Department of Science
& Technology
Government of India

EUROPEAN
COMMISSION

International Conference on Innovations in Sustainable Water and Wastewater Treatment Systems (ISWATS)

APRIL 21 - 23, 2016

SOUVENIR

Lead Organizers

NEERI

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Jointly Organized By

India - EU Science & Technology Research Collaboration Projects

NaWaTech SWINGS Saraswati ECO-India

Compact SBR-MBR system at Amanora Park Town-
NaWaTech Project

Intake Well NaWaTech Project

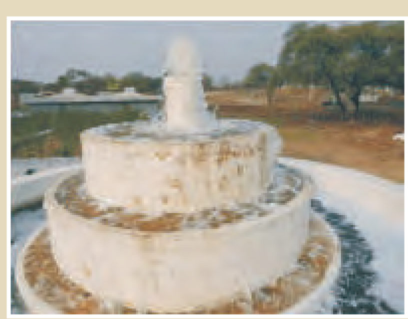
Grey water Recycling system at IIT, Madras
SARASWATI Project

HYSAF Package Plant SARASWATI Project

Vertical Garden at Maharashtra Jeevan Pradhikaran
NaWaTech Project

Planted Gravel Filter at COEP-NaWaTech

UASB-High Rate Algal Pond combination
for black-water treatment
SARASWATI Project



Ordnance Factory Estate
Ambajhari Nagar Nagpur
NaWaTech

NIT Dayanand Park,
Nagpur
NaWaTech Project

∽ PREFACE ∼

The changing perceptions on population dynamics, globalization, land use & land cover, expanding water users base, unwarranted changes in monsoon behaviour and Government policies have been impounding intangible complexity on water use and water security in India. Increasing threats from emerging pollutants coupled with indiscriminate use of water resources have produced comparable complexities even in Europe. It is, in this context, a series of negotiations between India and EU have culminated in the proposal of joint programmes to address most of the challenges being faced by India and EU in water sector.

The India-EU collaborative water projects designed and developed under the aegis of DST from India and the Directorate General(Research and Innovation), European Commission from the EU side have provided ample opportunities to address many critical problems pertaining to water and waste water treatment systems. Under this programme, four major research projects viz., Saraswati, NaWaTech, ECO-India and SWINGS were supported by the EU and the DST while one more on Crops4India has been supported by the DBT and EU. These projects mainly deal with the identification of quality criteria and come up with low energy consumption, minimum maintenance and cost effective treatment technologies. These programmes from inception have the unique advantage of adopting the state of the art technologies, traditional knowledge and practices and involve the stake holders from public and government. Contemporary technologies like River Bank Filtration, Anaerobic Digester, AO, ABR, Sequential Batch Reactor, MBR, SAR, MBBR, HYSAF, UASB, Solar Disinfection, UV, etc. adopted have resulted in implementation of deployable solutions from household to Small and medium communities and Public establishments

The Indian Government and the European Union have felt it apt to disseminate the knowledge and showcase the technologies and deliberate on the lessons learnt and proposed future strategies and prospective areas of collaboration of mutual interest in the field of water resources. The present international conference on Innovations in Sustainable Water and Wastewater Treatment Systems, ISWATS 2016 is an event to realize these goals and also bring in the scientific, government and end user community from both the continents into this fold and form a part of the water management technology and implementation system.

We are highly optimistic that the results obtained in this programme will take the India EU collaboration a long way forward and significantly contribute to the betterment of human life. This small volume contains the basic information on the India-EU projects as well as the experiences of others in this field.

Department of Science and Technology
Directorate General (Research and Innovation)
Government of India
European Commission
Pune, 21.4.2016

प्रो. आशुतोष शर्मा
Prof. Ashutosh Sharma

सचिव
भारत सरकार
विज्ञान और प्रौद्योगिकी मंत्रालय
विज्ञान और प्रौद्योगिकी विभाग
Secretory
Government of India
Ministry of Science and Technology
Department of Science and Technology

19th April, 2016

MESSAGE

I am delighted to note that an International Conference on "*Innovation in Sustonible Water & Wastewater Treatment Systems (ISWATS)"* is being held at Pune during April 21-23. 2016 under the aegis of India-EU framework Science & Technology cooperation. The aims of this conference are to disseminate and showcase the outcomes of the five India-EU research and development projects on wastewater treatment which were supported jointly by Department of Science and Technology (DST), Gol from Indian side and Directorate General Research and Innovation European Commission from EU side.

As all of us aware that, Indian is witnessing the severe water related challenges. This conference would provide an excellent platform to disseminate exchange of knowledge, technologies, tools for implementation and operation of the sustainable water and wastewater treatment systems among academia and public authorities, skilled service provides and SME's enabling research partnerships and creating favorable environments for the application of treatment systems and technologies for sustainable water / wastewater treatment reuse and recycle. The conference will see the participation of eminent experts from R&D and academic institutes, administrations, water supply authorities, government and non-government officials, industries, community representative and students from across the world. The conference will stimulate in-depth discussions on key issues of selection and implementation of water and wastewater systems sustainable water management for smart cities, future water research and innovation needs such as adaptability and reliability of technologies to accelerate national programs in water sectors.

I am fully confident that this conference will reflects the success of the Department of Science and Technology and the European Commission's collaborations and will pave the way for more focused innovations and developments in the field of sustainable water and wastewater treatment systems. I wish the conference resounding success and encourage all the stakeholders to participate in the same.

I sincerely appreciate the efforts of the local organizers NEERI Nagpur and Ecosan Services Foundation, Pune and other partnering institutions for coordinating and shaping the whole program successfully.

I wish ISWATS 2016 a grand success.

