Supporting consolidation, replication and up-scaling of sustainable wastewater treatment and reuse technologies for India
Project funded by EC FP7 and DST-GOI

Pune 21 April 2016

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Overview Saraswati “Session”

15:45 – 16:15 Overview project Saraswati (BOKU/IITR)

16:15 – 16:25: Techno-economic assessment of small scale wastewater treatment systems (IITR)

16:25 – 16:35 TRICKLING- FILTER- BASED SOLUTIONS FOR urban WASTEWATER TREATMENT AND REUSE IN INDIA (CENTA)

16:35 – 16:45 Does design of a wastewater treatment plant matter for its acceptance? Results from a study in Raisen, Madha Pradesh (BOKU)

16:45 – 16:55 Results from the three year EU/ India SARASWATI joint research project on GROW and GROW Hybrid successfully turning ‘grey’ wastewater into reusable ‘green’ water at IIT-M (Chennai). (HYDROK)

16:55 – 17:05 Pilot UASB-high rate algal pond combination for blackwater treatment and mobile anaerobic digester for digestion of septage (IIT KGP)

17:05 – 17:15 Result HYSAF Pilot (IITR)

17:15 – 17:25 Community Participation in Wastewater Treatment and Reuse (TISS)

17:25 -17:45 Q&A

Overview Project Saraswati:

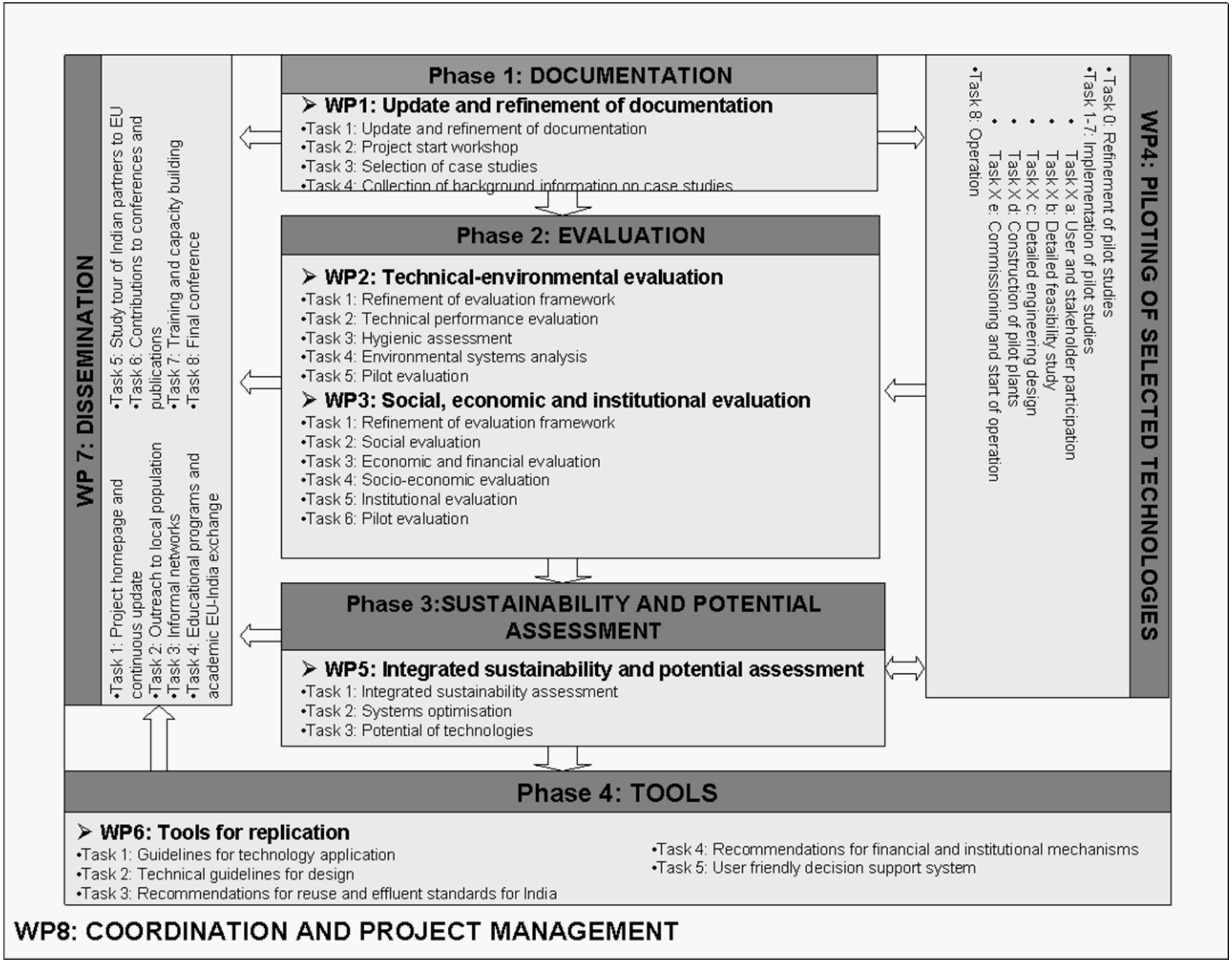
(preliminary) results and achievements

Following slides present all parts of project Saraswati in an overview fashion – more detailed information provided for selected parts in the following paper presentations.

Overview project consortium

Participant no.	EU Participant organisation name	Country
1	Coordinator: University of Natural Resources and Life Sciences, Vienna (BOKU)	Austria
2	Bureau de Recherches Géologiques et Minières (BRGM),	France
3	Fundacion Centro de las Nuevas Tecnologias del Agua (CENTA), Sevilla	Spain
4	Centro de Estudios e Investigaciones Técnicas de Gipuzkoa (CEIT)	Spain
5	University of Exeter (UNEXE)	UK
6	Centre for Environmental Management and Decision Support (CEMDS), Vienna (Austria)	Austria
7	A3i	France
8	Simbiente - Engenharia e Gestão Ambiental	Portugal
9	Hydrok UK Ltd.	UK
	India Participant organisation name	
1	Coordinator: Indian Institute of Technology, Roorkee (IIT-R), Uttarakhand	India
2	Indian Institute of Technology, Kharagpur (IIT-Kgp), West Bengal	India
3	Indian Institute of Technology, Madras (IIT-M), Tamil Nadu	India
4	Tata Institute of Social Sciences (TISS), Mumbai, Maharasthra	India
5	National Institute for Industrial Engineering (NITIE), Mumbai, Maharasthra	India
6	Doshion Veolia Water Solutions (DVWS), Ahmedabad, Gujarat	India
7	Madras School of Economics (MSE), Chennai, Tamil Nadu	India

Overview work packages



GANTT Chart

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Q16
SARASWATI
WP 1: Update and refinement of documentation
Task 1: Update and refinement of documentation
Task 2: Project start workshop
Task 3: Selection of case studies
WP 2: Technical-environmental evaluation
Task 1: Refinement of evaluation framework
Task 2: Technical performance evaluation
Task 3: Hygienic assessment
Task 4: Environmental systems analysis
Task 5: Pilot evaluation (for pilots in WP4)
WP 3: Social, Economic& institutional evaluation
Task 1: Refinement of evaluation framework
Task 2: Social evaluation
Task 3: Economic and financial evaluation
Task 4: Socio-economic evaluation
Task 5: Institutional evaluation
Task 6: Pilot evaluation (for pilots in WP4)
WP 4: Piloting of selected EU technologies
Task 0: Refinement of case study sites and progress reports (D4.1, D4.2)
Task 1-7: Implementation of pilot studies**
Task 1-7 a: User and stakeholder participation
Task 1-7 b: Detailed feasibility study
Task 1-7 c: Detailed engineering design
Go / No Go pilot studies
Task 1-7 d: Construction of pilot plants
Task 1-7 e: Commissioning and start of operation
Task 8: Operation of all pilot systems
WP 5: Integrated sustainability and potential assessment
Task 1: Integrated sustainability assessment
Task 2: Systems optimisation
Task 3: Potential of technologies
WP 6: Tools for replication
Task 1: Guidelines for technology application
Task 2: Technical guidelines for design
task 3: Recommendations for reuse and effluent standards for India
task 4: Recommendations for financial and institutional mechnisms
Task 5: User friendly decision support system
WP 7: Dissemination
Task 1: Project homepage and continous update
Task 2: Outreach to local population
Task 3: Informal networks
Task 4: Educational programs and academic EU-India exchange
Task 5: Contributions to conferences and publications

Overview project objectives

		Status
1	To provide a comprehensive documentation of existing wastewater treatment, reclamation and reuse technologies in India	Completed
2	To conduct an integrated assessment of existing and piloted technologies in India	Largely completed
3	To pilot proven EU technologies that have a potential to solve real life water challenges in India	Largely completed
4	To suggest strategies for measures to improve further the sustainability of both EU and non-EU technologies for solving water challenges in India and to assess the overall potential of all technologies	Ongoing
5	To provide tools to facilitate large scale deployment of the technologies with the best potential to cope with the targeted real life water problems in India	Ongoing
6	To synthesize the research results and to achieve an effective dissemination, exploitation and take-up in practice and mainstreaming of results	Ongoing

