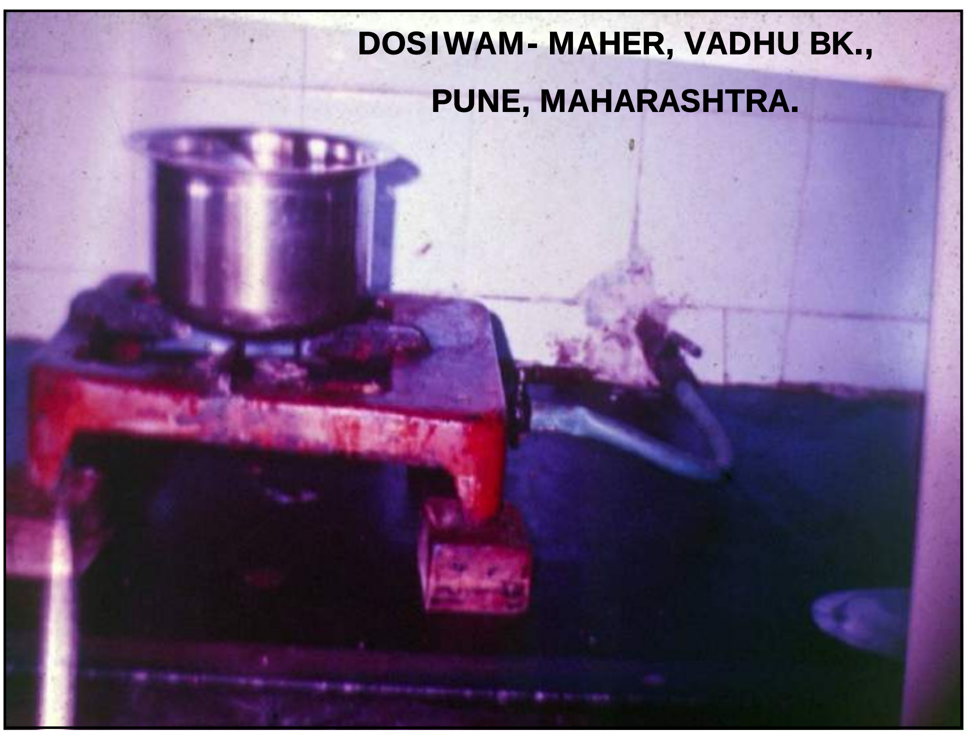
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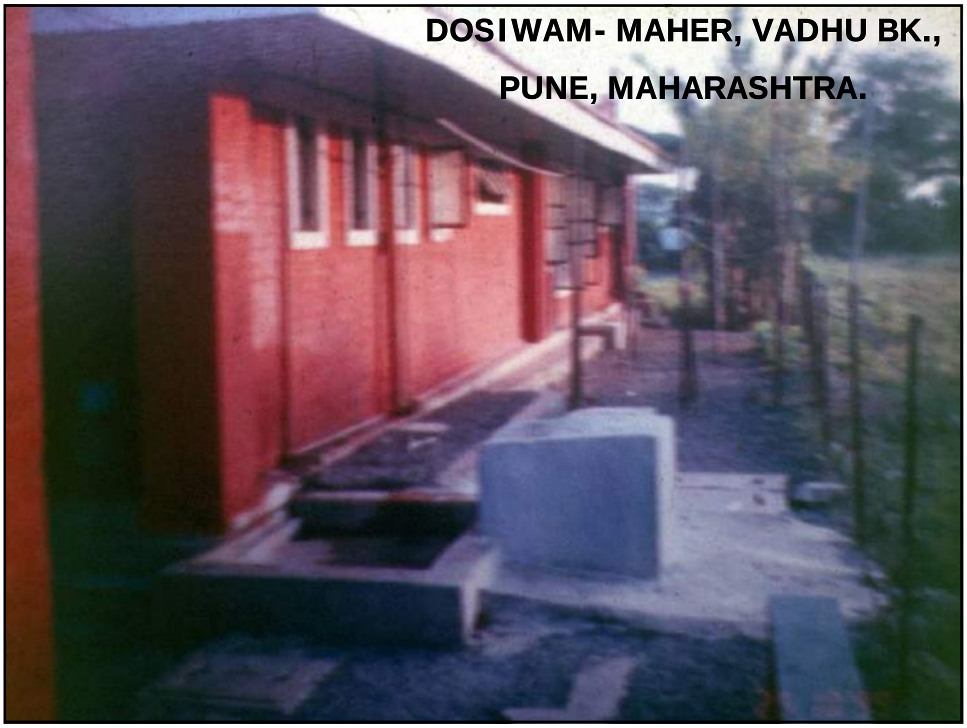