(Prof. Ashutosh Sharma)

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International Conferenceon Innovations in Sustainable Water & Wastewater Treatment Systems (ISWATS)

YASHADA, Pune | April 21 -23,2016

Day1|April 21,2016 (Thursday)			
8.00 am – 9.30 am	**Registration**		
9.30 am – 10.30 am	**Inaugural Ceremony** **Introduction to Indo-European Water Technology Programme, Invited Lectures and Keynote Address**		
10.30 am – 11.00 am	*Coffee Break*		
11.00 am – 1.00 pm	**PRESENTATIONS:** NaWaTech Project		
1.00 pm –2.00 pm	*Lunch*		
2.00 pm – 3:30 pm	**SESSION1** Approaches to assess water & wastewater challenges in Indian communities	**SESSION2** Natural and compact technological solutions	**SESSION3** Sustainable in vestment strategies for Water & Wastewater management
3.30 pm – 3.45 pm	*Coffee Break*		
3.45 pm – 5.45 pm	**PRESENTATIONS:** Saraswati Project		
5.45 pm – 7.00 pm	Traveling Time to Reach Amanora Town Park		
7.00 pm – 8.00 pm	**LEADERSHIP CONCLAVE** Panel discussion Session **Theme- Sustainable Water Management for Smart Cities:** Through Innovation – Technology - Smart Financing		
8.00 pm onwards	*Reception Dinner*		

Day 2 | April 22, 2016 (Friday)			
7.30am – 9.00 am	**FIELD VISIT** **(CoEP Hostel Campus, Pune / Indradhnushya Centre, Pune)**		
9.00 am – 11.00 am	**PRESENTATIONS:** SWINGS Project		
11.00 am – 11.15 am	*Coffee Break*		
11.15 am – 1.15 pm	**PRESENTATIONS:** Eco India Project		
1.15 pm– 2.00 pm	*Lunch*		
2.00 pm – 3.15 pm	**PANEL DISCUSSION:** **Key issues of selection and implementation of Water and Wastewater Treatment Systems**		
3.15 pm – 3.30 pm	*Coffee Break*		
3.30 pm – 5.30 pm	**PRESENTATIONS:** Water 4 Crops		
5.30 pm – 7:00 pm	**SESSION 4** Water quality monitoring & treatment	**SESSION 5** Nano-Technological Solutions for wastewater treatment	**SESSION 6** Biological/Microbiological issues in Water & Wastewater treatment
7.15pm – 8.15 pm	*Cultural Programme*		
8.15 pm onwards	*Social Dinner*		

Day 3|April 23, 2016 (Saturday)			
9.30am –11.00am	**FRAME WORKS FOR THE EU-INDIA COOPERATION IN THE WATER AREA**		
11.00am–11.15am	*Coffee Break*		
11.15 am –1. 00am	**PANEL DISCUSSION:** **Future water research and innovation needs: Priorities for joint India -EU action**		
1.00pm – 2:00pm	*Lunch Break*		
2.00pm – 3:30pm	**SESSION 7** Industrial wastewater treatment	**SESSION 8** Integrated urban water management	**SESSION 9** Emerging approaches for water & wastewater management
3.30pm – 4.30 pm	**PANEL DISCUSSION AND CLOSURE** **Theme: Adaptability and replicability of technologies to accelerate the national programs (suchas SBM, Smart cities)**		
4.30pmonwards	*High Tea*		

Natural Water Systems and Treatment Technologies to cope up with water shortages in urban India (NaWaTech)

PROJECT DETAILS

NaWaTech

Natural Water Systems and Treatment Technologies to cope with Water Shortages in urbanised Areas in India

SEVENTH FRAMEWORK PROGRAM

India- European Union cooperation in water technology and management

I. Project Background

Water Supply and Sanitation are the key components to be addressed to improve the quality of life of the people. Providing adequate water supply and sanitation, particularly in urban areas, is a challenging task for governments throughout the world. This task is made even more difficult due to predicted dramatic global changes. Facing population growth and rapid urbanisation, increasing pollution from agriculture and industry, climate change and technical and financial drawbacks of conventional systems, cities of the future will experience difficulties in efficiently managing scarcer and less water.

The WHO-UNICEF Joint Monitoring Report 2010 had estimated that 52% of the urban population in India (almost 160 millions of people) had no or unsafe access to water. Further it was postulated that India would become the most populated country by 2030. In 2011, about 30 % of India's people (almost 300 million) lived in citiesand towns. The supply of adequate water in these ever-growing urban areas, population growth, relocation of human resources from rural to urban areas, limited fresh water sources in urban areas and increase in the per capita water consumption all have posed additional challenges for India.

Figure: Water bodies (streams and lakes) in urban areas receive waste streams, which degrade their aesthetics and quality. (Photo: SERI)

It has been demonstrated that the conventional approach to water management has serious inefficiencies- high quality drinking water for all domestic purposes, large piping systems are difficult to construct and maintain, large quantities of drinking water to transport human excreta, dependency of extensive energy supply for advanced treatment system, production of large quantities of sludge and loss of useful elements with the sludge (e.g. phosphorus). Thus there must be a paradigm shift in our approach if we are to face the water crisis head on:

This integrated approach should include several actions such as:

- Interventions over the entire urban water cycle (considering wastewater and freshwater both as integrated part of water resources in general);
- Optimisation of water use by reusing wastewater and preventing pollution of freshwater sources;
- Prioritisation of small-scale natural and technical systems, which are flexible, cost-effective and require low operation and maintenance.

This need of a future wastewater management to be flexible and robust systems capable of adapting to new, different or changing requirements and capable of coping with uncertainties and highly and widely varying pollution loads, has been the crux of the research activity conducted under the Seventh Framework of India – European Union Science & Technology Cooperation. One such collaborative effort has seen the coming together of 14 different water and sanitation experts (7 each from EU and

India) to form the working consortium of the Natural Water Systems and Treatment Technologies for coping up with water shortages in urban India (NaWaTech) project.

II. NaWaTech Project – Introduction

Natural **Wa**ter Systems and Treatment **Tech**nologies for coping up with water shortages in urban India (**NaWaTech**) is a three-year collaborative project under India-European Union Call for Proposals on Water Technology, Research and Innovation approved by the Department of Science and Technology (DST), Government of India and the European Commission. The purpose of the project is to cope with water shortages in urbanised areas in India in an attempt to demonstrate the effective use of natural water treatment systems by shifting the approach from the conventional end-of-pipe to an integrated water management one.

Natural water systems, such as manmade wetlands and compact technical systems such as SBRs and MBRs have made a great development step in the last years. Moreover, they can absorb highly and widely varying pollution loads; buffer seasonal fluctuations in the availability of water; and they can be integrated into the urban planning as green infrastructures providing additional socio economic benefits such as amenity.