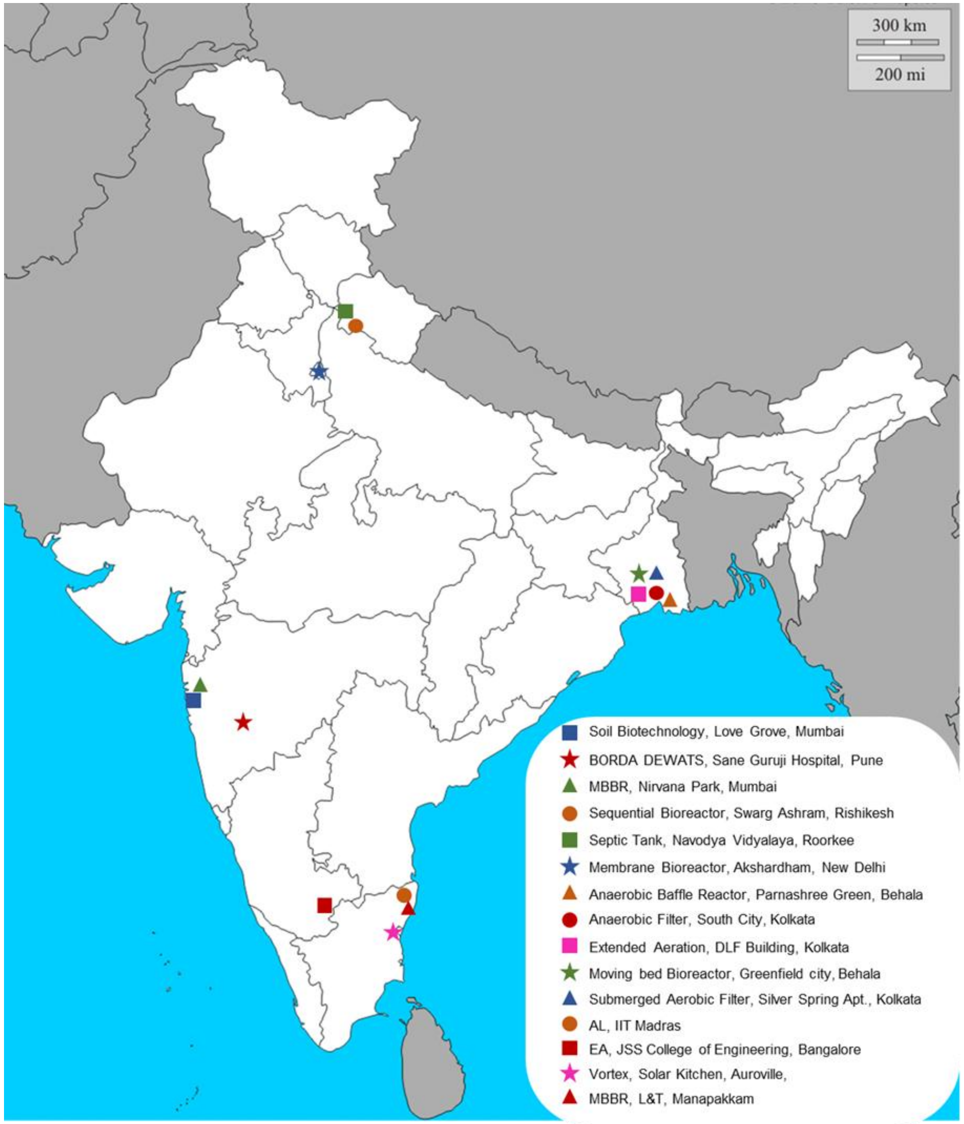
WP 1: Documentation

Summary of Results

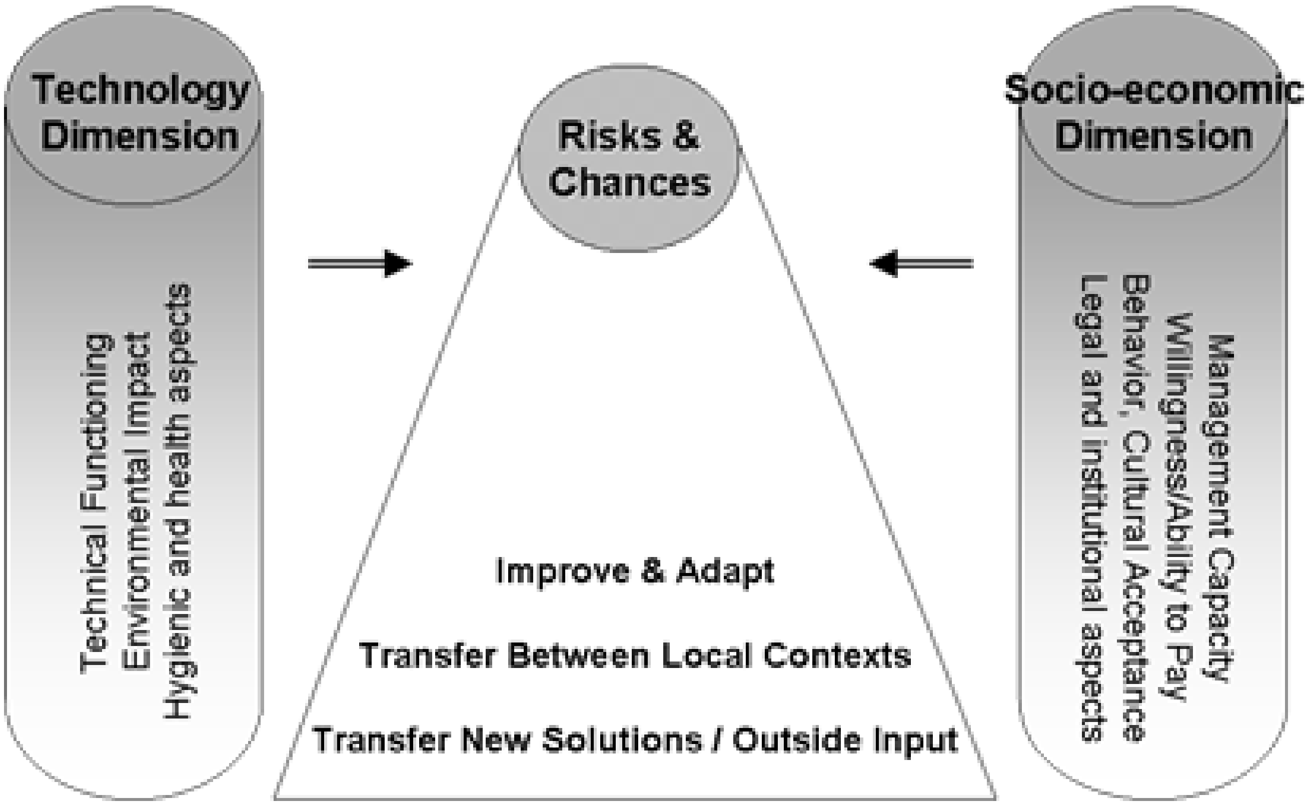
	Type of Technology	Short name	Number of plants in India	%
	Rural Areas with cheaper land availability and on-site package septic systems for all areas			
1	Waste stabilization ponds/Duckweed Pond/Water Hyacinth Pond	WSP	136	9
2	Karnaltechnology	KT	5	0.3
3	Onsite package (PWTS-AM series, THST series, CCST series)	On-Site- Package	402	26.5
	Rural Areas and peri-urban areas with cheaper limited space			
4	DEWATS/BORDA	DEWATS/BORDA	45	3
5	DEWATS Others	DEWATS Others	53	3.5
6	VORTEX System	VORTEX	2	0.1
7	SoilBio Technology	SBT	34	2.2
8	AnaerobicFilter	AF	33	2.2
9	AeratedLagoon	AL	24	1.6
10	UASB	UASB	53	3.5
	Peri-Urban areas with expensive and limited space			
11	New GPT- ASP Type- Ion Exchange India Ltd	EA-Package	58	3.8
12	ConventionalActivatedsludgeprocess	ASP	109	7.2
13	Extended aeration	EA	46	3
14	TricklingFilter	TF/BT	16	1.1
15	NBF (10 KLD to 150 KLD)	Contact Aeration-Package	79	5.2
16	Settler + Contact aeration (STBF series)	On-site Aerobic- Package	42	2.8
	Peri-Urban areas with expensive and limited space and strict effluent quality			
17	Moving bed biofilm reactor (including FAB)	MBBR	150	9.9
18	Submerged Aerobic Fixed film SAFF process	SAFF	1	0.1
19	Membrane Bioreactor	MBR	5	0.3
20	Sequencing Batch Reactor	SBR	171	11.3
		Unknown	53	3.5
		Total	**1517**	**100**

WP 2: Technical-environmental evaluation

Details in following presentation of Prof. Kazmi



WP 3: Social, economic and institutional eval.



WP 3: Social, economic and institutional eval.

- **Tasks 2 and 5: Social and institutional evaluation**

Overview

- 12 plants for detailed social and institutional evaluation
- Methodology: Triangulation of qualitative and quantitative data
- Purposive sampling
  - Technology, Institutional management and Social groups associated with the plant
- Methods, techniques, and tools:
  - In-depth interviews ,
  - Group discussion,
  - Observation of the plant activities,
  - Secondary sources: files, documents, newspaper articles, videos maintained by the stakeholders
- Analysis: thematic analysis, cross case analysis

Sl.No	Name of the plant	Data collection Status	Methodology
1.	Soil Bio Technology, Mumbai	Completed	Qualitative data Interviews and group discussions
2	Fluidised Aerobic Bio-Reactor (FAB), Mumbai	95% Completed	Qualitative and quantitaive data Interviews and group discussions Questionnaires
3	Borda DEWATS, Pune	95% Completed	Qualitative data Interviews and group discussions PRA tech with children
4	Extended Aeration, Pune	95% Completed	Qualitative and quantitaive data Interviews and group discussions Questionnaires
5	Aeration and Filtration Process, Chennai	Completed	Qualitative data Interviews and group discussions
6	Moving Bed Bioreactor (MBBR), Chennai	Completed	Qualitative and quantitaive data Interviews and group discussions Questionnaires
7	Extended Aeration (EA), Chennai	In Complete	Qualitative data Interviews
8	Vortex DEWATS, Puducherry	In complete	Qualitative data Interviews
9	Submerged Aerated Fixed Film (SAFF) and	Completed	Qualitative data Interviews and group discussions
10	Extended Aeration (EA), Kolkata	Completed	Qualitative data Interviews and group discussions
11	Sequential Batch Reactor (SBR), Uttarakhand	Completed	Qualitative and quantitaive data Interviews and group discussions Questionnaires
12	Membrane Bio-Reactor, Delhi	Completed	Qualitative data Interviews and group discussions

Determinants of Evaluation

Social	Institutional
•***Awareness:*** •WWT Recycle, Reuse, Acceptance, Perception •***Gender***: •Difference in perception •***Participation***: •Decision making, Feedback mechanism, Community engagement •***Obstacles***: •Freedom of association and collective bargaining •***Social security***: •better pay, Provident fund, Insurance, others •***Social responsibility***: •Hygiene practices, Relationship with providers, Improved Environment Sensitivity to indigenous rights •***Benefits of WWT***: • Job opportunities/equal opportunities, Transparency, End of life responsibility •***Secure living conditions***: •Healthy, Safety, De-localisation and migration •***Health***: •Health issues and Available Facilities: Issues, Accessibility, Frequency of visits, Expenditure •***Ecological/bio-diversity*****:** •Impact on environment, good environmental management, Minimum waste, Eco friendly Resource utilisation : Optimal, Reuse potential, Sustainability	•**Governance :** •Red tape, Information, Transparency, Funding, Corruption •***Popularity among community***: •Satisfaction, Relationship with consumers, End of life responsibility •***Laws related to WWT***: •Awareness, Implementation and Effectiveness of the Laws, Statutory bodies •***Economic :*** •Cost: Water charges, Affordability, Income, Economical, Operating cost /management cost: Expenses, Funding, Competitive Job opportunities: Adequate salary for workers: Sufficient, Working hours Contribution to economic development: Sustainable

Plants/ S&IE Indicators	Soil Bio Technology, Mumbai	Fluidised Aerobic Bio-Reactor (FAB), Mumbai	Borda DEWATS, Pune	Extended Aeration, Pune	Aeration and Filtration Process, Chennai	Moving Bed Bioreactor (MBBR), Chennai
Social Evaluation Indicators	Awareness Participation Obstacles Social security Social responsibility Benefits of WWT Secure working conditions Delocalisation and migration Health Marine diversity Collection of WW	Awareness Participation Social security Benefits of WWT Secure living conditions Health Safety Ecological/bio-diversity	Participation Gender Sensitivity to indigenous rights Awareness Freedom of association and collective bargaining Ecological/bio-diversity	Social security Benefits of WWT Funding Sensitivity to indigenous rights Ecological/bio-diversity Geographic and demographic context	Technology development Awareness Diverse population Participation Health	Awareness Social security Benefits of WWT Secure working conditions Safety
Institutional Evaluation Indicators	Governance Economic aspects	Governance Satisfaction, Relationship with consumers, End of life responsibility Legal mandate	Governance Popularity among community	Governance Legal mandate Satisfaction, Relationship with consumers, End of life responsibility	Governance Economic aspects Resource utilisation	Governance Economic aspects Legal mandate

Plants/ S&IE Indicators	Extended Aeration (EA), Chennai	Vortex DEWATS, Puducherry	Submerged Aerated Fixed Film (SAFF) Kolkata	Extended Aeration (EA), Kolkata	Sequential Batch Reactor (SBR), Uttarakhand	Membrane Bio-Reactor, Delhi
Social Evaluation Indicators	Working Conditions Participation Health	No data	Social security Benefits of WWT Funding Working Conditions	Social security Benefits of WWT Funding Working Conditions	Awareness Social security Social responsibility Marine diversity/Ecological/bio-diversity Collection of WW	Social security Benefits of WWT Secure working conditions Health Safety
Institutional Indicators	No data	Governance Technology development	Governance Legal mandate End of life responsibility	Governance Legal mandate End of life responsibility	Governance Economic aspects	Governance, Client satisfaction, End of life responsibility Legal mandate

Conclusion

- Social Evaluation
  - Awareness: less among stakeholders
  - Gender: invisible
  - Participation: lack of involvement in the process
  - Social Security: absent for lower level workers
- Institutional Evaluation
  - Governance: top to bottom
  - Cost effectiveness: huge capital investment
  - Legal Mandate: STPs out of legal requirement
  - Popularity among community: lack of contact with general public

Plans from May 2016 to November 2016

- Finish data collection at pilot plant
- Deliverables
- Process publications
- Stakeholders' workshop
- Final Report

WP 3: Social, economic and institutional eval.

- **WP3 – task 3 “Economic Evaluation”**

WP 3: Social, economic and institutional eval.

- **Example MBR New Delhi**
  - Size: 4,5 MLD
  - Infrastructure costs: 2400 lacs (Financed by: NG Loan)
  - O&M Costs (Financed by: State Government)

Year for which the cost data have been collected:	01.04.2014 – 31.03.2015
	Annual amount
Annual personnel costs for this year	33.66 Lacs
Annual consumable/material costs for this year	7.2 Lacs
Annual energy costs for this year	38.63 Lacs
Annual costs for any repairs (if not budgeted under consumables/material)	17.5 Lacs
Etc. (add any other cost items that have occurred in that year) water testing	8.5 Lacs
Etc.	-
Total annual O&M costs	105.49 Lacs

WP 3: Social, economic and institutional eval.

Type of Technology	Soil Technology	BORDA DEWATS	Sequential Bioreactor	Septic Tank, Anaerobic filter	Membrane Bioreactor
Technology Location Site	Love Grove, Worli, Mumbai	Sane Guruji Hospital, Hadapsar, Pune	Swargashram, Hrishikesh	Navodya Vidyalaya, Roorkee	Akshardham, New Delhi
Total Infrastructure Capital costs					
Unit 1	3 crores (Unit 1+Unit2+Unit 3)	19.29 lakhs (Unit 1+Unit2+Unit 3+Unit 4)	6 crores	0.5 lakhs	24 crores
Unit 2					
Design Lifetime (years)					
Civil			30	30	30
Electrical			15	15	15
Mechanical	NA	NA	15	15	15
O & M cost (Total/year)					
Personnel	3 lakhs (8 months operation, not operated in monsoon)	12 000	12 lakhs		33.66 lakhs
Consumable		Not required	6.38 lakhs		7.2 lakhs
Energy		Not required	18.5 lakhs		38.63 lakhs
Repairs		Not required	5 lakhs		17.5 lakhs
Etc		6500	4.5 lakhs	0.015 lakhs	8.5 lakhs
Financing					
Donor/Loan		19.29 lakhs			
National Gov. Grant			6 crores	0.5 lakhs	24 crores
State Gov. Grant					
Other	3 crores				
Financing O & M cost (Total/year)					
Revenue	3 crores				
From user fees					
From taxes for WWTP					
Other	3 lakhs	12000	46.38 lakhs	0.015 lakhs	1.0549 crore
Etc		6500			

WP 3: Social, economic and institutional eval.

Type of Technology	Anaerobic Baffle Reactor	Anaerobic filter	Extended Aeration	Moving bed bioreactor	Submerged Aerobic Filter	EA	AL	MBBR	CSR
Technology Location Site	Parnashree Green, Behala	South city, Kolkatta	DLF building, Kolkata	Greenfiled city, Kolkata	Silver spring apartments, Kolkata	JSS	IITM	L&T	SK
Total Infrastructure Capital costs									
Unit 1	25 lakhs	18 lakhs	30 lakhs	21 lakhs	18 lakhs	2.45 crores	1 crores	9.375 lakhs	4.2857143 crores
Unit 2									
Design Lifetime (years)									
Civil	30	30	30	30	30				
Electrical	15	15	15	15	15				
Mechanical	15	15	15	15	15				
O & M cost (Total/year)									
Personnel	10.8 lakhs	8.64 lakhs	14.4 lakhs	7.2 lakhs	9.84 lakhs	4 lakhs	9.5 lakhs	47500	1.77 lakhs
Consumable									
Energy									
Repairs									
Etc									
Financing									
Donor/Loan									
National Gov. Grant									
State Gov. Grant									
Other									
Financing O & M cost (Total/year)									
Revenue									
From user fees									
From taxes for WWTP									
Other									
Etc									

WP 3: Social, economic and institutional eval.