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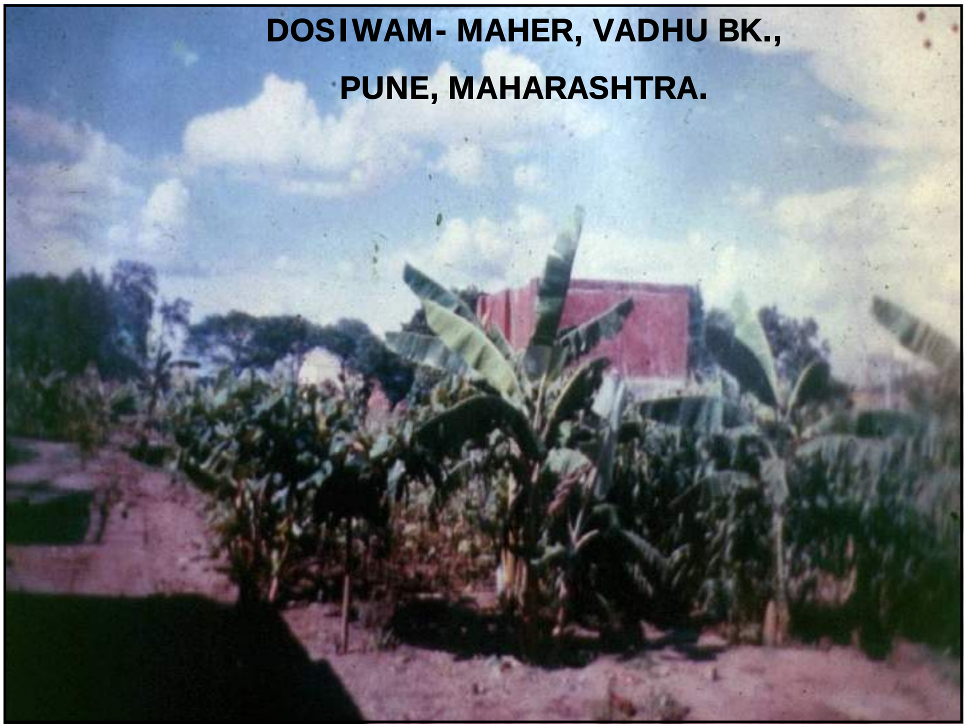
DOSIWAM- MAHER, VADHU BK.,