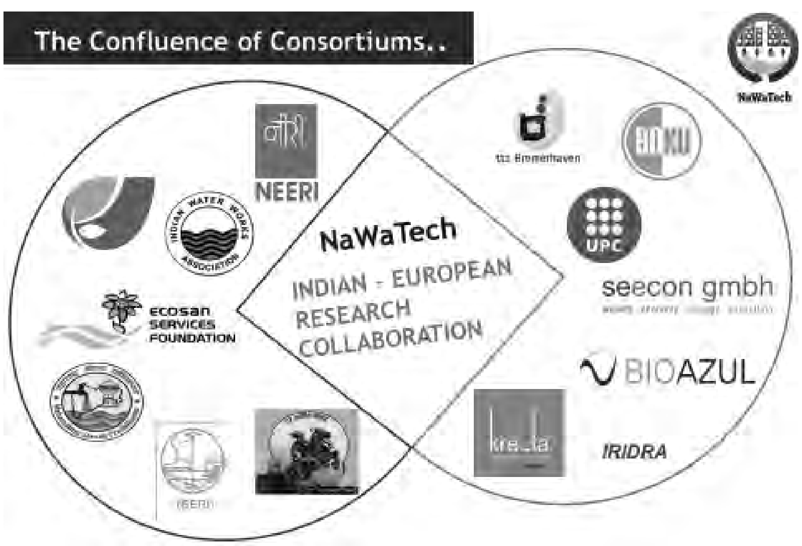


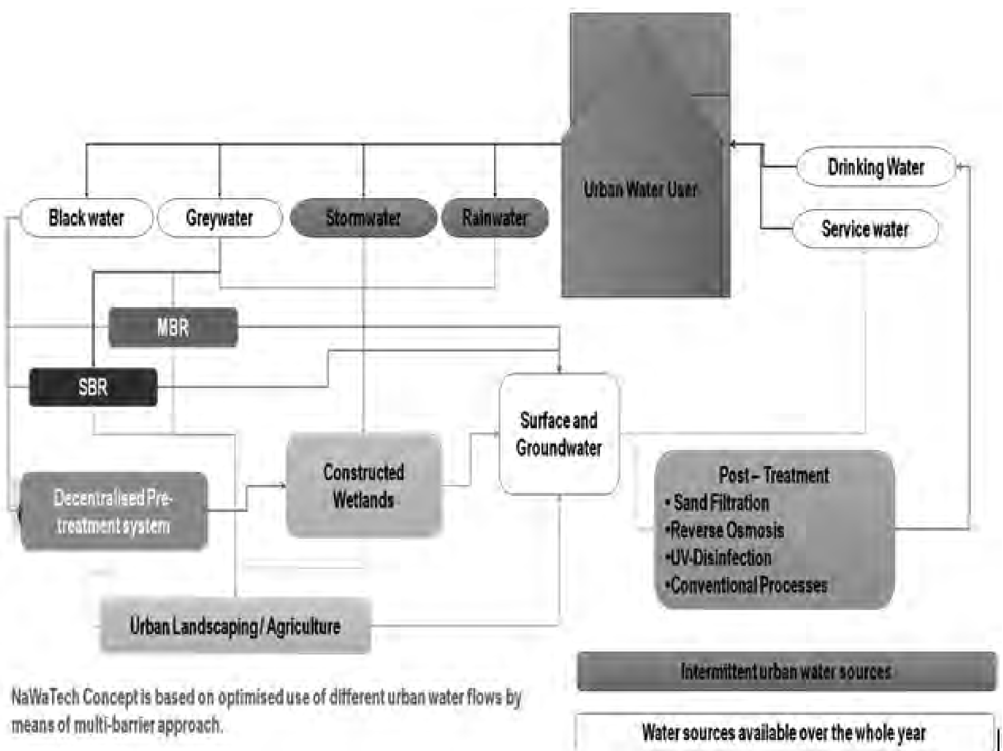
Figure: Indian Consortium: NEERI, ESF, SERI, VEIPL, IWWA, MJP and PMC;

EU Consortium: ttz, seecon, Bioazul, IRIDRA, UPC, BOKU and Kre_Ta

The NaWaTech concept is based on optimised use of surface water supply, rain water, storm water and grey / black water flows by treating each of these flows via a modular natural system taking into account the different nature and degree of pollution of the different water sources. The project has 7 Indian and 7 European consortium partners working jointly to assess and enhance the potential of natural and technical water treatment systems (Engineered Wetlands, SBRs, and MBRs etc.) to suit the local climatic and hydro geological conditions and to optimize use by treating different urban water flows using natural system depending on varying quality of water. The project NaWaTech aims at maximising the exploitation of natural and compact technical systems and processes for the effective management of municipal water resources, of water supply and sanitation services, and of the municipal water cycle as a whole in urbanised areas of India. On the basis of a detailed inventory of natural and technical treatment systems, the European and India consortia have identified several promising axes

III. NaWaTech – Aims and Objectives

The Indian-European Union Cooperation during the development of the NaWaTech system the following problems was planned so as to be overcome high costs, high energy dependency, complicated O&M methods, lack of user acceptance of the reuse of treated high loaded wastewater streams (black water) and high dependency on fresh water supply (from Municipal Corporation). Besides the positive impacts on India, it was postulated to have relevant learnings for EU countries facing increasing global challenges such as urbanization, sub-standard performance of conventional water treatments systems, and in particular climate change, all of which could result in similar



environmental conditions than we know today in urbanized areas of India.

The planned **strategic objectives of NaWaTech divided among 6 work packages** are:

1. **Assessment:** To assess the technical, financial and environmental potential of natural water treatment technologies to cope with water shortages in urbanized areas in India.
2. **Enhancement:** To enhance the natural water treatment systems for the production of recycled water to supplement water sources considering extreme climatic conditions and highly and widely varying pollutions loads (e.g. monsoon floods) and to implement 6 NaWaTech sites for the benefit of 4800 persons equivalent (p.e.) in Maharashtra.

3. **Dissemination and training:** To disseminate, exploit, ensure replication and mainstreaming of NaWaTech activities and output by key stakeholders (e.g. end-users, SMEs and service providers, decision makers). Develop technical guidelines, tools, and manuals for design, implementation, operation and maintenance as well as policy briefs.
4. **SME promotion:** To ensure the interest and potential benefit to SMEs by supporting the development of local market of natural water treatment and reuse technologies, and facilitating the local SMEs by organizing training and capacity building workshops.
5. **Mainstreaming:** To create an enabling institutional environment in order to allow the take-up in practice and mainstreaming of the results (e.g. align NaWaTech initiatives with existing urban water and sanitation plans, strategies and policies).
6. **Reject management strategy:** To ensure proper treatment of the end-product i.e. 'sludge' of the NaWaTech system in a scientific manner, by design and development of an effective sludge / reject management strategy.
7. **EU-India Research Partnership:** To establish long-term cooperation between EU and India in water technologies as part of the Strategic Forum for International Science and Technology Cooperation (SFIC) and establishing bridgeheads among research institutions to ensure the take up of the NaWaTech approach in educational curricula).