- **WP3 – task 4 “Socio-economic Evaluation”**

Estimation of willingness to pay for wastewater treatment: A case study of Chennai, Tamil Nadu

Objective:

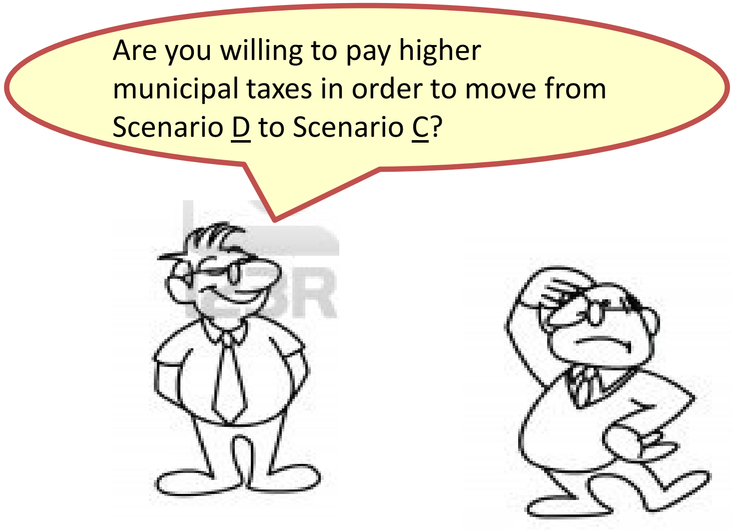
- Elicit residents' Willingness to Pay (WTP) for improvement of WW treatment (i.e., non-market value of improved treated WW)

Method:

- Contingent Valuation (CV) survey

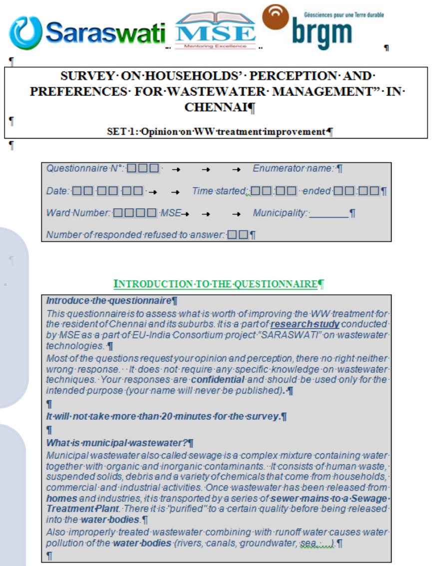
Implementation :

- Chennai case study as representative of urbanised coastal area



Buckingham canal, Chennai

CV questionnaire design


Saraswati MSE Mentoring Excellence brgm Géosciences pour une Terre durable

SURVEY ON HOUSEHOLDS' PERCEPTION AND PREFERENCES FOR WASTEWATER MANAGEMENT" IN CHENNAI

SET 1: Opinion on WW treatment improvement

Questionnaire N°: □□□ Enumerator name:

Date: □□ □□ □□ Time started: □□:□□ ended □□:□□

Ward Number: □□□□ MSE Municipality: ________

Number of responded refused to answer: □□

INTRODUCTION TO THE QUESTIONNAIRE

Introduce the questionnaire

*This questionnaire is to assess what is worth of improving the WW treatment for the resident of Chennai and its suburbs. It is a part of **research study** conducted by MSE as a part of EU-India Consortium project "SARASWATI" on wastewater technologies.*

*Most of the questions request your opinion and perception, there no right neither wrong response. It does not require any specific knowledge on wastewater techniques. Your responses are **confidential** and should be used only for the intended purpose (your name will never be published).*

It will not take more than 20 minutes for the survey.

What is municipal wastewater?

*Municipal wastewater also called sewage is a complex mixture containing water together with organic and inorganic contaminants. It consists of human waste, suspended solids, debris and a variety of chemicals that come from households, commercial and industrial activities. Once wastewater has been released from **homes** and industries, it is transported by a series of **sewer mains to a Sewage Treatment Plant**. There it is "purified" to a certain quality before being released into the **water bodies**.*

*Also improperly treated wastewater combining with runoff water causes water pollution of the **water bodies** (rivers, canals, groundwater, sea, …).*

Respondent profile

- Personal information (age, sex, birth place, period of residence, …)
- Socioeconomic status (household size, education level, employment, household income, ethnic group origin, …)

Household water WW provision

- Questions about water provision (source of water use, water filtration practices, …)
- Questions about wastewater services (type of toilet facility, …)

Knowledge about wastewater treatment

- Knowledge on WW in general terms (e.g. where your ww go?)
- Questions regarding ww treatment (SWT utilities, technologies …)
- Benefits of ww treatment

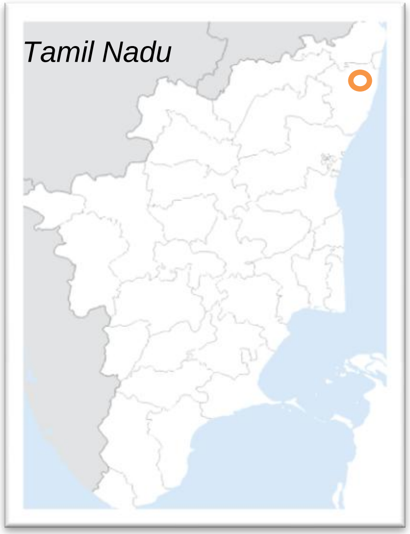
CV questions

- Introduction to municipal WW treatment and reuse
- Description of hypothetical scenarios / options to be valuated (e.g. wastewater quality level)
- Explanation of payment vehicle
- CV exercise

What do think?

- Questions about environmental sensibility
- Opinion about rivers pollutions
- Opinion about origin of pollution / part of urban wastewater
- …

Survey administration



Mode: face-to-face interviews

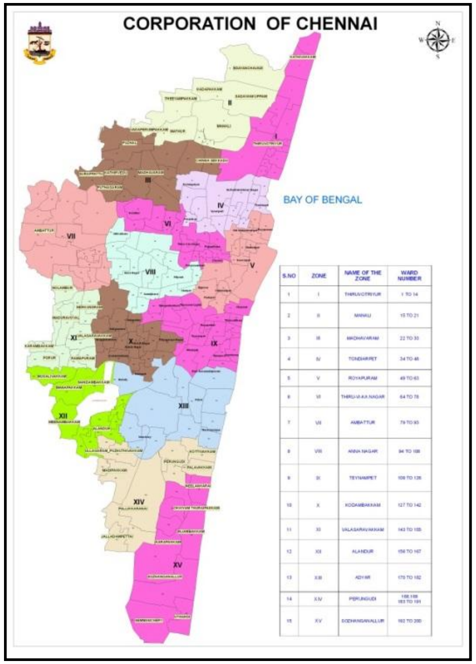
Date: February and March 2015

Spatial scope: 15 zones of CMWSSB (*Chennai Metropolitan Water Supply and Sewage Board*)

Sample(*): 200 residents (households) randomly selected covering the 15 zones

WTP measurement unit: Rupees/month

Vehicle payment: payment card based on the CMWSSB' taxes as sewage cess (7% of the Annual rental value)



(*) The survey was administered to be representative of the sample population in terms of income, social status, proximity to ***Adyar river and Buckingham Canal***

CV Elicitation

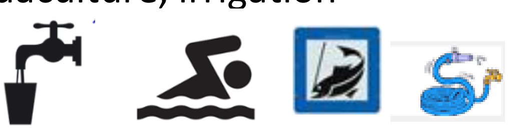
Residents were presented with four distinct WW treatment programs, characterised in terms of the quantity and quality of water, including the present situation, i.e., status quo:

- **Scenario D** (mostly present situation): Not suitable for drinking, swimming, aquaculture and irrigation

- **Scenario C**: Not suitable for drinking, swimming, aquaculture and irrigation for eatable crops

- **Scenario B**: Suitable for swimming, aquaculture, irrigation. Not suitable for drinking.

- **Scenario A**: Suitable for drinking, swimming, aquaculture, irrigation



e.g. CV questions: change from scenario D to C

- Would it be to achieve WW treatment as per scenario C (e.g. water can be reused for irrigate no eatable crops)
  ☐ Yes ☐ No ☐ Don't know
- Are you willing to pay higher municipal taxes in order to move from Scenario D to Scenario C?
  ☐ Yes ☐ No ☐ Don't know
- If yes, what would the most you are willing to pay a municipal tax per year to achieve scenario C?
  Rs / year _______________ see Payment Card

Socioeconomic characteristics of the sampled households

Characteristics	Mean (SE)
Age (in years) of the respondent	44.7 (10.9)
Number of years lived in the area	28.99 (16.98)
Number of members in the household	4.26 (1.39)
Number of children less than 10 years of age	0.34 (0.78)
Monthly Household income (Rs)	14087.50 (9484.77)
Monthly household spending on water (Rs)	**340.32** (405.15)
Number of years residing in the house	13.58 (11.38)
Distance from nearest canal/river	**2.39** (3.25)
Household head completed primary education	15
Household head completed secondary education	34.5
Employment in service sector=1,0 otherwise	11.7
Self-employed	22.4
Manual worker	46.3
Monthly income 5000-10000	74
Monthly income 10000-15000	49

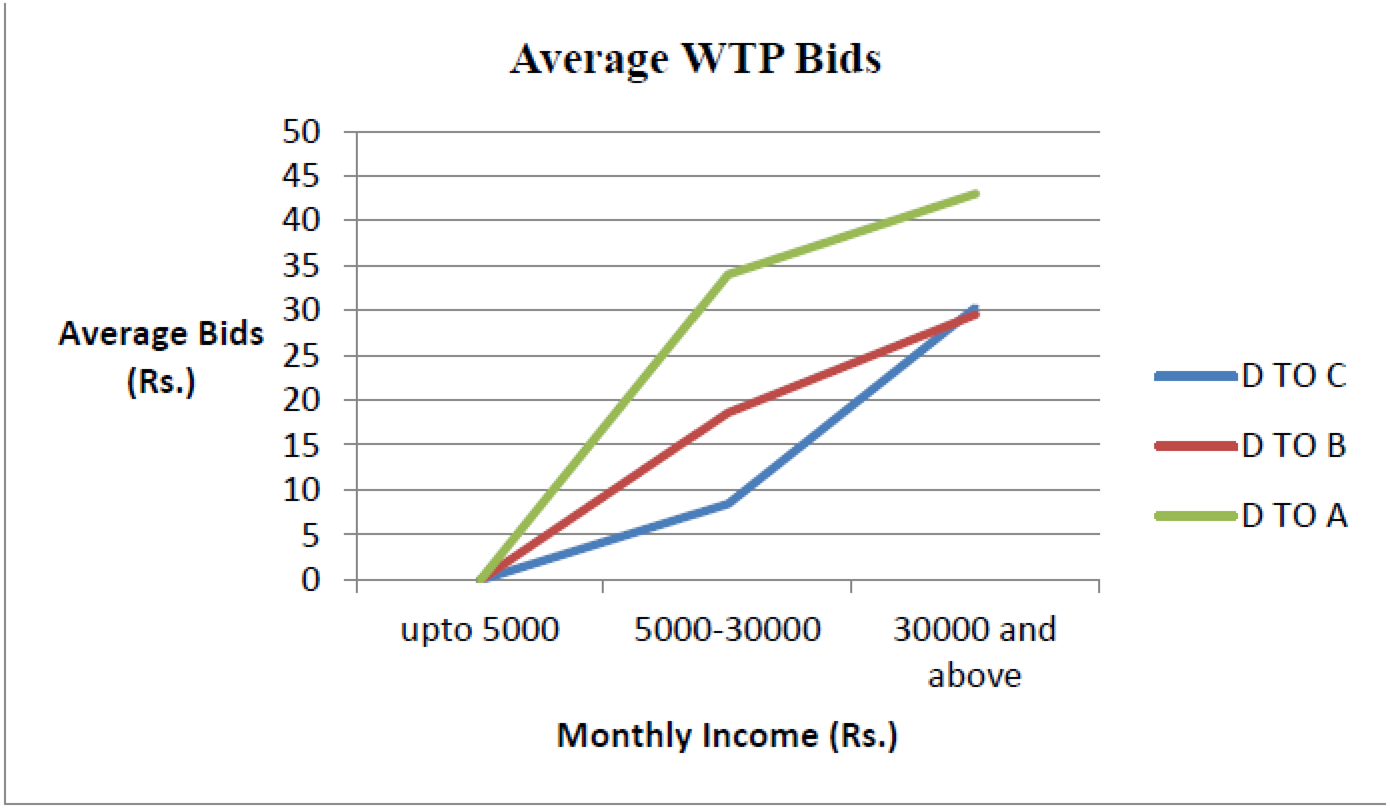
Logistic regression on determinants of WTP for wastewater Treatment programs