PUNE, MAHARASHTRA.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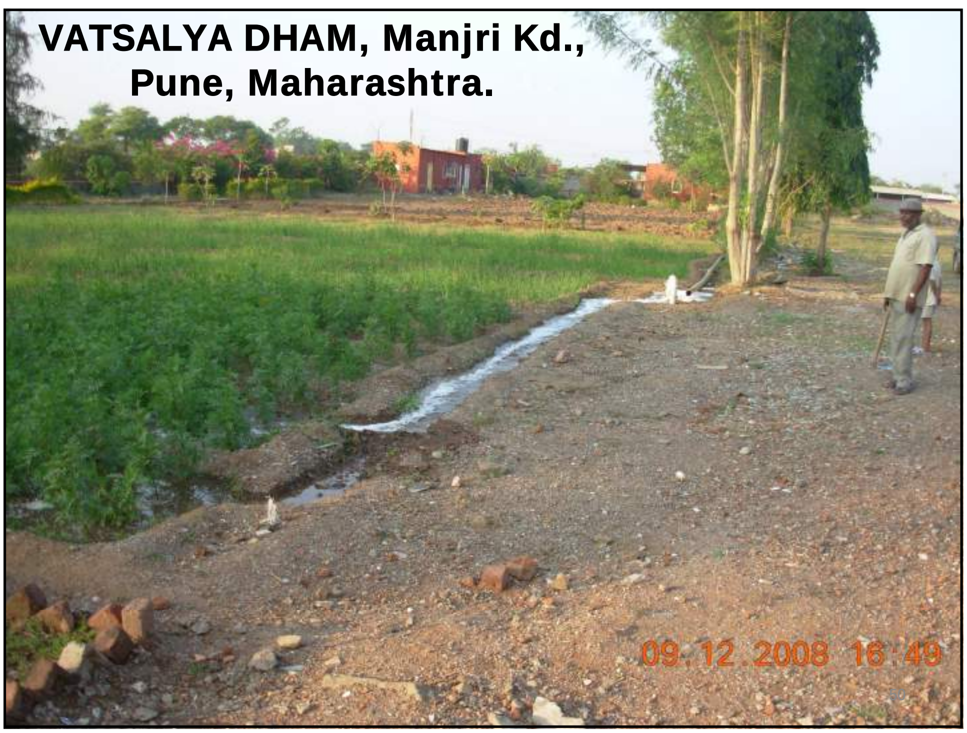
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DOSIWAM

is

a sustainable, ecofriendly,

hygienically safe

sanitation process

based on natural bio-digestion

which converts

waste to wealth

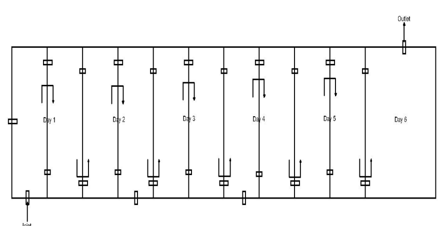



Recent Project at Bibawewadi, Pune: Stabilisation Tank

Recent Project at Bibawewadi, Pune: 2 Pit Latrines

Description 2) Stabilization Tank

Plan for stabilization tank



Description 3) Active vermicomposting of B. M. W.

Advantages of 1) Malaprabha biogas plant

1. Family sized plants can be accommodated even inside the house
2. Maintenance of the plant can be easily managed by owner. It does not evoke any repulsive feeling.
3. Direct handling or carriage of night soil is not required at any stage.
4. Night soil is not exposed to surroundings it is fed directly to the plant. Hence insects and animals do not and animals do not get access to the night soil.
5. Aesthetically it is clean and odorless.
6. There is no contamination of surface soil or subsoil water.
7. The effluent digested slurry is virtually free from disease causing Organisms (Pathogens).
8. As it is harmless and hygienic. It is asset for community health.
9. It meets energy needs of the family through augmentation in fuel supply.
10. Slurry is usable as manure.

Advantages of 2) Stabilization Tank

1. Zero mechanical instruments required
2. Can fit below ground
3. C.O.D. and B.O.D. removal efficiency is about 80 % to 88%
4. No noise / air / soil pollution during operation
5. One time cost only for construction
6. No electricity required
7. No chemicals required
8. No technical operator required
9. Treated water can be used for flushing, gardening, floor washing (no smell)