IV. Natural Water Technologies Implemented under the project

The natural treatment technologies implemented under NaWaTech projects are as follows:

Constructed Wetlands (Horizontal Flow): The wetlands are implemented using brick masonry with 1.5 mm thick HDPE geomembrane sandwiched between 2 layers of non-woven geotextile for waterproofing. The wetlands are filled with rounded river bed media of different layers and gradations. These wetlands are planted with Typha latifolia and Canna indica with a density of 4 plants/m^2. CWs provide good removal performances for Organic Matter (COD, BOD5), TSS and pathogens in all configurations. HFs are more efficient in denitrification. Plants provide suitable environments for microbiological attachment, aerobic biofilm growth, and transfer of oxygen to the root zone.

Sludge Drying Reed Beds (SDRB): It is divided into 3 sectors, which are hydraulically connected. The beds are filled with rounded river bed media of different layers and gradations and planted with reeds i.e. Typha latifolia. Due to mineralization process of the sludge around the root zone of reeds, the generated amount of sludge is further minimized.

French Reed Bed (FRB): It is divided into 03 hydraulically connected cells. It treats raw wastewater without any pre/preliminary treatment. The beds are filled with rounded river bed media of different layers and gradations and planted with reeds i.e. Typha latifolia.

Up-flow Attached Growth Anaerobic Filter (UAGAF): In up-flow attached growth anaerobic filter a specially designed filter media is used for microbial growth. The biofilm formed over the time on filter media substantially remove the organic matter. Filter media is made of high density poly ethylene (HDPE) material and offers 150 m^2/m^3 specific surface area. The biogas generated in this process is collected in biogas collection system, which is proposed to be utilised as fuel in the nearby canteen.

Short Rotation Plantation (SRP): It is a part of green belt development by using treated wastewater from FRB. Soil and plants in wastewater-irrigated SRPs work as a living wastewater treatment system. Coarse particles are removed by filtration through the soil matrix, which corresponds to the first step in conventional wastewater treatment systems. Soluble organic compounds are mineralized in the soil profile by a microorganism, which corresponds to the second step of conventional treatment. Macro soil habitants like earthworms and other members of macro fauna provide the required oxygen by mixing und aerating the soil. Nitrogen compounds and phosphates, which are usually removed by chemical treatment methods, are directly taken up by the plants. This corresponds to the third step of conventional wastewater treatment. Furthermore metals are removed from the wastewater through adsorption and ion exchange.

Decentralised Treatment System (DTS): DTS is an anaerobic treatment system consisting of Anaerobic Settler (AS), Anaerobic Baffle Reactor (ABR) and Anaerobic Up Flow Filter (AF). AS allows physical separation of the solids. ABR and AF consists of multiple chambers in which the wastewater passes through the activated sludge blanket. High density poly ethylene material with a high specific area is used as filter material in AF. The filter media provides a substrate to the microorganism to attach and there by provides efficient clarification of wastewater. There is reduction in the organic matter (BOD, COD) of the wastewater. Two such systems of capacities of 40 m^3 per day (for black water) and 100 m^3 per day (for sewage) have been installed at College of Engineering Pune.

Constructed Wetlands (Vertical flow): The constructed wetlands are constructed in brick masonry. A HDPE liner along with geotextile is provided so as to make the wetland waterproof. The drainage layer is at the bottom and consists of rounded aggregates (40 mm). It is topped with coarse gravels

(12 mm) followed by sand and again a layer of coarse gravels. Phragmites, Cyprus and Canna Indica are planted in the top layer. The wastewater is fed from the top of the bed and the treated water is collected from the bottom. Vertical flow constructed wetlands provide good removal performances for organic matter (COD, BOD5), TSS and pathogens. Plants provide suitable environments for microbiological attachment, aerobic biofilm growth, and transfer of oxygen to the root zone. One constructed wetland of capacity 40 m^3 per day (for grey water) and three of capacity 34 m^3 per day (for sewage) have been implemented at College of Engineering Pune.

Eco Filtration Bank (EBF): In EBF the wastewater passes through biologically activated soil (Organotreat™) filtration medium supported by sand and gravel for attached growth of bacteria. It is combination of bioremediation and phytoremediation technique. The biodegradable organic matter is consumed by bacteria present in specialized layer of Organotreat™. Then the green plant in the system absorbs the mineralized products of organic matter. EBF is implemented in the Indradhanushya (Environment and citizenship centre of Pune Municipal Corporation) to treat the wastewater flowing in Ambil stream.

Vertical gardens (VG): VG consists of cascade arrangements of small pots containing light expanded clay aggregates (LECA) and soil. Flowering plants planted in these pots and grey water from the pantries and wash basins in the Maharashtra Jeevan Pradhikaran office building is fed to this system from top. The feeding system is controlled using an electronic valve based on feeding time. The water passes from pot and drips into the lower pot couple of times before going out of the system. VG give good aesthetic appearance and provide sufficient treatment to the less concentrated grey water.

V. Project sites under NaWaTech

Presented below are the details of the project sites in Pune and we foresee that the research activities within the scope of the project at these sites will substantially help in improving the technology and will enhance the knowledge base of the practitioners seeking to incorporate such themes in their business lines (for more information please visit www.nawatech.net&facebook page of NaWaTech-Community Of Practice):

Site 1: College of Engineering Pune, Hostel Campus

Head	Details
Site location	COEP Hostel, Pune
Details of Treatment System Implemented	Decentralized treatment system coupling gravity based anaerobic system and aerobic system in the form of a vertical flow constructed wetland Total volume: 180 m^3/day - Intended for reuse in gardening and flushing
Date of commissioning of the site	September 2015

Sample Site Results (March 2016)

Sr. No.	Parameter	Unit	Anaerobic Treatment Systemfor Black Water (40 m^3/day) – primary treatment only		Vertical Flow Wetland for Grey Water (40 m^3/day)		Anaerobic + Constructed Wetland for Sewage (100 m^3/day)	
			Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
1.	pH	-	6.61	6.75	6.44	7.31	6.61	7.71
2.	Electric Conductivity	Umhos/cm	642	828	294	471	609	824
3.	Biological Oxygen Demand (BOD_3) at 27^{0}C	mg/l	247.5	69	48	6.15	168	8.4
4.	Chemical Oxygen Demand (COD)	mg/l	617.32	166.98	111.32	21	419.98	28
5.	Total Suspended Solids (TSS)	mg/l	186	59.6	56	12	220	14
6.	Dissolved Oxygen (DO)	Mg/l	0	0	3.44	6.41	1.43	5.26
7.	Sulphates as SO_4	mg/l	1.59	1.19	4.76	20.21	3.7	12.15
8.	Ammonia as NH_3	mg/l	55.94	41.66	53.56	< 0.12	149.38	6.82
9.	Phosphates as PO_4	mg/l	23.55	22.23	2.97	< 0.6	22.95	1.21
10.	Nitrates as NO_3	mg/l	7.78	4.79	2.39	38.91	14.37	31.01
11.	Total Kjeldahl Nitrogen (as N)	mg/l	65.59	56.99	46.3	2.08	134.75	6.08
12.	Total Oil & Grease	mg/l	46.4	8	8.4	< 5	21.6	< 5
13.	Total Dissolved Solids	mg/l	432	538	172	276	356	516
14.	Coliform MPN	/100 ml	> 1600	> 1600	> 1600	920	> 1600	> 1600
15.	E. coli	CFU/100 ml	>1600	>1600	>1600	400	>1600	500