Variables	Scenario D to C	Scenario D to B	Scenario D to A
	Coeff(SE)	Coeff(SE)	Coeff(SE)
Constant	-4.98*** (1.43)	-4.91*** (1.43)	-5.66***(1.50)
Age	.0064(.019)	.0065 (.019)	.019 (.02)
No of Children	-1.04*** (.41)	-.96***(.39)	-.59 (.38)
Income	.000***(.00)	.000***(.00)	.000***(.00)
Female	-.54(.56)	-.61 (.556)	-.92 (.61)
Water quality	1.18** (.613)	1.22***(.621)	1.62**(.738)
Education	.79 (.499)	.83* (.51)	.63 (.52)
improved health	-.19 (.42)	-.42(.42)	-.44 (.44)
Reduction in overflowing cesspits	1.02**(.47)	1.27***(.48)	1.23***(.48)
Avoid groundwater contamination	-1.03**(.49)	-1.08**(.49)	-1.05**(.51)
Reduced river pollution	.202 (.42)	.16 (.43)	-.04 (.44)
Lower degradation of river ecosystem	.55(.49)	.51 (.49)	.83(.52)

**** indicates significance at 1% level ** indicates significance at 5% level and * indicates significance at 10% level.*
Source: Wastewater treatment household survey(2015)

- **More is the level of water quality, more the people are willing to pay**

Estimated average WTP Bids



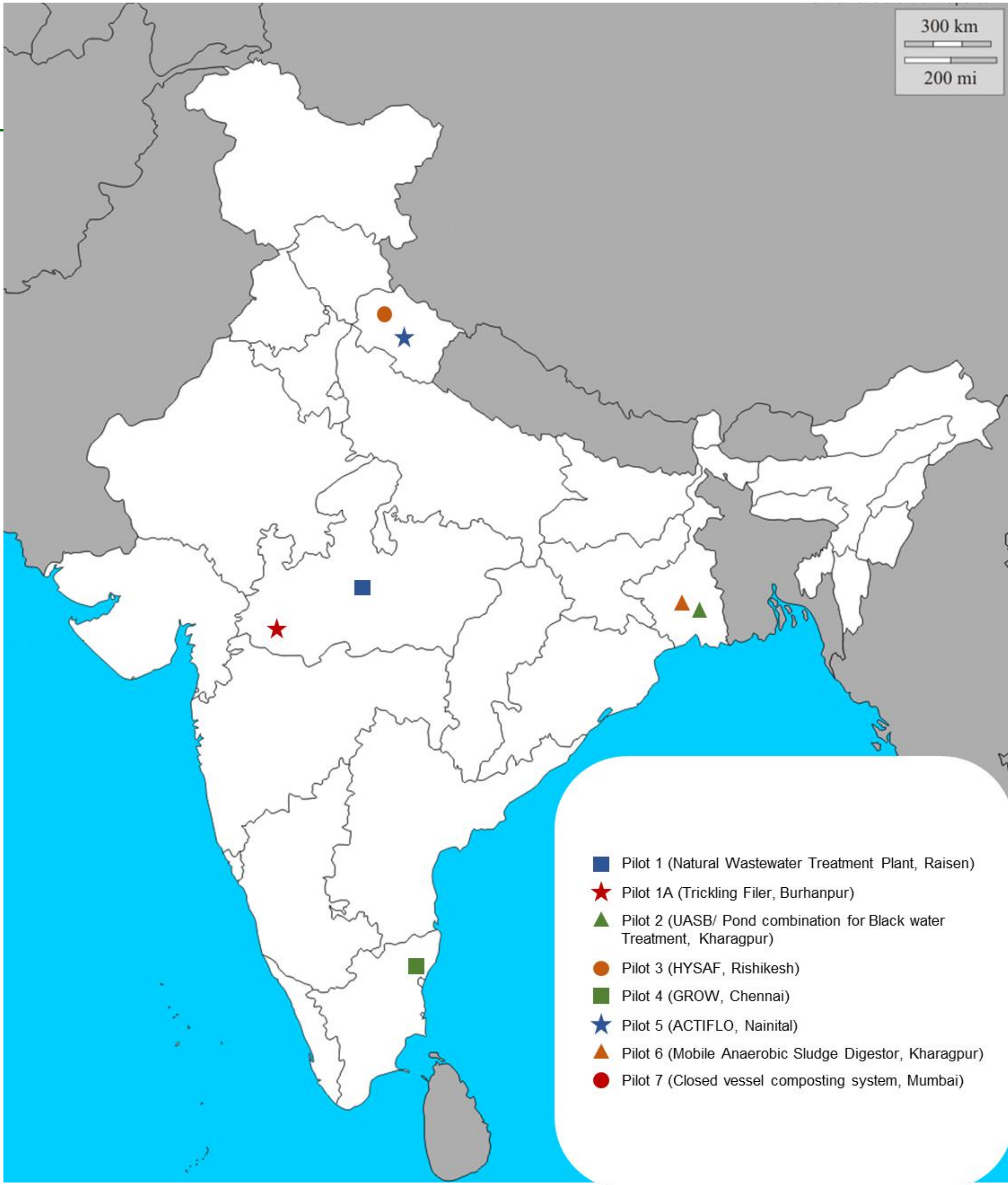
The average WTP bids including all three scenarios range from none i.e. zero valuation to a maximum of **Rs 43 per month** per household (**Rs 516 per year**)

Main finding

- The benefit estimates reported in this study reveal that an **average** household in the sample would be **willing to pay yearly Rs 516 (~8 $/yr) as sewage tax**
- This WTP value is much less than the 'international' WTP value resulted from our meta-analysis (**53 $/yr**)
- When aggregated over the entire Chennai population (4.45 million inhabitants, Census 2011) it amounts around **Rs 240 crores** per year for an improvement from worst scenario (D) to best one (A).
- To be compared to the cost of **Rs 720 crores** for first phase (2011) involving upgradation of the STPs and of sewage pumping stations (Chennai City River Conservation Project).
- This 'back-of-the-envelope' cost-benefit analysis (CBA) would suggest that even though the residents' welfare would increase as a result of an improvement of the current STPs, the water and sewerage tax revenues may not be sufficient to meet the costs and hence need additional financial sources for the financing of this endeavour.

WP 4: Piloting of selected EU technologies

Overview Pilots



Pilot 4

GROW
Nov 2013

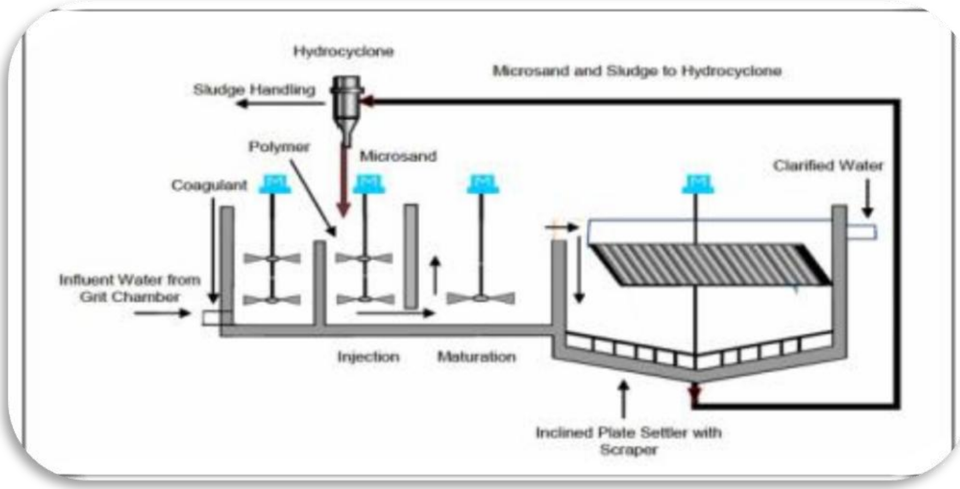
WP 4: Piloting of selected EU technologies

- **Pilot 1 and 1A, 2, 3, 4**
  - More detailed information in following presentations

WP 4: Piloting of selected EU technologies

- **Pilot 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 m3/day
Effluent Quality	BOD < 30 mg/L, TSS < 20 mg/L
Intended Reuse	Direct Discharge to Lake
Beneficiaries	lake Pollution Control

Status: To be installed and Commissioned in September 2015

Material and Methods

Study Area

Slide 1

Site at Nainital

Drain at site

Activities	Year-2013				Year-2014				Year-2015				Year-2016
	Quarter				Quarter				Quarter				Qua-rter
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st
Identification of sites													
Land Allocation from Nainital Municipality													
1st tender floated													
2nd time tender floated & work order placed													
Work started at site													
Work stopped due to objection of LDA													
Fabrication of plant completed													
Court Judgement													
Permission from Housing Dept., Govt. of Uttarakhand													

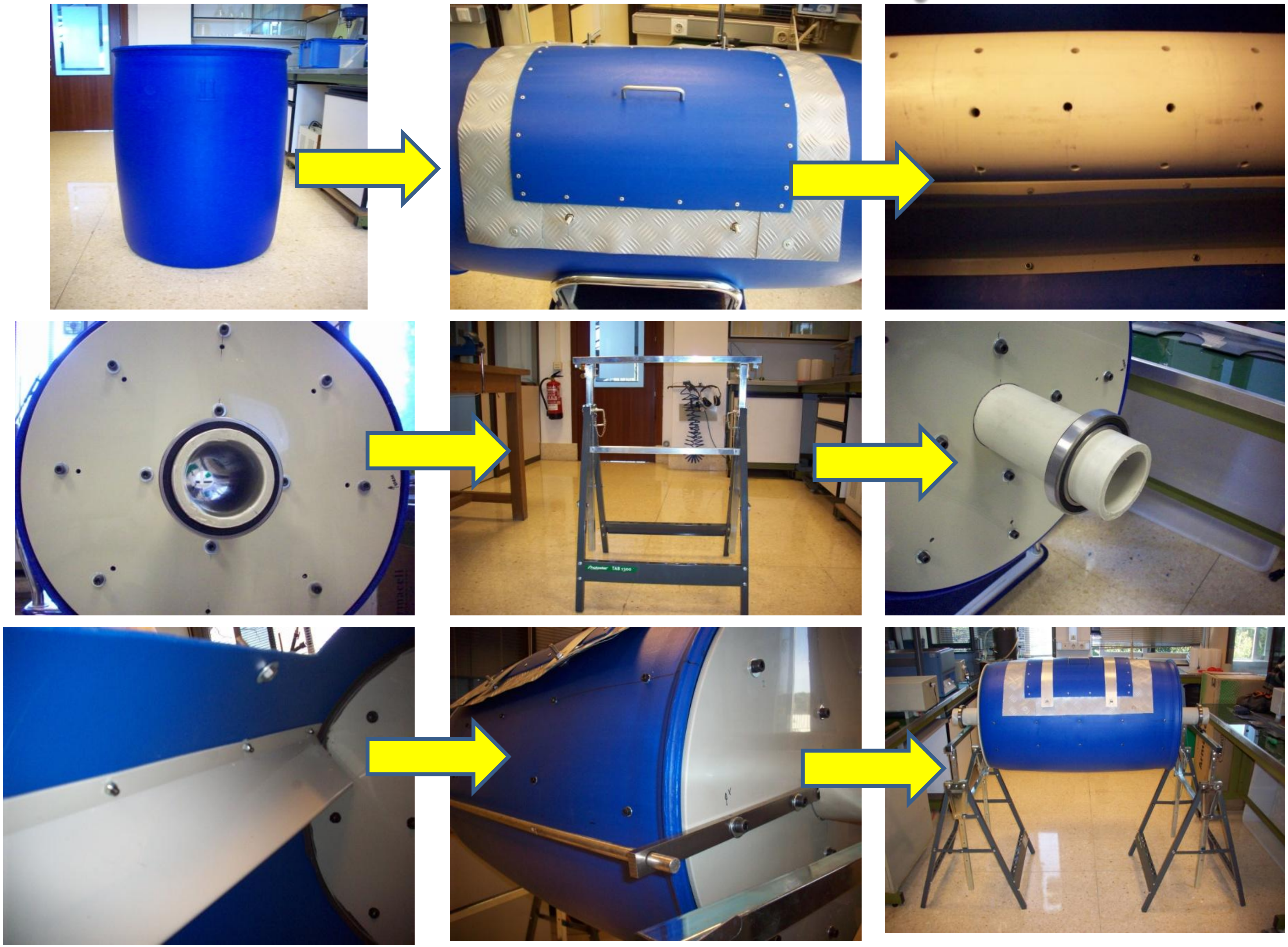
Slide 1

S.No	Items ready for installation
1	Ballasted sand flocculation settling unit including media for tube settler
2	Hydro cyclone
3	Dosing pump
4	Dosing tank
5	Agitator
6	Agitator skid
7	Turbidity analyzer
8	Panel
9	Chemicals
10	Pipes, valves, cables and fittings etc.