Results of Experimentation on Grey Water

		Analysis Carried Out In The College Lab								Analysis Carried Out From Certified Lab			
Sr. No.	Parameters	28th April 2014		07th May 2014		15th May 2014		31th May 2014		Sample1		Sample2	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
1	pH	8	6.9	6.9	7.8	6.95	7.15	6.89	7.1	6.95	7.15	7.03	7.31
2	Turbidity	13.7	1.1	70	0.3	17.5	0.7	21.1	3.2	15.5	3	18	2.9
3	T.S (mg/l)	270	160	1220	140	230	150	480	300	382	56	301	48
4	T.D.S(mg/l)	210	150	250	130	170	130	460	170	308	56	265	48
5	T.S.S (mg/l)	60	10	970	10	60	20	20	130	74	Nil	36	Nil
6	BOD (mg/l)	76	20	144	22	114	4	120	12	120	18	92	12
7	COD (mg/l)	180	25	210	30	200	80	250	40	206	60	174	53
8	MPN(/100ml)	>17	10	25	12	36	9	38	16	32	8	26	10
9	Phosphates (mg/l)	-	-	-	-	-	-	-	-	9.6	4.2	7.2	3.5

Cost Analysis

1. Each system has only one time investment that is construction cost.
2. Construction cost for R. C. C. Stabilization tank comes around 10 rs/ litre
3. Construction cost for R. C. C. Malaprabha BioGas plant is 15 rs/ litre
4. active vermicomposting costs 30 % less than traditional 7 day vermicomposting.