Site photos

Figure: DTS at COEP college

Figure: Planted Gravel Filter at COEP

Site 2: Amanora Park Town

Head	Details
Site location	Sewage Treatment Plant, Amanora Park Town
Details of Treatment System Implemented	Aerobic Biological Treatment with compact Sequential Batch Reactor (SBR) & Membrane Bioreactor (MBR) technologies. Total volume: 40 m^3/day - Intended for reuse in gardening and flushing
Date of commissioning of the site	July 2014

Sample Site Results (May 2015)

Sr. No.	Parameter	Unit	Inlet	Outlet (MBR)	Outlet (SBR)
1.	pH	-	7.12	7.48	7.39
3.	Biological Oxygen Demand (BOD_3) at 27^{0}C	mg/l	148.90	10.80	20.90
4.	Chemical Oxygen Demand (COD)	mg/l	368.30	43.20	32.60
5.	Total Suspended Solids (TSS)	mg/l	156.00	28.00	38.00
6.	Sulphates as SO_4	mg/l	14.60	4.60	12.30
7.	Phosphates as PO_4	mg/l	2.55	0.28	0.60
8.	Nitrates as NO_3	mg/l	1.25	0.58	1.80
9.	Ammonia as NH_3	mg/l	18.20	0.80	5.60
10.	Total Kjeldahl Nitrogen as N	mg/l	26.10	2.20	4.10
12.	Dissolved Oxygen	mg/l	0.00	3.90	3.00
13.	Coliform MPN	/100 ml	>1600	27	

Site photos
 *Figure: Compact SBR-MBR system at Amanora Park Town*

Site 3: Maharashtra Jeevan Pradhikaran

Head	Details
Site location	Maharashtra Jeevan Pradhikaran Office
Details of Treatment System Implemented	Demonstration unit comprising of 2 wall-mounted vertical garden units holding different plants. Research whether grey water from office spaces can be treated effectively by such systems Capacity: 250 - 300 litres / day Total area 2 m^2; Intended for reuse in gardening
Date of commissioning of the site	September 2014

Sample Site Results (August 2015)

Sr. No.	Parameter	Unit	Inlet	Outlet
1.	Biological Oxygen Demand (BOD5) at 270C	mg/l	13.90	2.50
2.	Chemical Oxygen Demand (COD)	mg/l	32.90	6.60
3.	Total Suspended Solids (TSS)	mg/l	46.00	22.00
4.	Phosphates as PO4	mg/l	0.18	0.11
5.	Ammonia as NH3	mg/l	3.95	1.40
6.	Total Kjeldahl Nitrogen as N	mg/l	5.00	3.25
7.	E. Coli	mg/l	14.00	11.00
8.	Coliform MPN	/100 ml	33	27

Site photos

Figure: Vertical garden at MJP

Site 4: Indradhanushya Training Centre

Head	Details
Site location	Indradhanushya (Citizen Environment Cell, PMC), Near Mhatre Bridge
Details of Treatment System Implemented	Eco Filtration Bank. This system is being implemented by Shrishti Eco-Research Institute (SERI), also a NaWaTech Partner. The idea is to treat water from nearby Ambil Odha and use the water for gardening. Capacity: 50 m^3 per day
Date of commissioning of the site	April 2016

Site photos

Figure: Ecofiltration Bank Unit at Indradhanushya Training Centre (left) and Intake well (right)

Site 5: Ordnance Factory Estate, Ambajhari Nagar Nagpur

Head	Details
Site location	Ordnance Factory Ambajhari Estate, Nagpur
Details of Treatment System Implemented	A full scale Techno- economical Sewage treatment plant of Capacity 100 m^3/day has been implemented by CSIR – NEERI, Nagpur. The wastewater generated by staff colony is treated and reused for maintaining parks, orchids and sports complexes. Sludge drying reed beds manage sludge generated through primary clarifier. Also, a pilot scale French Reed Beds is implemented which treats raw wastewater without any pretreatment. The treated water of FRB is utilised for green belt development through Short Rotation Plantation (SRP).
Date of commissioning of the site	January 2016

Site Results (March 2016)

Parameter	Unit	Inlet	Final Treated Effluent
pH	-	7.5	6.8-7.0
TSS	mg/L	118	5-10
COD	mg/L	220	10
BOD	mg/L	150	5
TKN	mg/L	28	1
Phosphate	mg/L	3.3	<0.5

Site photos

Figure: Ordnance Factory Ambajhari Site in Nagpur

Site 6: NIT Dayanand Park, Nagpur

Head	Details
Site location	Jaripatka, Nagpur
Details of Treatment System Implemented	Different configurations of Horizontal and vertical flow constructed wetlands of total capacity 100 m^3/day are being implemented by CSIR –NEERI Nagpur. The treated wastewater will be used in sprinkling of the park. The park is spread over an area of 7 acres and daily 1500 – 2000 people give visit the area. During summer, water level in the surrounding open well goes down hence raw sewage was used. With implementation of natural sewage treatment system, lot of fresh water resources would be saved and aesthetics and public health would also be ensured.