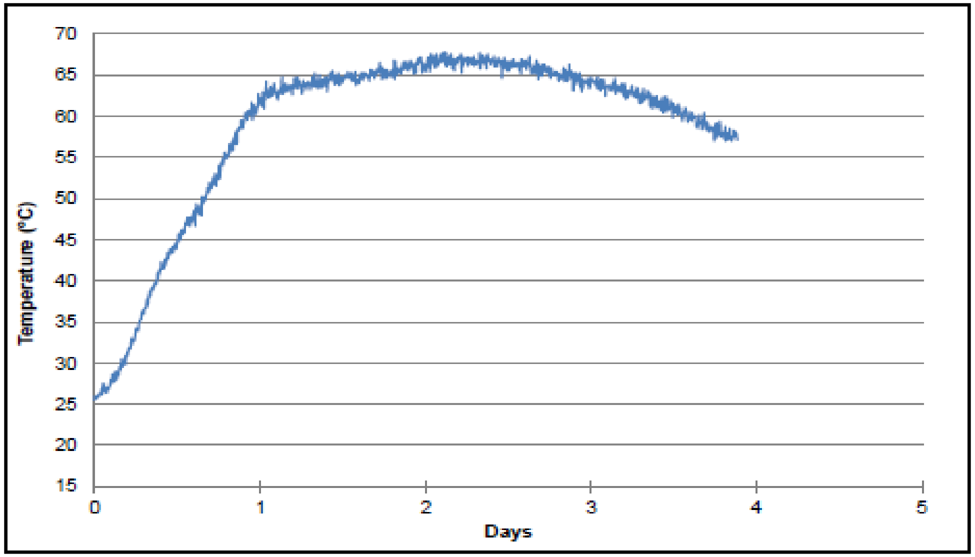
WP 4: Piloting of selected EU technologies

- **Pilot 7**

Reactor Assembly



Experiments at CEIT, Spain



Characteristics of the mixture		
	Theoretical	Real
TS (%)	30.00	33.56
TS content (kg)	30.00	30.00
Total weight (kg)	89.39	89.39
Volatile Fraction (VF, %)		49.99
VS (%)		16.78

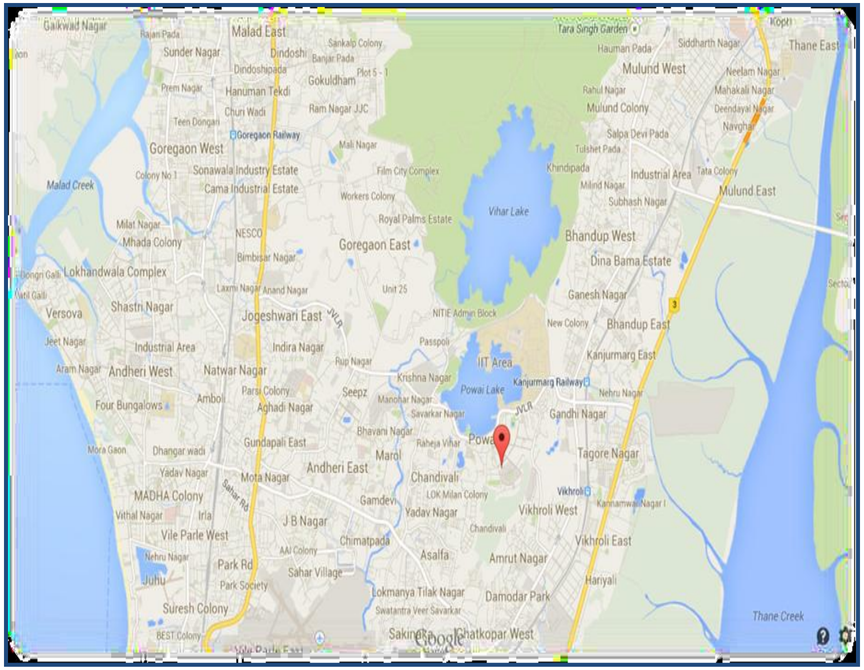
Components	TS (%)	VS (%)	VF (%)	Percentage (on a kg TS basis)	TS (kg)	Total weight (kg)	% (on a wet kg basis)	VS (kg)
Sewage sludge	25.00	16.00	64.00	60.00	18.00	72.00	80.54	11.52
Bulking agent	69.00	20.00	28.99	40.00	12.00	17.39	19.46	3.48
(Additional component 1)	100.00	0.00	0.00	0.00	-	-	-	-
(Additional component 2)	15.00	13.00	86.67	0.00	-	-	-	-
(Additional component 3)	30.00	5.00	16.67	0.00	-	-	-	-
				0.00	-	-	-	
			TOTAL	**100.00**	**30.00**	**89.39**	**100.00**	**15.00**

Site For Sludge Composting Unit

Site Details

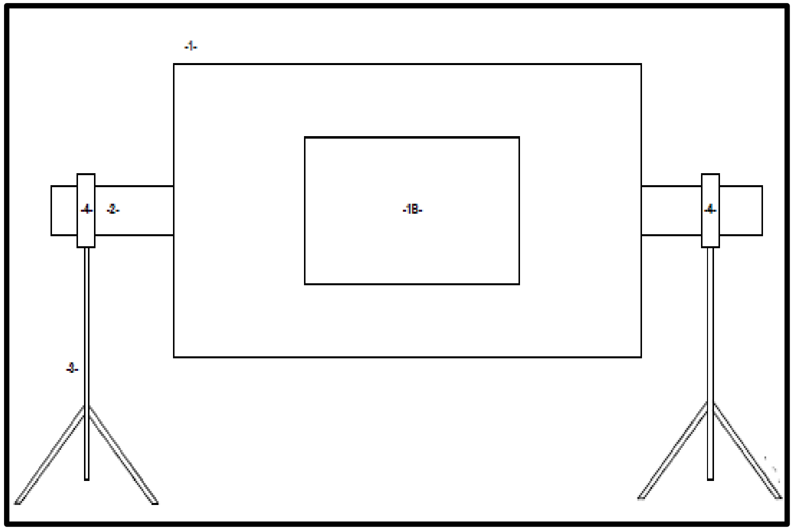
- **Name:** Nirvana Park, Mumbai
- **Address:** Hiranandani Gardens, Powai, Mumbai
- **Technology:** MBBR
- **Reuse applications:** Gardening, Toilet Flushing,
- Construction
- **Capacity:** 2 MLD
- **Startup Year:** 2005

Chemical	Quantity used per year
Chlorine	64203 kgs
Alum	162130 kgs
Lime	39409 kgs



Reactor set up in NITIE Lab & on site

- The reactor consists of a horizontal plastic drum (made of high density polyethylene), 200 L of volume. It contains a perforated polypropylene pipe (length of 2 m) to allow a passive aeration of the composting mixture. The drum can be turned manually.



Installation and Commissioning – 1st November 2014

Composting

- Garden waste specifically the fallen dried leaves were used as bulking agent and the thermophilic stage temperature profile was used as main indicator for gauging if the composting process is developing correctly.

- Dried garden leaves and sludge did not give the desired rise in temperature except once in spite of trying various combinations of moisture content, freshness of sludge and leave properties.

- Wood shavings and chips were used as the second choice and gave the desired thermophilic temperature in first instance.

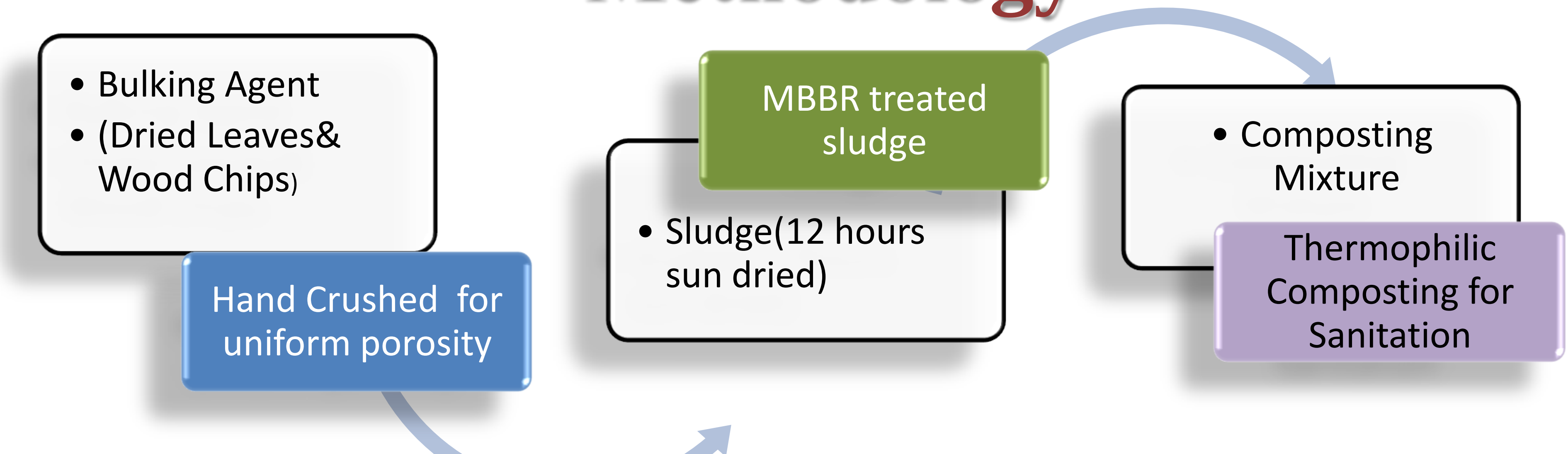
- The effects of the aforementioned process variables on temperature, moisture content, C: N ratio, organic matter content, pH, metal concentration, sanitation level and stability of the final product are being studied.

Objectives

To carry out composting of sludge without adding any easily biodegradable carbon source unlike CEIT in Spain.

To study the influence of process variables (turning frequency, effect of additive i.e household food waste, lime, zeolite, type of bulking agent and sludge/bulking agent mixing ratio) on the performance of the sewage sludge composting process using a rotary drum and vertical drum pilot scale reactors, in order to optimize the thermophilic stage and reduce the processing time.

Methodology



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Experimental set up using Bulking Agent as Dried Garden Leaves

Bulking Agent

Sludge

Mixture

Reactor setup

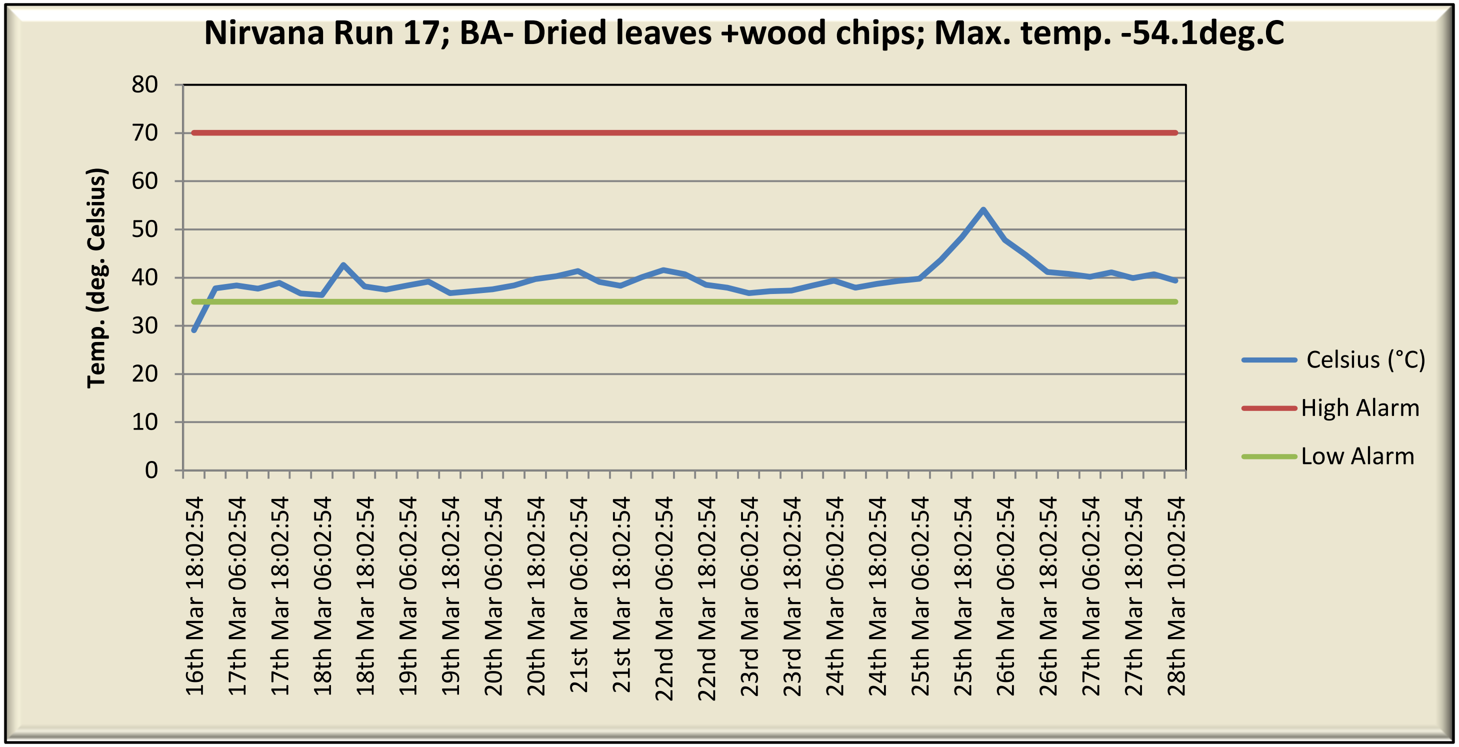
Experimental set up using Bulking Agent as Mixture of Dried leaves and wood shavings

Bulking Agent – Wood shavings

Mixture

Observations (Pilot on-site)