Water Holding Bucket

Sludge Valve

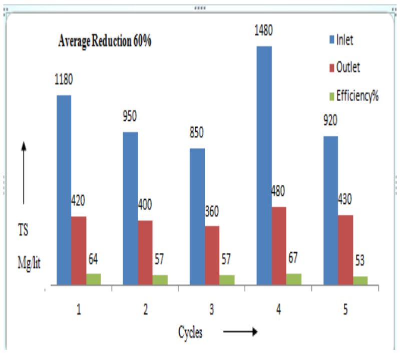
Leak Detection if any


Inlet Outlet

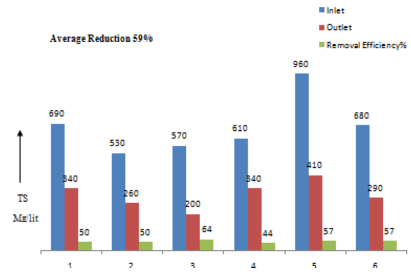

Inlet Outlet

Results and Discussion

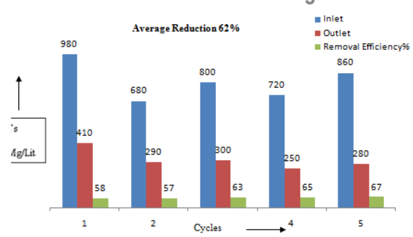
Total Solids



TS Variation of Greywater

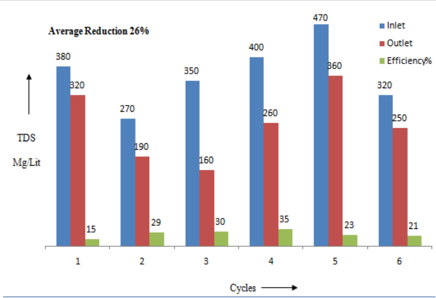


TS Variation of Sewage

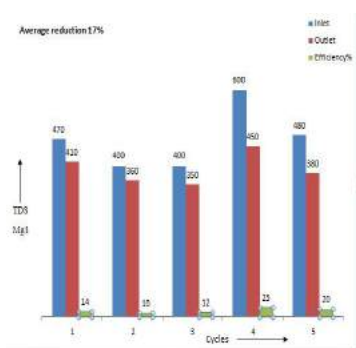


TS Variation of Sewage with EM Solution

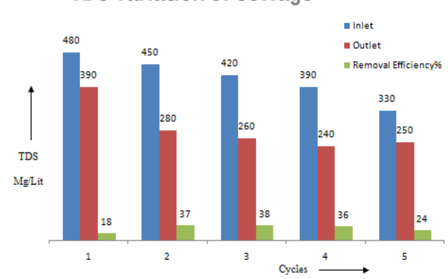
Total Dissolved Solids



TDS Variation of Sewage

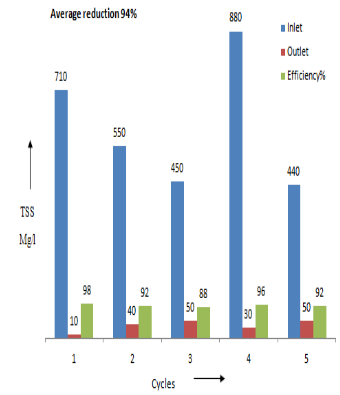


TDS Variation of Grey Water

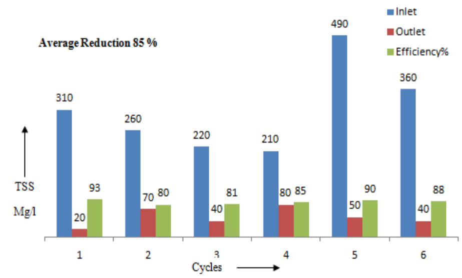


TDS Variation of Sewage with EM Solution

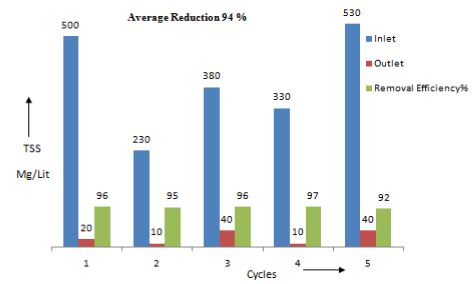
Total Suspended Solids (Discharge limit 100)



TSS Variation of Grey Water



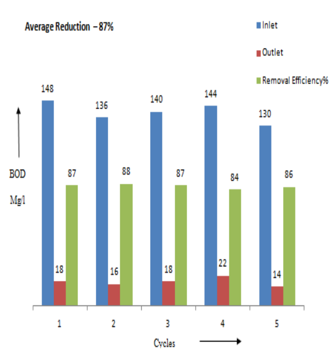
TSS Variation of Sewage



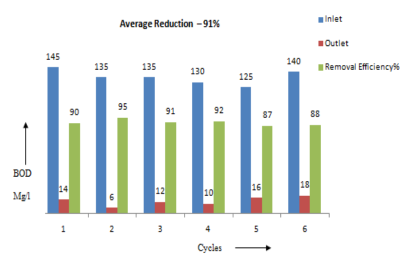
TSS Variation of Sewage with EM Solution

Biochemical Oxygen Demand

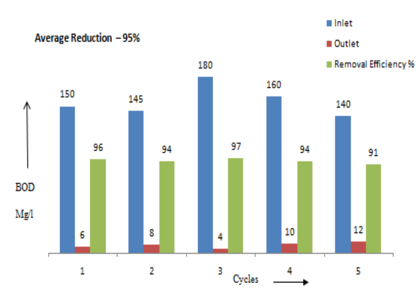
(Discharge limit 20)



BOD Variation of Greywater



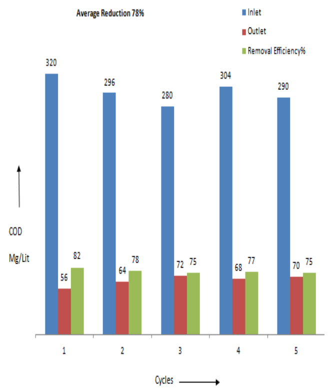
BOD Variation of Sewage



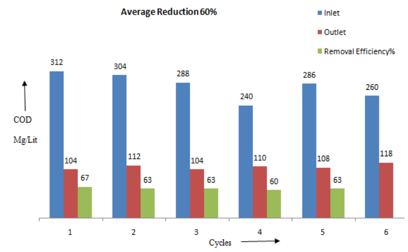
BOD Variation of Sewage with EM Solution

Chemical Oxygen Demand

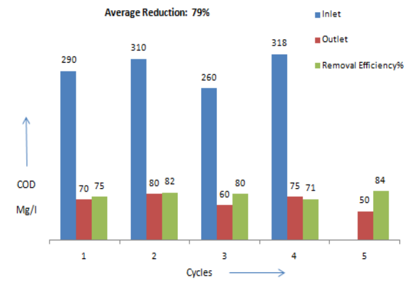
Discharge limit 250



COD Variation of Greywater



COD Variation of Sewage



COD Variation of Sewage with EM Solution

Conti….