Site photos

Figure: NIT Garden Dayanand Park Site, Jaripatka in Nagpur

VI. Significant Achievements

- The project includes 6 implementation sites (pilot + full scale) and each is endowed with different technical innovations:
  - MBR & SBR for treatment + toilet flushing and garden irrigation as re-use at Amanora
  - Vertical Garden for grey water treatment at MJP: First time in India and novel approach worldwide
  - Vertical flow constructed wetlands at COEP
  - Eco-filtration bank at Indradhanushya Center
  - First line with anaerobic treatment + subsurface horizontal flow constructed wetland, + pilot line with French wetland + short rotation plantation. (first time in India) at Ordnance Factory (OJAF)
  - Combination of horizontal flow + vertical flow subsurface constructed wetland, integrated in the landscape at Dayanand Park

- Number of Beneficiaries:
  - COEP: 1500 p.e (100m^3/day wastewater + 40m3/day grey water).
  - OFAJ: 1000 p.e; 100m^3/day
  - Amanora Park Town: 205 p.e; 30 m^3/day
  - Dayanand Park: 1000 p.e; 100m^3/day
  - Indadhanushya Center (Rainbow museum): 250 p.e.
  - MJP Vertical Gardens – 125 – 250 l/day

- Peer-reviewed publications:
  - Publications (3 articles in Journals, 5 conference proceedings) + 1 special edition of the Sustainable Sanitation Practice journal on NaWaTech including 14 papers.
  - 2 extra papers have been submitted to journals and are waiting for acceptance.
  - Further the consortium has prepared Compendium of natural water systems and treatment technologies to cope with water shortages in urbanized areas in India (NaWaTech Compendium) which could be beneficial to all research partners, researchers, SMEs and other interested stakeholders.

- Workshops and other dissemination activities:
  - Three specialised international workshops
  - Two SME training programmes.

- NaWaTech final conference/ ISWATS conference conducting
- 9 oral presentations at conferences and workshops (5 EU, 4 India)
- 2 recommendation papers
- Publication of NaWaTech Case studies in the SUSANA platform.
- Publication of NaWaTech video.

- The project has strengthened EU-India cooperation and knowledge exchange by the MSc-PhD Student twining program:
  - Indian Students with thesis based on the project: 6 MSc + 2 PhD
  - No. of weeks spent in EU by the Indian Students: 24 (MSc) + 40 (PhD)
  - European Students with thesis based on the project 8 MSc, 2 PhD
  - No. of weeks spent in India by the European Students 88 (MSc) + 4 (PhD)
  - No. of EU postdocs whose research was based on NaWaTech: 1 Post-doc

- The project addressed environmental and health safety during constructional and operational phase.
- In order to involve community with the project an initiative has been taken for the formation of Community of Practice (CoP).
- The project has made integration with Cewas South Asia for SME breeding and Entrepreneurship promotion.

1.0 BACKGROUND

Saraswati is a research project jointly funded by the European Commission (FP7) and the Government of India, Department for Science and Technology, under the joint program "EU-India cooperation in water technology: research and innovation".There are nine project partners from EU side and six from Indian side (Table 1).

Untreated domestic and municipal wastewater is a major source of water and environmental pollution. India still suffers from a low level of adequate wastewater treatment and hence from drastic levels of related pollution. Untreated wastewater has e.g. been identified as the main source of pollution of the river Ganga. The situation is not much better for other rivers such as e.g. the river Yamuna. At the same time, water pollution reduces the available unpolluted freshwater resources and therefore causes increased costs for safe water supply. Treatment of wastewater thereby not only avoids pollution but also provides a valuable additional source for water supply. Treated wastewater can e.g. be used for agricultural irrigation or for non potable purposes such as toilet flushing.

Table 1. Saraswati Project Partners

BOKU	UniversitaetfuerBodenkultur Wien, Austria
brgm	Bureau de RecherchesGéologiques et Minières, France
centa	Centro de lasNuevasTecnologias del Agua, Spain
ceit	Centro de Estudios e InvestigacionesTécnicas, Spain
University of Exeter	University of Exeter , UK
emds	ZentrumfürUmweltmanagement und Entscheidungstheorie, Austria
A3i	A3i SARL , France
simbiente	Simbiente – Engenharia e GestãoAmbiental LDA, Portugal
HYDROK Water Engineering Solutions	Hydrok UK Ltd., UK
भारतीय प्रौद्योगिकी संस्थान रूड़की Indian Institute of Technology Roorkee	Coordinator: Indian Institute of Technology, Roorkee
Indian Institute of Technology Kharagpur	Indian Institute of Technology, Kharagpur
भारतीय प्रौद्योगिकी संस्थान मद्रास Indian Institute of Technology Madras	Indian Institute of Technology, Madras
TISS	Tata Institute of Social Sciences), Mumbai
NITIE National Institute of Industrial Engineering	National Institute for Industrial Engineering, Mumbai
MSE Madras School of Economics	Madras School of Economics, Chennai

2.0 OBJECTIVES

SARASWATI has three main objectives:

1. In view of the lack of actual performance data on technical-environmental as well as socio-economic situation of in particular smaller scale decentralized wastewater treatment plants, Sarawasti firstly aims at conducting an integrated evaluation of already existing decentralised wastewater treatment and reuse technologies across India.
2. Second, selected proven European technologies for wastewater treatment and reuse will be piloted in India and their potential for application in the Indian context assessed.
3. Third, based on the results of the previous two objectives recommendations for replication and up-scaling of suitable wastewater treatment and reuse technologies will be elaborated

3.0 METHODOLOGY

The evaluation of all technologies for wastewater treatment and reuse will be based on two conceptual pillars: technology and socio-economy. The technological dimension includes aspects related to the physical functioning and performance of the technology, such as its treatment capacity, environmental impact or technical robustness. Health issues are also most relevant for reuse systems. Therefore, hygienic along with health assessment will be included in the technical perspective. The socio-economic dimension covers all aspects related to the use of the technology, such as user acceptance, affordability and institutional arrangements as well as governance which are crucial for achieving sustainable solutions.

4.0 EXPECTED RESULTS

The project will develop recommendations and guidelines for replication and up-scaling of suitable wastewater treatment and reuse technologies for the Indian context, encompassing all aspects related to the two conceptual pillars of SARASWATI. Further, the piloting of the proven European technologies will show the potential of these technologies for India and allow the involved SMEs to explore a new potential market for their technologies. In turn, SARASWATI will help Indian policy makers to solve pressing water problems and above all, foster Europe-India cooperation in jointly tackling the major water problems India is facing.

5.0 DOCUMENTATION

During the first phase of the project Saraswati all existing wastewater treatment plants across India will be documented. The documentation will build up on secondary sources such as governmental reports. So far almost 1.500 wastewater treatment plants across India could be documented.

6.0 EVALUATION

After the documentation has been completed, technologies and case studies will be selected for evaluation. The evaluation will encompass a technical-environmental as well as socio-economic aspects.

The technical-environmental evaluation will verify the technical functioning of the wastewater treatment plants and conduct an environmental systems analysis. The socio-economic evaluation will document the costs of the WWTPs as well as study social and institutional aspects.