Exp no.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	March 2015-March 2016															
OM content of Sludge (%)	12	16	17	17	27	27	27	38	42	29.85	39.44	9.16	12.5	24	28	29.62
VSS Content of Mixture	Analysis not done									73.16	65.12	--	20	30.15	36.19	65.78
VSS Content of Sludge										52.86	52.91	--	39.12	13.2	48	43.98
VSS Content of BA										22.19	21.92	23.09	18	18.55	29.53	28.22
C:N ratio of mixture	Analysis not done									24:1	26:1	25:1	16:1	21:1	32:1	33:1
pH of mixture	7.7	7.3	7.3	7.5	7.6	7.2	7.2	7.5	7.5	7.7	7.2	8.1	6.9	6.9	7.2	6.8
Moisture content of mixture	Analysis not done									78	82	79	80	83	85	64
Sludge / B.A Ratio	3:2(30 Kg+20 Kg)	3:1(30 Kg +10Kg)	3:1 (36 kg +12Kg)	3:1 (15 kg +5Kg)	5:1(25 Kg +5Kg)	5:1(25 Kg +5Kg)	5:1 (25 Kg +5Kg)	5:1 (50kg + 10 kg)	5:1 (25kg + 5kg)	3:1(24kg+8kg)	3:2(30kg+20kg)	4:1(40kg+10kg)	3:2(30kg+20kg)	3:1(30kg +10kg)	3:1(30kg +10kg)	3:1(30kg+10kg)
Max Tem (Degree Celsius)	57.1	53	48.3	45.2	47.3	39	43.6	35	40	39.6	41.5	41.6	40.8	41.8	42.5	**54.1**
Turning frequency(hours)	Every 6-8 hours	Every 6-8 hours	Every 6-8 hours	Every 6-8 hours	Every 24 hours	Every 24 hours	Every 24 hours	Every 24 hours	Every 24 hours	Every 24 hours	Every 24 hours	Every 12 hours	Every 12 hours	Every 12 hours	Every 12 hours	Every 12 hours


Nirvana Run 17; BA- Dried leaves +wood chips; Max. temp. -54.1deg.C
Temp. (deg. Celsius)
80
70
60
50
40
30
20
10
0
16th Mar 18:02:54
17th Mar 06:02:54
17th Mar 18:02:54
18th Mar 06:02:54
18th Mar 18:02:54
19th Mar 06:02:54
19th Mar 18:02:54
20th Mar 06:02:54
20th Mar 18:02:54
21st Mar 06:02:54
21st Mar 18:02:54
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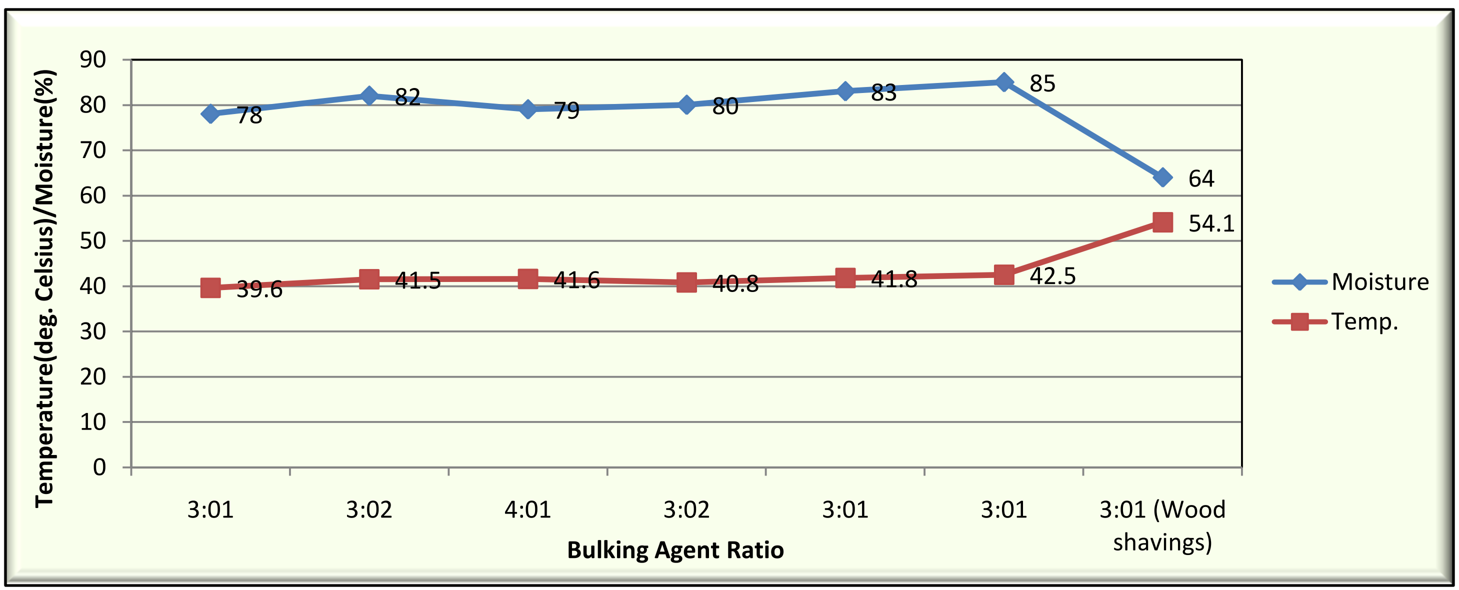
23rd Mar 06:02:54
23rd Mar 18:02:54
24th Mar 06:02:54
24th Mar 18:02:54
25th Mar 06:02:54
25th Mar 18:02:54
26th Mar 06:02:54
26th Mar 18:02:54
27th Mar 06:02:54
27th Mar 18:02:54
28th Mar 10:02:54
Celsius (°C)
High Alarm
Low Alarm


Temperature(deg. Celsius)/Moisture(%)
90
80
70
60
50
40
30
20
10
0
78
82
79
80
83
85
64
54.1
39.6
41.5
41.6
40.8
41.8
42.5
3:01
3:02
4:01
3:02
3:01
3:01
3:01 (Wood shavings)
Bulking Agent Ratio
Moisture
Temp.

Observations

- Analysis are been conducted at lab scale to determine and control the basic parameters required for the process of composting viz. Total Organic Matter content ,Volatile Solid Content and Moisture for the Sludge, Bulking Agent and Mixture. Also the Rotary drum is being rotated regularly at an interval of 12 hours during the experimental setup.

- For the pilot setup no. 17 a maximum temperature of 54.1 deg. Celsius which is closely related to thermophilic temperature was obtained on the 3rd day of composting. The moisture content of the mixture was maintained between 60-65 percent and the Solid Content ranged between 35-40 percent. The C:N ratio of the mixture was found to be 33:1.

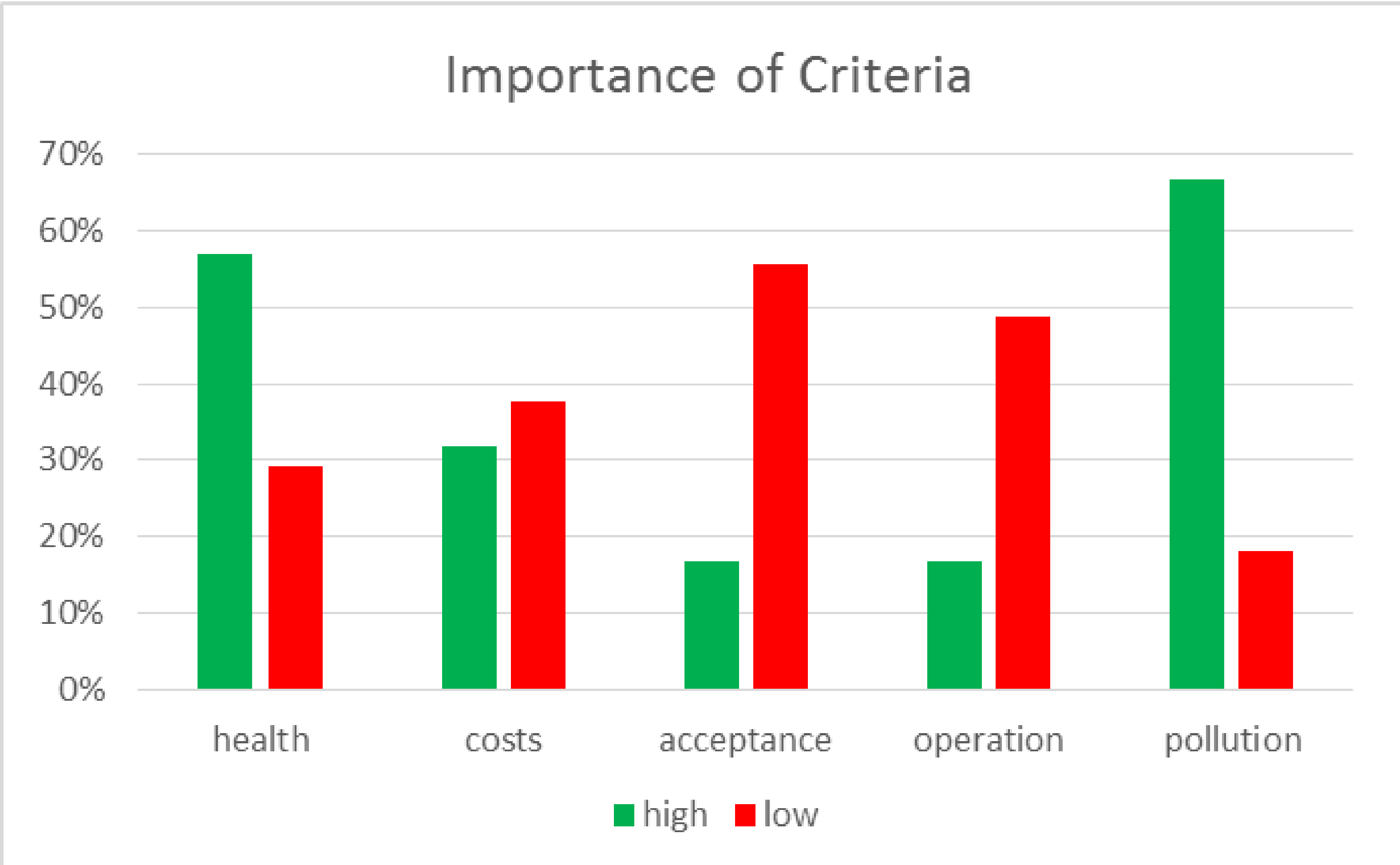
- Reactor is now being run repeatedly at the site of STP to attain higher temperature. Initially the runs were conducted using dried leaves as Bulking Agent.

- For the runs conducted from January 2016 onwards, a mixture of crushed dried leaves or wood shavings of specific size (0.5-2.0cm) have been used as Bulking Agent.

WP 5: Integrated sustainability assessment

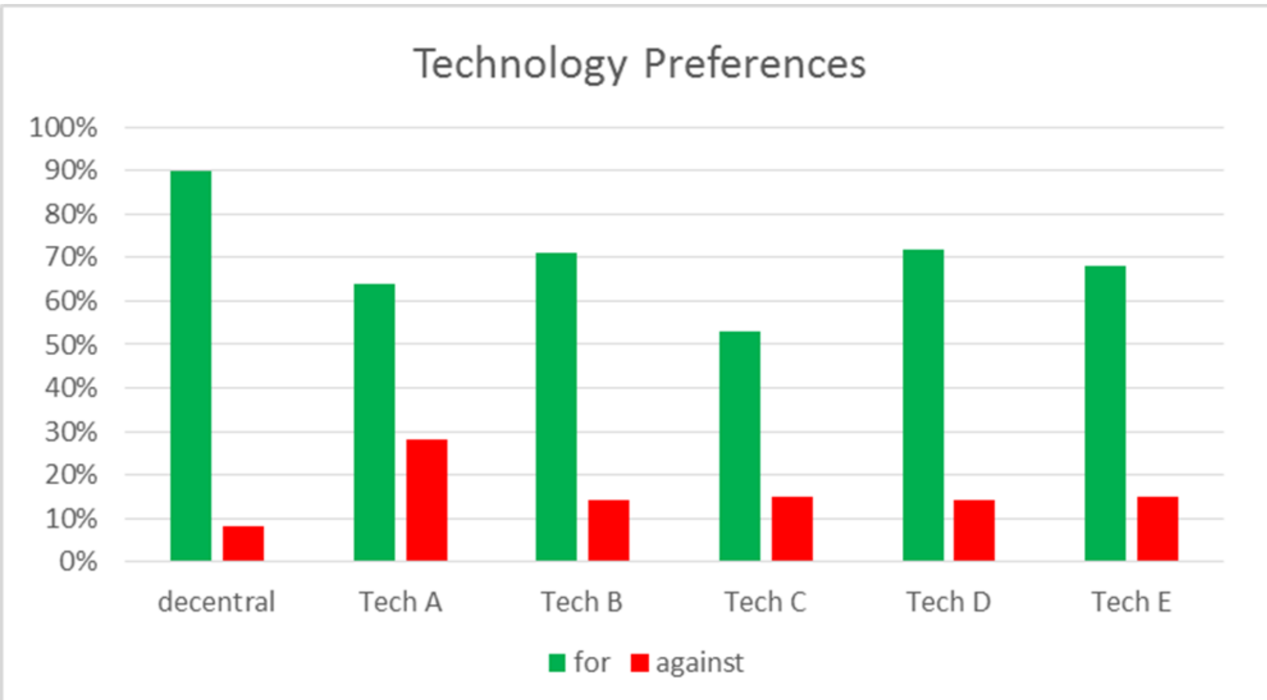
- **Task 1. Integrated sustainability assessment**
  - Main goal: Aggregate the various components of the technical-environmental, social, economic and institutional evaluations in WP2&WP3
  - Challenges due to data gaps for certain aspects
  - Task has recently started with a literature review on sustainability criteria and indicators relevant for wastewater management
  - A questionnaire survey with stakeholders about the importance/relevance of main criteria groups was conducted last year
  - Results will also feed WP6