Treatment Assembly

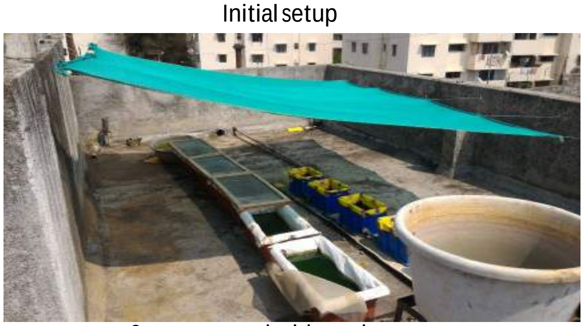
Assembly covered with garden net

Inlet and outlet

inlet and outlet of 3rd , 4th and 5th compartment are covered with such wire mesh to prevent entry of fish into pipe

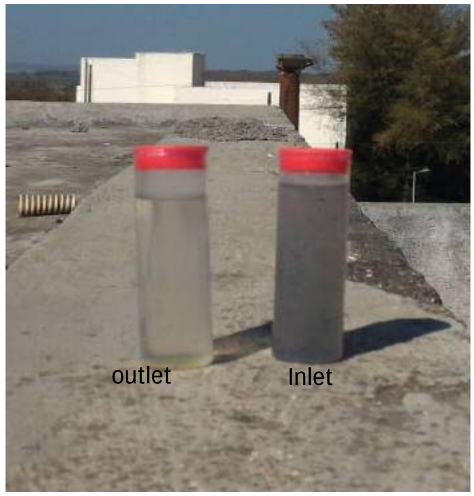
Some Photographs of Model

Initial setup



Setup covered with garden net

Setup fed with EM solution

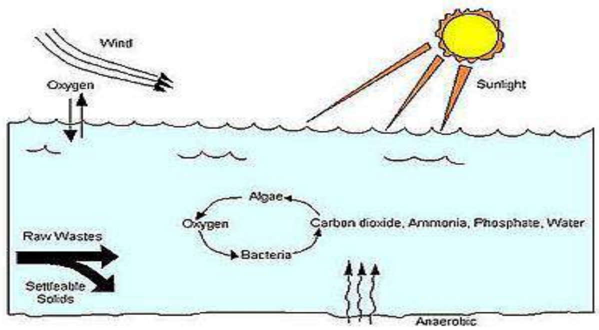


After use of EM solution outlet and inlet respectively

Working

Conti....

- The system works on the principle of oxidation pond.



- The system is provided with alternate openings due to which zigzag flow occurs hence natural aerobic conditions are maintained.
- It gives ideal plug-flow condition
- In the system, bacteria, algae and sunlight help to reduce the organic and inorganic solids. (shown in fig above)

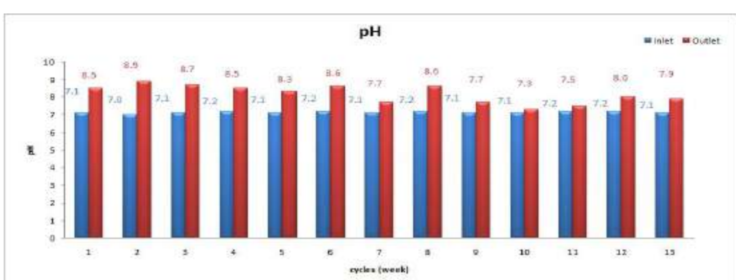
Analysis of parameter

Parameter	Method
pH	Electrometric Method
Total Suspended Solids	Gravimetric Method
Chemical Oxygen Demand	Reflux Method
Bio-Chemical Oxygen Demand	Dilution Method
Nitrogen	Total kjeldahls nitrogen Method
Phosphorus	Spectrophotometer Method
Potassium	Flame photometer
MPN	MPN test
E-coli	PA test