7.0 SUSTAINABILTY ASSESSMENT

The sustainability assessment aims at providing an integrated assessment for all evaluated wastewater treatment technologies. It has been noted that little evaluation results are available and often only a few aspects have been evaluated. So far almost no truly integrated sustainability assessment has been carried out for decentralized wastewater treatment plants in India. Advanced assessment methods adapted to the Indian context will be applied.

The final and overall goal of Saraswati is to support consolidation, replication and up-scaling of decentralized wastewater treatment plants across India. Therefore, tools for replication will be an important outcome of the project. These will encompass guidelines for technology selection and application, guidelines for sustainable management of these technologies as well as decision support tools.

8.0 PILOTING WASTEWATER TREATMENT SYSTEMS

A key aspect of SARASWATI is to pilot proven European technologies for wastewater treatment and reuse in an Indian context. In different case studies across India the following technologies will be piloted:

- Natural wastewater treatment technologies and combinations
- Package treatment plants
- Ballasted Flocculation system for stormwater treatment
- Mobile application for anaerobic digestion
- Closed vessel composting for sludge treatment

About 7 pilots were implemented all over India. The detail of each is provided below:

8.1 Pilot study 1: Natural wastewater treatment plant system, Raisen Madhya Pradesh. (Pilot Hardware and Infra Funded by EU & O&M by DST)- BOKU, Vienna and IITR

Site	Raisen, Madhya Pradesh
Technology	Imhoff Tank + trickling Filter
Type of Wastewater	Combined
Flow Rate	1926.2m^3/day
Effluent Quality	BOD < 30 mg/L, TSS < 50 mg/L,
Intended Reuse	Agriculture
No. of Beneficiaries	17353

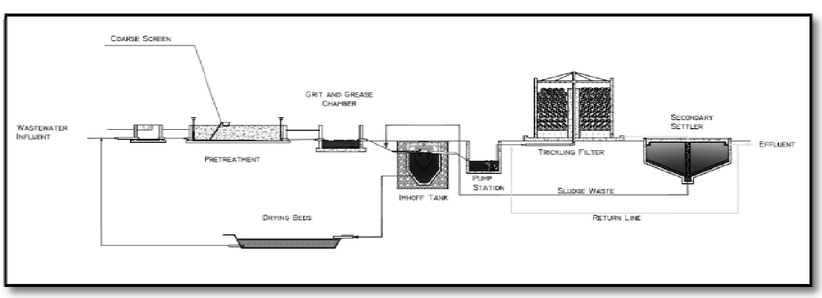


Figure 1.Natural wastewater treatment plant system

8.2 Pilot study 2: UASB-Pond combination for black-water treatment, West Bengal (Design by EU, Pilot Infra and O&M by DST)- IIT Kgp& CENTA, Spain

Site	Kharagpur, West Bengal
Type of Technology	Anaerobic and natural treatment plant for black-water Treatment
Type of Wastewater	Blackwater
Flow Rate	50-100 m^3/day
Effluent Quality	BOD < 30 mg/L, TSS < 50 mg/L,
Intended Reuse	Agriculture
No. of Beneficiaries	500-600 persons

Figure 2.UASB-High Rate Algal Pond combination for black-water treatment

Table 2. Influent and effluent characteristics treated using UASB

Month	COD inlet (mg/L)	COD outlet (mg/L)	% removal	Soluble COD inlet (mg/L)	Soluble COD outlet (mg/L)	% removal	Remarks
November	167	123	27	110	77	30	Reactorgetting commissioned
December	162	79	49	94	35	63	Performance improved
January	193	98	49	93	38	59	Sludge washout
February	265	79	56	78	33	57	Performance getting stabilized
March	250	100	58	101	35	63	Improving Performance

8.3 Pilot study 3: HY-SAF package WWTP, Rishikesh (Uttarakhand) (Pilot Hardware Funded by EU & Infra and O&M by DST)- IIT R and HYDROK-UK

Site	Rishikesh
Type of Technology	HY-SAF Package STP
Type of Wastewater	Combined
Flow Rate	30-100 m3/day
Effluent Quality	BOD < 10 mg/L, TSS < 10 mg/L,
Intended Reuse	Non-Potable urban Resue
No. of Beneficiaries	300-1000

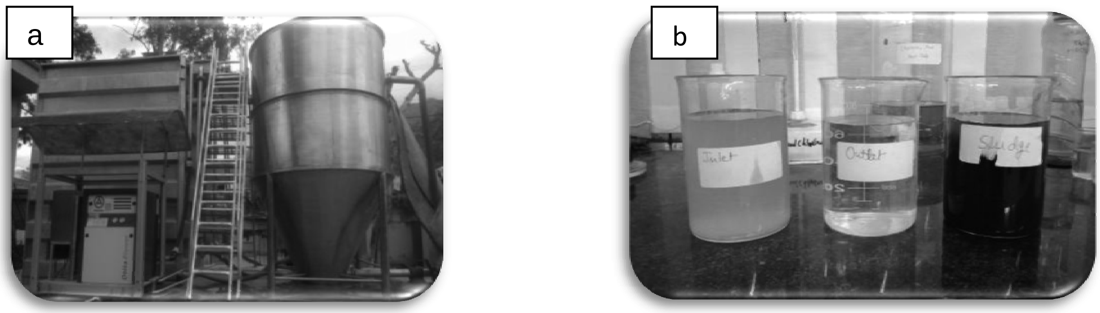


Figure 3. a) HYSAF Package Plant; b) Inlet, Effluent and sludge of HYSAF

Table 3. Characteristics of Influent and Effluent treated using HYSAF

Parameter	Start up – I*	Steady state (DO ~ 2.5 - 3)	Start up – II*	Intermittent aeration –I @ 3 DO	Intermittent aeration –II @ 4.5 DO	Variable DO	Intermittent feeding (6 h on/off)
pH	7.25	7.38	7.30	7.1-7.5	7.2-7.6	6.9-7.5	7.15-7.45
COD (mg/L)	49	38	58	33[a] 29[b] 42[c]	28[a] 42[b] 54[c]	80[d] 62[e] 25[f]	34[m] 40[e]
BOD (mg/L)	23	22	26	17[a] 13[b] 18[c]	13[a] 23[b] 26[c]	45[d] 30[e] 8[f]	17[m] 19[e]
TSS (mg/L)	35	27	38	17[a] 13[b] 15[c]	15[a] 20[b] 33[c]	55[d] 38[e] 15[f]	18[m] 22[e]
Fecal coliforms (MPN/100 ml)	300	318	415	430[a] 13[b] 11[c]	45-318	247-413	512-674