WP 5: Integrated sustainability assessment



WP 6: Tools for replication and upscaling

- **Why?**



A: natural tech.
B: low tech
C: combinations
D: Conventional
E: Advanced

WP 6: Tools for replication and upscaling

- **5 tools:**
  - 1. Guidelines for technology application
  - 2. Technical guidelines for technology design (pilot technologies)
  - 3. Recommendations for reuse and effluent standards
  - 4. Recommendations for financial and institutional mechanisms and policy instruments
  - 5. Decision support tool for technology selection

WP 6: Tools for replication and upscaling

स्वच्छ भारत

एक कदम स्वच्छता की ओर

Technological Options for

Solid and Liquid Waste Management in Rural Areas

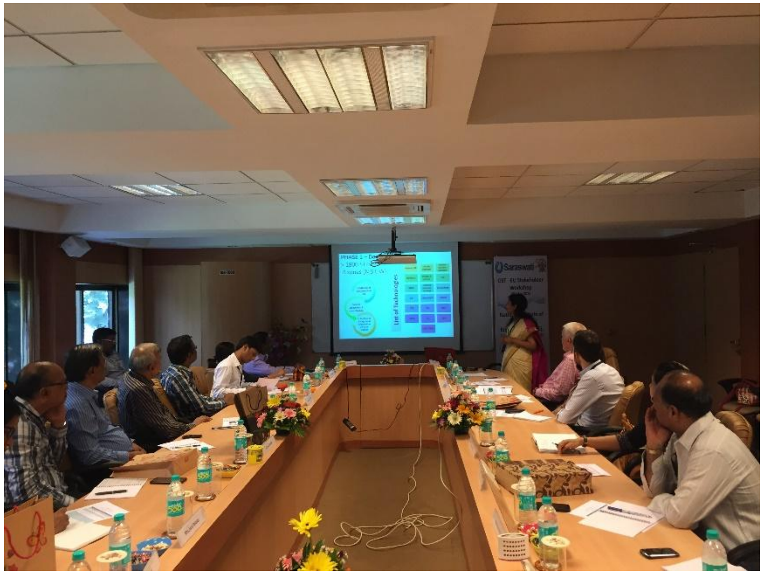
MINISTRY OF DRINKING WATER AND SANITATION

GOVERNMENT OF INDIA

April 2015

WP 6: Tools for replication and upscaling

- At the start of this WP 3 stakeholder workshops were condcuted in Chennai, Mumbai and Delhi (May 2015)
- „Wishes/suggestions“ of stakeholders with respect to those tools were discussed and included in the tasks as far as posisble



WP 6: Tools for replication and upscaling

- **Guidelines (Kazmi)**
  - Guidelines for technology application
  - Technical guidelines for technology design
  - Recommendations for reuse and effluent standards

GUIDELINES AND OBJECTIVE

Aim at providing tools that can help to replicate and upscale suitable technologies for wastewater treatment and reuse in India, based on the results and experiences of SARASWATI Project .

These tools are being elaborated in consultation with relevant stakeholders and authorities from India and include:

Task 6.1
GUIDELINES FOR TECHNOLOGY APPLICATION

Technical aspects, both of technologies evaluated in India as those introduced from EU, are dealt , as well as the summary of lessons learned and recommendations on the potential of application of each technology.

Task 6.2
TECHNICAL GUIDELINES FOR TECHNOLOGY DESIGN

Focused on detailed technological design of specific technologies, based on the evaluation results and pilot actions, as well as on relevant Indian-EU information

Task 6.3
RECOMMENDATIONS FOR WATER REUSE

Including a review of already existing international standards and recommendations for the Indian context in the light of evaluated technologies and pilot actions developed in SARASWATI project.

This Guideline is not intended to replace the existing Indian Guidelines. It should be a technical document that provides useful information in order to contribute to the development of integrated water resources management in India, within a framework of knowledge sharing and collaboration between EU-Indian stakeholders involved in the wastewater management.

1ST STAGE: **Review of existing similar type of guidelines in India, EU and International**
2nd STAGE: **Present and discuss the Guideline content with Indian technicians**
3rd STAGE**: According to Indian technicians recommendations, the information included for each of the technologies covered in the Guideline can be summarised as following**:

- ❑ Fundamentals of the process
- ❑Flow diagrams that represent the typical configurations of each technology
- ❑Treatment characteristics
    - ✓removal efficiency
    - ✓population range recommended for its implementation,
    - ✓surface required,
    - ✓energy consumption,
    - ✓influence of weather conditions,
    - ✓establishment and operational costs (**Indian costs**),
    - ✓influence of the topography,
    - ✓adaptability to population variations,
    - ✓reliability of the technology,
    - ✓complexity of O&M,
    - ✓generation of sewage sludge and the environmental impacts

- Start-up operations
- Operation and maintenance (O&M)
- Advantages and disadvantages
- Possible combinations
- Criteria for technology selection
- Section on sludge management
- Section on disinfection
- Legislative framework (wastewater discharge and water reuse)
- Summary of learned lessons (SARASWATI Project)
- Successful case-studies (SARASWATI Project)
- Photo gallery of Indian technologies included in the SARASWATI project
- References
- Contact

6.2. TECHNICAL GUIDELINE FOR TECHNOLOGY DESIGN

- Technical Guideline will be focused on **detailed technology design** of specific technologies, based on the evaluation results of **Pilot actions (WP4)**:

  - Task 4.1: Pilot study 1: Natural wastewater treatment plant system, Raisen, Madhya Pradesh
  - Task 4.1A Pilot study 1A: Trickling filter based treatment system, Burhanpur, Madhya Pradesh
  - Task 4.2: Pilot study 2: UASB/Pond combination for black-water treatment, West Bengal
  - Task 4.3: Pilot study 3: HY-SAF package WWTP, Rishikesh (Uttarakhand)
  - Task 4.4: Pilot study 4: GROW grey-water recycling system, Chennai (Tamil Nadu)
  - Task 4.5: Pilot study 5: Actiflo storm-water treatment system, Nainital (Uttarakhand)
  - Task 4.6: Pilot study 6: Mobile anaerobic sludge digester, West Bengal
  - Task 4.7: Pilot study 7: Closed vessel composting system

  - Sub-tasks c) **Detailed engineering design**: A detailed engineering design including technical drawings will be prepared.

- Feedback with SARASWATI´s Decision Support tool (Task 6.5), principally with key component: "A grafical user interface aimed at facilitating context specific data input, visualising outputs (**design**….."

- Consultation with relevant Indian authorities, such as Pollution Control Board, as is indicated in the proposal

6.3. RECOMMENDATIONS FOR REUSE AND EFFLUENT STANDARDS IN INDIA

Review of existing international standards according different uses:

- WHO (2006)
- EPA (2012)
- FAO Guidelines for agricultural use (1999)

- Australian Guidelines (2003)
- Israel Guidelines (2000)
- Tunisian Decree 89-1047 (1989), Tunisian standard NT106.03 (1989), Proposal of Tunisian Reuse Standard – ONAS, (2011)

- Spanish Royal Decree (1620/2007)
- French Decree (2014)
- Portuguese Norm (NP 4434, 2005), Technical Guidelines for wastewater reuse, (2010)

- Jordanian Standards JS 893/1995 (revised in 2002)
- Turkish Water Pollution Control Regulation (1991)
- Recommended Guidelines by the Palestinian Standards Institute for Treated Wastewater Characteristics according to different applications (Irrigation)
- Morocco (Arrete N° 1276-01 des Normes de Qualite des Eaux Destinees a l'Irrigation) (2002)
- China National Reclaimed Water Quality Standard
- Abu Dabhi, Dubai, Oman, Bahrain (UAE), Qatar… Legislations, (Standards of quality)
- Mexican official Norm-NOM-001-ECOL-1996
- **Indian Guidelines for reuse of treated wastewater (CPHHEO Manual, 2012)**
- **Etc….**

6.3. RECOMMENDATIONS FOR REUSE AND EFFLUENT STANDARDS IN INDIA

Related with Indian standards for water reuse, in the light of the SARASWATI results of WP2 , recommendations for improvement and implementation of other uses, will be elaborated.

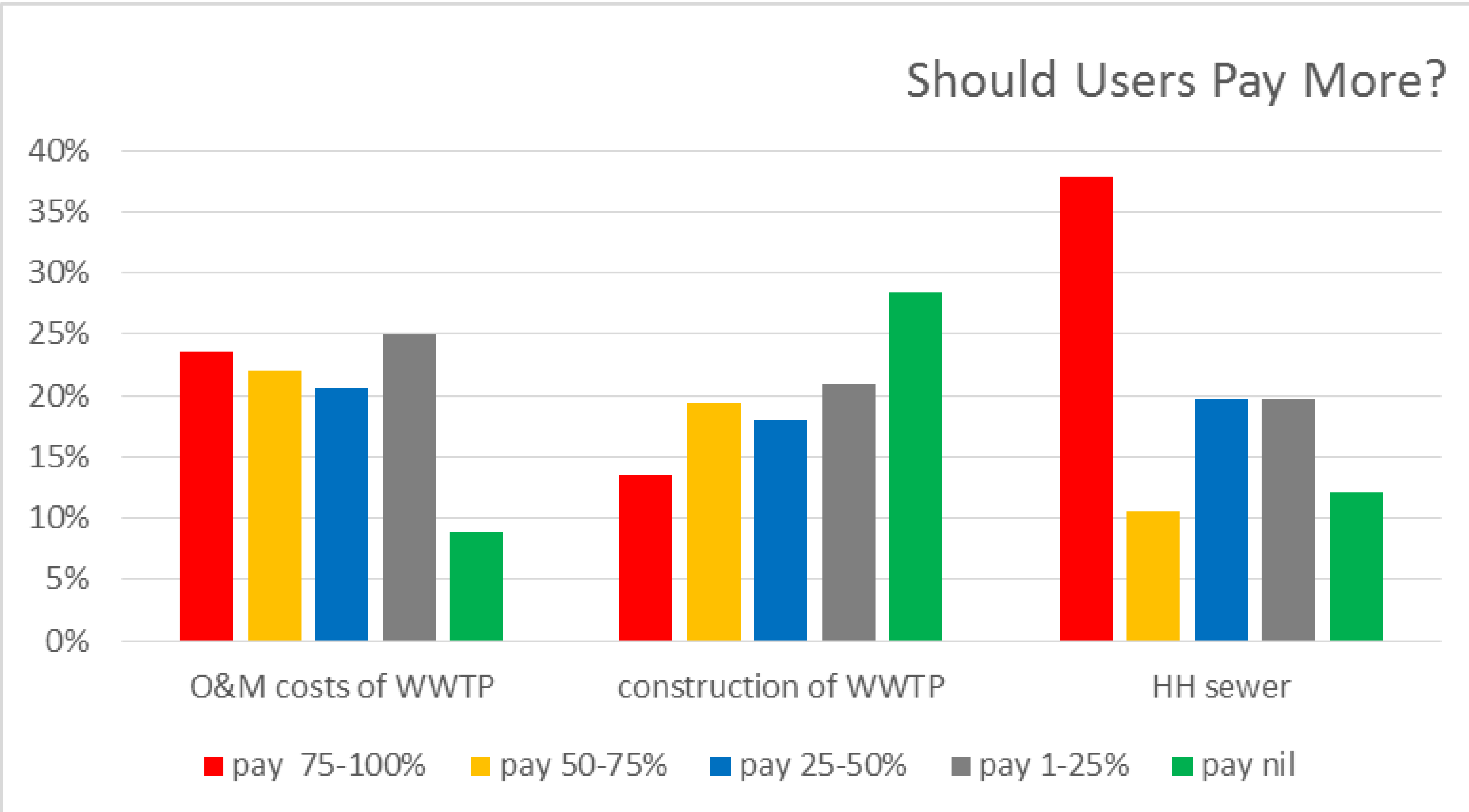
WP 6: Tools for replication and upscaling