Result and Discussion

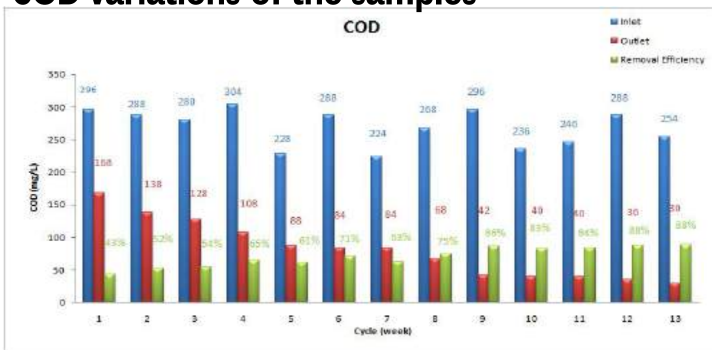
pH variations of the samples

•The pH of inlet and outlet was within range of 7.0 to7.2 and 7.3 to 8.5 respectively.
•The pH is observe to vary up to 8.9 because of sunlight penetration and photosynthesis.



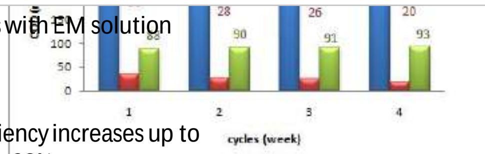
COD variations of the samples

Results Without EM Solution



43-88 % COD reduction

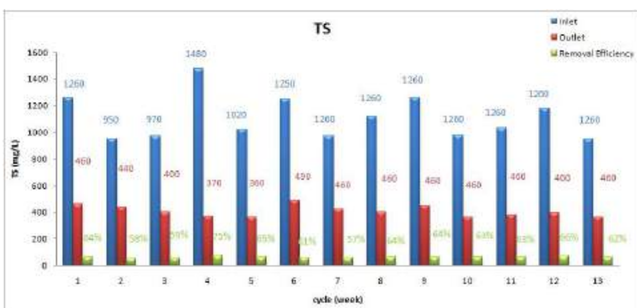
Results with EM solution



Removal efficiency increases up to 93%

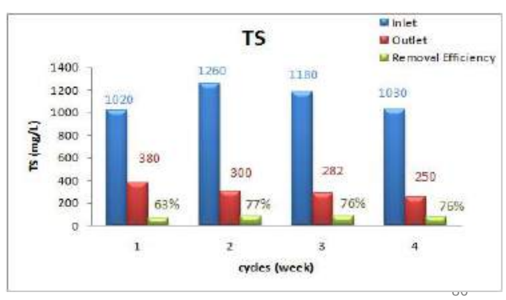
TS variations of the samples

Results Without EM Solution



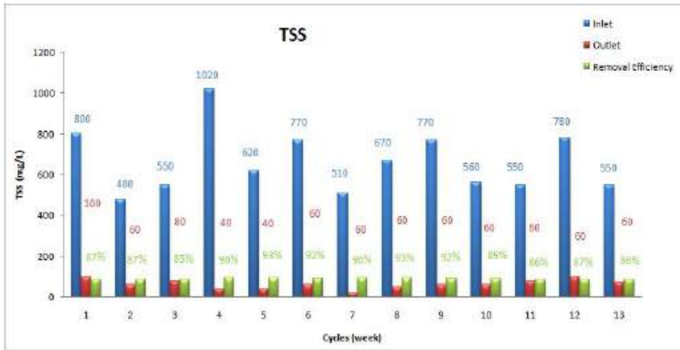
54 – 75% TS reduction

Results with EM solution



Removal efficiency increases up to 77%

TSS variations of the samples

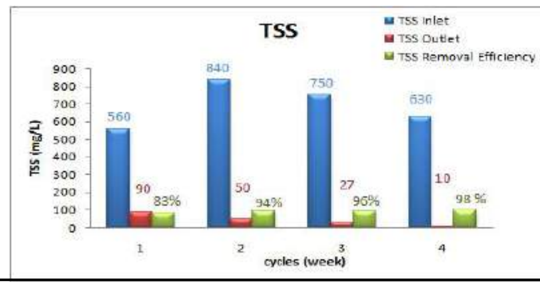


Results Without EM Solution

85 -95 % TSS reduction

Results with EM solution

Removal efficiency increases up to 98%



DO variation with respect to cycles

Cycles (week)	1	2	3	4	5	6	7	8	9	10	11	12	13
Inlet (mg/l)	Nil												
Outlet (mg/l)	8.1	8.0	8.3	8.5	7.9	7.8	7.8	7.9	7.9	8.1	8.3	8.1	7.9

Summery of Results

Parameter	Inlet	Outlet		Permissible limit Surface water
		Without EM solution	With EM solution	
pH	7-7.2	7.3-8.5	-	6.5-9.0
COD (mg/L)	220-304	30-168	20-36	250
BOD (mg/L)	128-204	16-60	12-22	30
TS (mg/L)	950-1480	360-490	250-380	-
TSS (mg/L)	480-1020	40-100	10-90	100
TDS (mg/L)	400-490	280-430	240-290	2100

Cost economics

1. For population of 5000

Total grey water generation per day = 450000 lit
Total grey water generation in 5 day = 2250000 lit
For this total area required = 1500 m^2

Costing

Excavation – Rs. 1,26,215 /-