8.4 Pilot study 4: GROW grey-water recycling system, Chennai (Tamil Nadu) (Pilot Hardware Funded by EU & Infra and O&M by DST)- IIT M and HYDROK-UK

Site	Chennai, Tamil Nadu
Type of Technology	GROW grey-water treatment plant
Type of Wastewater	Greywater
Flow	30-50 m^3/day
Effluent Quality	BOD < 10 mg/L, TSS < 10 mg/L
Intended Reuse	Non-Potable urban Reuse
No. of Beneficiaries	50

Figure 4. Grey water Recycling system (GROW) at IIT Madras

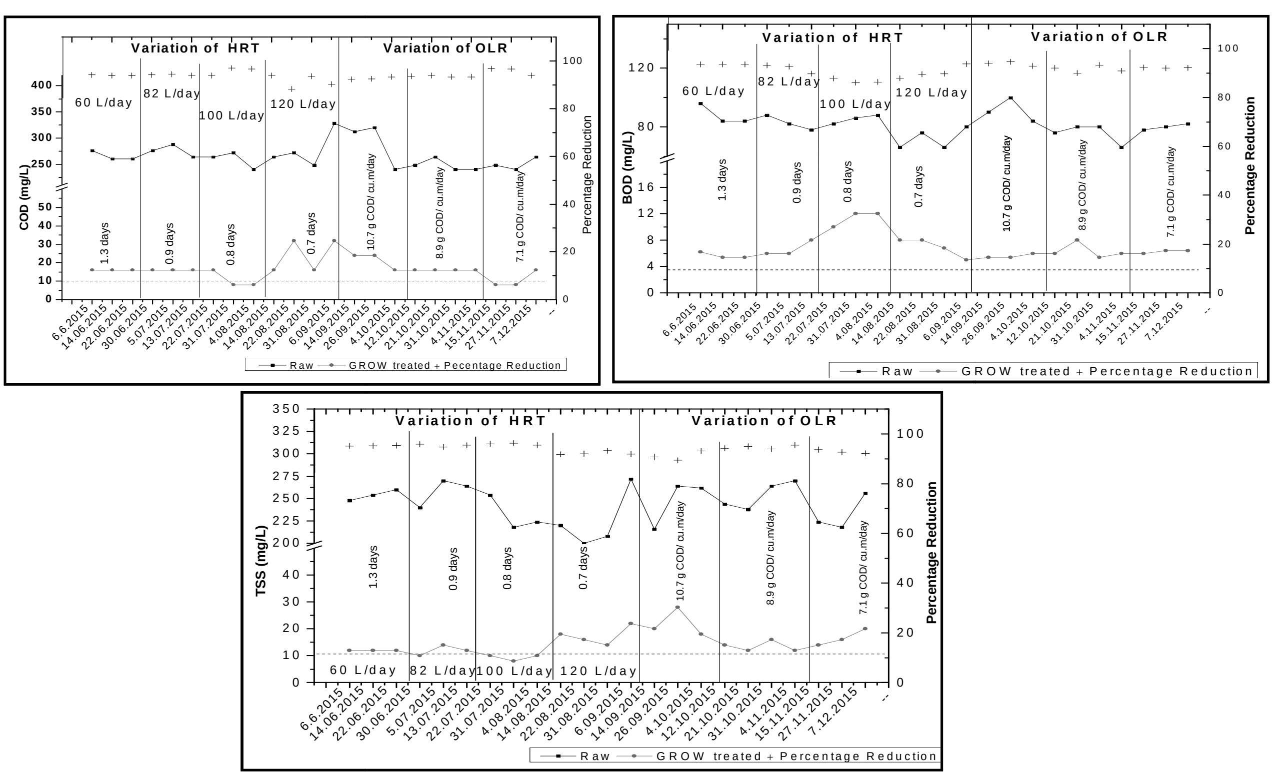


Figure 5. Changes in COD, BOD and TSS values against variation of HRT and OLR

8.5 Pilot study 5: Ballasted Flocculation Process (An EU Technology) Storm-water treatment system, Nainital (Uttarakhand) (Pilot Hardware, Infra and O&M by DST)- IIT R.

Site	Nainital, Uttarakhand
Type of Technology	Ballasted Flocculation
Type of Wastewater	Storwater, CSO, Dry weather flow
Flow Rate	1000 m^3/day
Effluent Quality	BOD < 30 mg/L, TSS < 20 mg/L
Intended Reuse	Direct Discharge to Lake
Beneficiaries	Lake Pollution Control

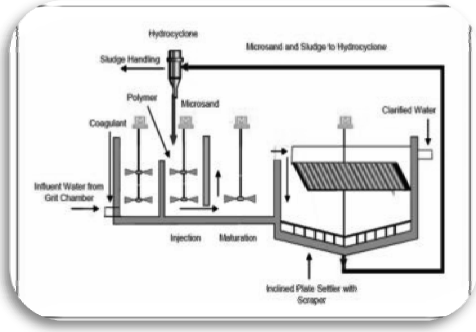


Figure 6. Ballasted Flocculation Process

8.6 Pilot study 6: Mobile anaerobic sludge digester, West Bengal. (Pilot Hardware Funded by EU & Infra and O&M by DST)- IIT Kgp&Simbiente, Portugal

Site	Kharagpur
Type of Technology	Mobile anaerobic sludge digester
Type of Waste	Septage
Volume	2 m^3
Effluent Quality	Digested Sludge
Intended Reuse	Biogas: Cook Stove, Sludge as manure
Beneficiaries	2-4 Household

Figure 7. Mobile anaerobic sludge digester

Table 4. Performance Analysis of Mobile sludge digester

HRT (days)	Biogas (L/kgVS destroyed)	Methane (L/kgVS destroyed)	TCOD rem %	SCOD rem %	TS rem %	VS rem (%)	Protein rem %	Outlet VFA	Outlet Alkalinity
15	213	138	81.52	81.31	80	58.3	38.1	236	583
20	268	179	83.88	81.52	85	61.3	63.1	233	584
25	303	216	87.94	70.82	90	62.8	62.7	221	596
30	329	240	81.7	84.25	92	68.2	68.8	216	603
35	334	262	88.58	71.86	94	69.9	71.54	210	635
40	345	276	88.55	70.79	95	69.9	73.91	190	672
45	355	280	89.2	69.78	95	70.2	72.03	181	673

8.7 Pilot study 7: Closed vessel composting system (Design by EU, Pilot Infra and O&M by DST)- NITIE & CEIT , Spain.

Site	**Mumbai, Maharashtra**
Technology	Closed vessel composting of sludge
Type of Waste	Sludge