- **Task 4: Recommendations for financial and institutional mechanisms**

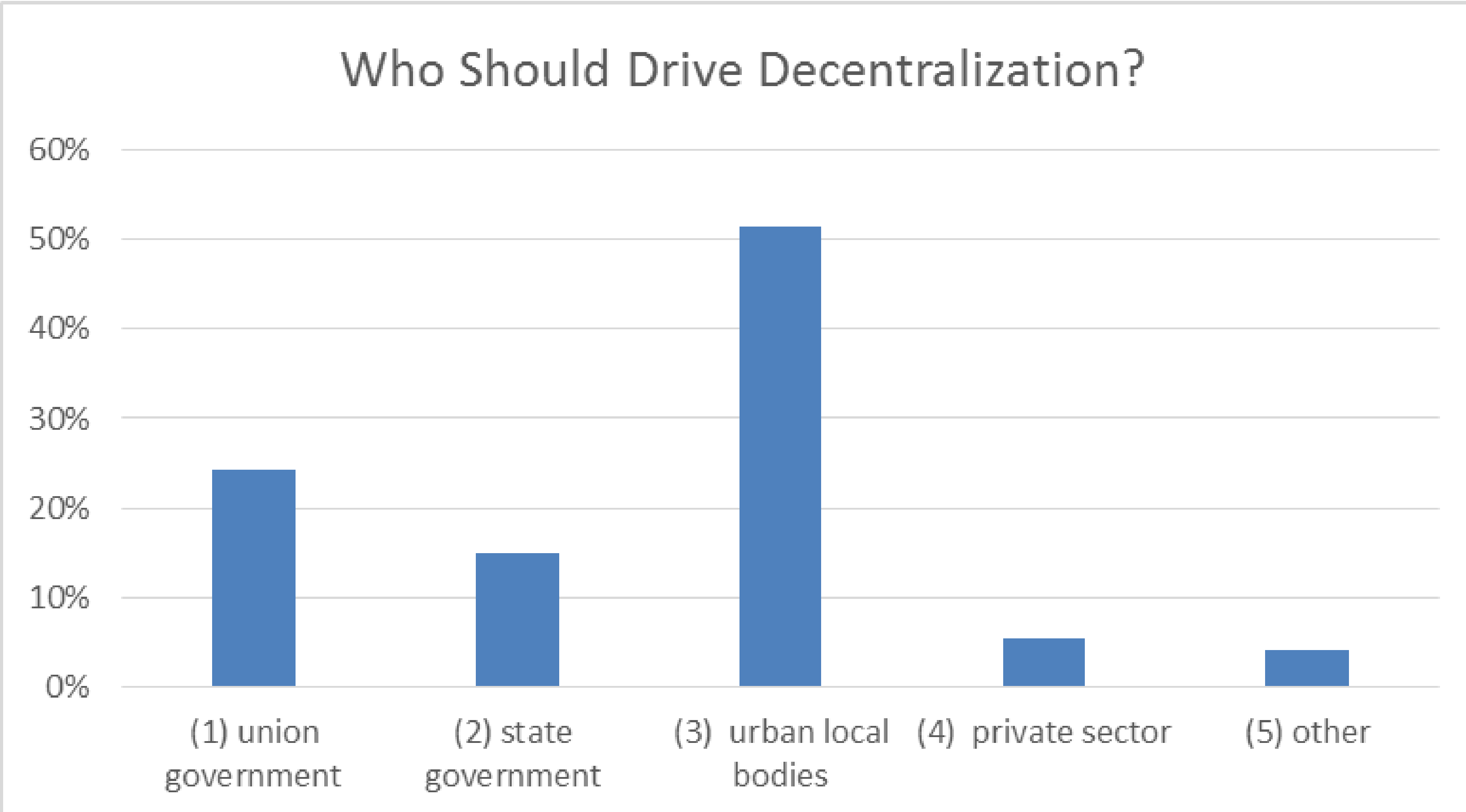
WP 6: Tools for replication and upscaling

- **Task 4: Recommendations for financial and institutional mechanisms**
  - During stakeholder workshops in May 2015 an initial questionnaire survey was conducted
  - Questions related to financing and policy instruments were included
  - 72 stakeholders returned the filled in questionnaire
  - Some results:

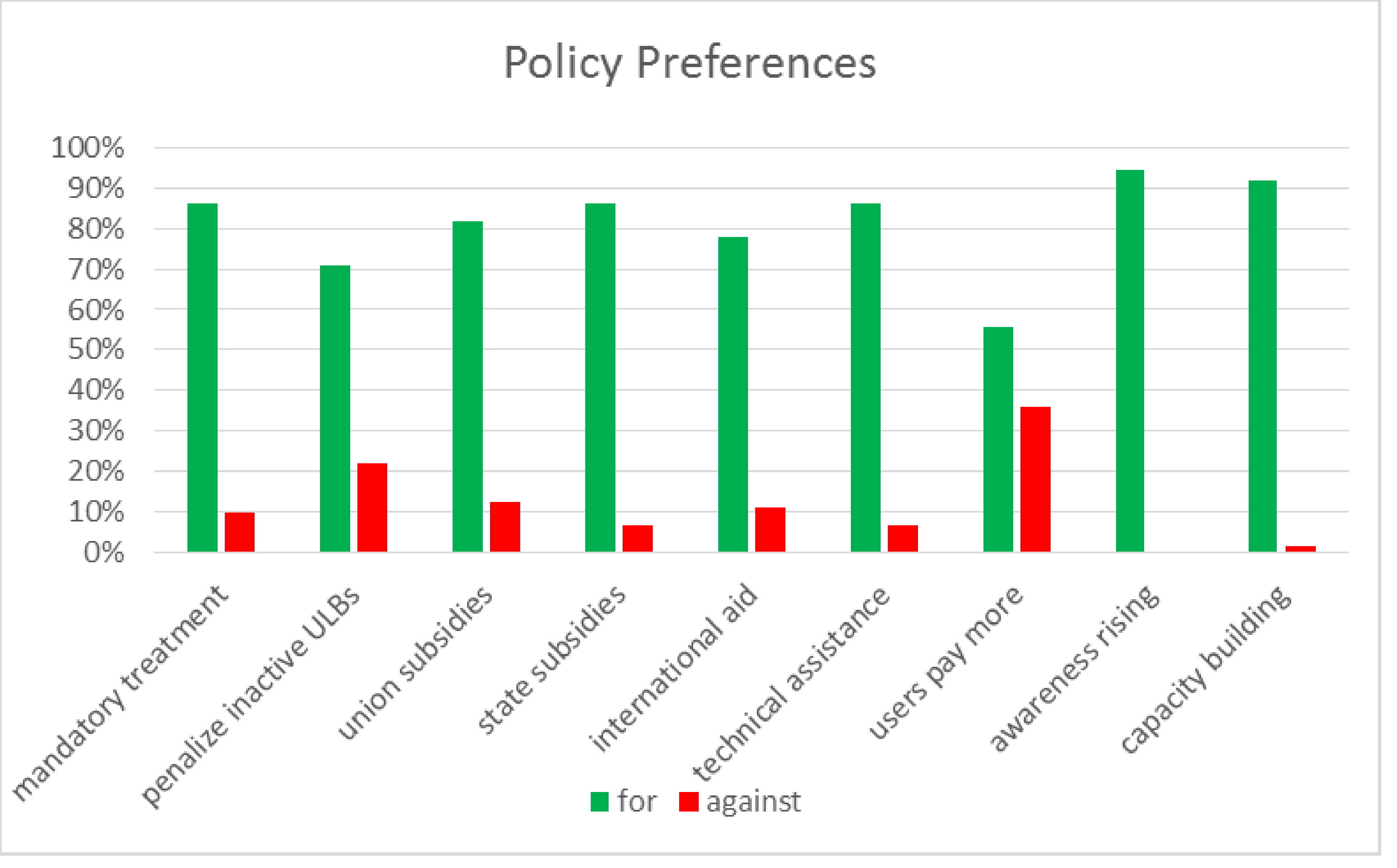
WP 6: Tools for replication and upscaling



WP 6: Tools for replication and upscaling



WP 6: Tools for replication and upscaling



WP 6: Tools for replication and upscaling

- **Task 4: Recommendations for financial and institutional mechanisms - conclusions**
  - No consensus among key stakeholders on key question of financing
  - ULBs and UG seen as most important for driving decentralized wastewater treatment solutions
  - Stakeholders open to various policy instruments
  - Further analysis over coming months

WP 6: Tools for replication and upscaling

- **Task 5: Decision support tool for technology selection**

DSS – technology selection

Treatment **system** selection mainly depends on
- Influent quality and quantity
- Effluent quality required to meet specific end use
- Available resources (cost, land, trained staff etc)

↑

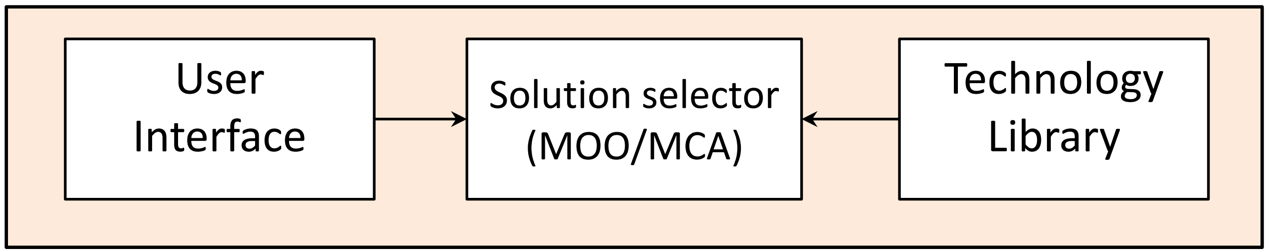
Preliminary treatment → Primary treatment → Secondary treatment → Tertiary treatment

↑

To perform **each stage** of treatment a range of technologies is available. Each technology has different:
- Operational envelop
- Cost
- Energy and carbon implications
- Treatment potential and resulting by-products

← **Pilots of this project**

WiSDOM



The focus of UNEXE effort is the development of **computational architecture** for a functional tool

T5.2 Technology Library (structure)

- **Comprises 7 key elements (and further sub elements)**
  1. **Technology description**
  2. **Technology installation**
  3. **Technology O & M**
  4. **Chemical requirement**
  5. **Cost (CAPEX AND OPEX)**
  6. **Social aspects**
  7. **Treatment performance for priority pollutants**

TECHNOLOGY LIBRARY TEMPLATE

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T5.2 Technology Library (example)

- **Structure of technology library – example of Conventional Activated Sludge**

1. TECHNOLOGY DESCRIPTION		
		Comments
Name of technology	Conventional Activated Sludge Process	
Technology lifespan (years)?	30	
Which sources of wastewater can be treated with this technology?	Domestic	
Does the technology need pretreatment? If so, please indicate here	Yes	
Is the technology suitable for rural/urban areas?	Both	
Does it require frequent monitoring?	Yes	
Is there any published literature, brochures, images, technical reports available?	Yes	
If so, please provide sources	see below	
Deliverable 1.1 + Joksimovic, 2006.		

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Task 6.5: User friendly Decision Support Tool

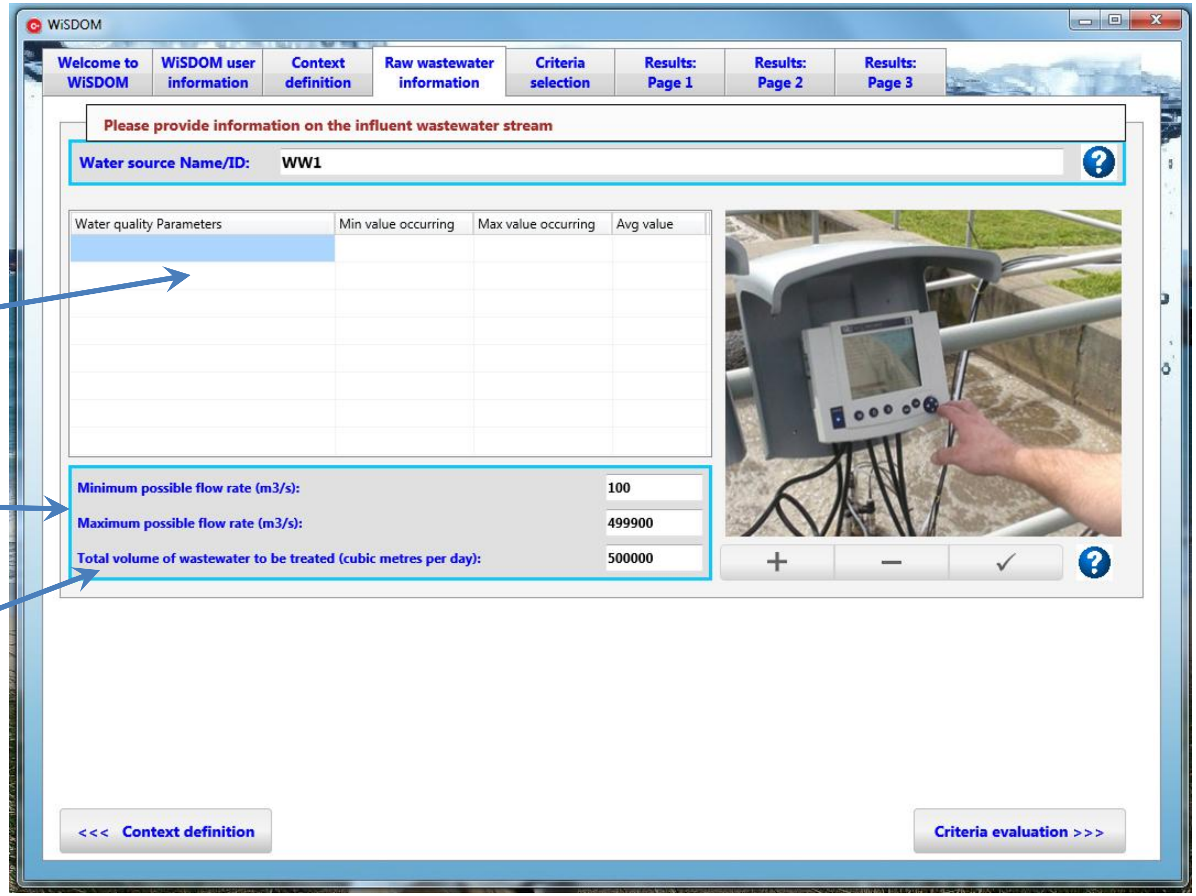
“WiSDOM”

Raw Wastewater Info tab

Agreed raw wastewater quality parameters will appear here:

Details of min and max flow rates entered by user

Total volume calculated automatically from info on Context Definition tab



WP 7: Dissemination

- Several dissemination activities at various events
- Peer reviewed publications in international journals

Awareness raising activities in the pilot study sites e.g.:

Environmental Science & Technology

Acknowledgements

- Project supported by the European Commission’s FP7 (Grant Number 308672) and DST, GOI under EU-India co-operation in water technology: research and innovation