Lining material – Rs. 3,97,848/-
Interconnecting pipe – Rs. 8,880/-
Intersecting tank – Rs. 62,225/-
Total cost for system **= Rs. 11,28,111/-** (excluding fish, garden net, land and drainage cost)

It concluded 0.5 Rupee per litre is the treatment cost with modified flow stabilization system.

Conti….

2. For population of 10000

Total grey water generation per day = 900000 lit
Total grey water generation in 5 day = 4500000 lit
For this total area required = 3000 m^2

Costing

Excavation – Rs. 2,58,257 /-
Lining material – Rs. 7,00,603/-
Interconnecting pipe – Rs. 8,880/-
Intersecting tank – Rs. 1,00,808/-
Total cost for system **= *Rs. 20,89,062/-*** (excluding fish, garden net, land and drainage cost)

It concluded 0.46 Rupee per litre is the treatment cost with modified flow stabilization system.

Conti....

3. For population of 20000

Total grey water generation per day = 1800000 lit
Total grey water generation in 5 day = 9000000 lit
For this total area required = 6000 m^2

Costing

Excavation – Rs. 5,24,487 /-
Lining material – Rs. 12,74,579/-
Interconnecting pipe – Rs. 8,880/-
Intersecting tank – Rs. 1,72,887/-
Total cost for system **= Rs. 37,88,778/-** (excluding fish, garden net, land and drainage cost)

It concluded that 0.42 Rupee per litre is the treatment cost with modified flow stabilization system.







APSPTN\Bibawewadi Inlet Video.mp4

APSPTN\Bibawewadi outlet video .mp4

- DSC_1083_Marathi Video.MOV

Thanks to Our Inspiration
Late Dr. S. V. Mapuskar
(Padmashree Award Winner - 2017 posthumously)
--- The Man Ahead of Time ---

THINK GLOBALLY ACT LOCALLY….

THINK GLOBALLY, ACT LOCALLY ….
PARTICIPATE INDIVIDUALLY…


Thank you