13th IWA Specialized Conference on Small Water and Wastewater Systems
5th IWA Specialized Conference on Resources-Oriented Sanitation

the international water association

Technological improvements in compact UASB/SBTF systems for decentralized sewage treatment in developing countries

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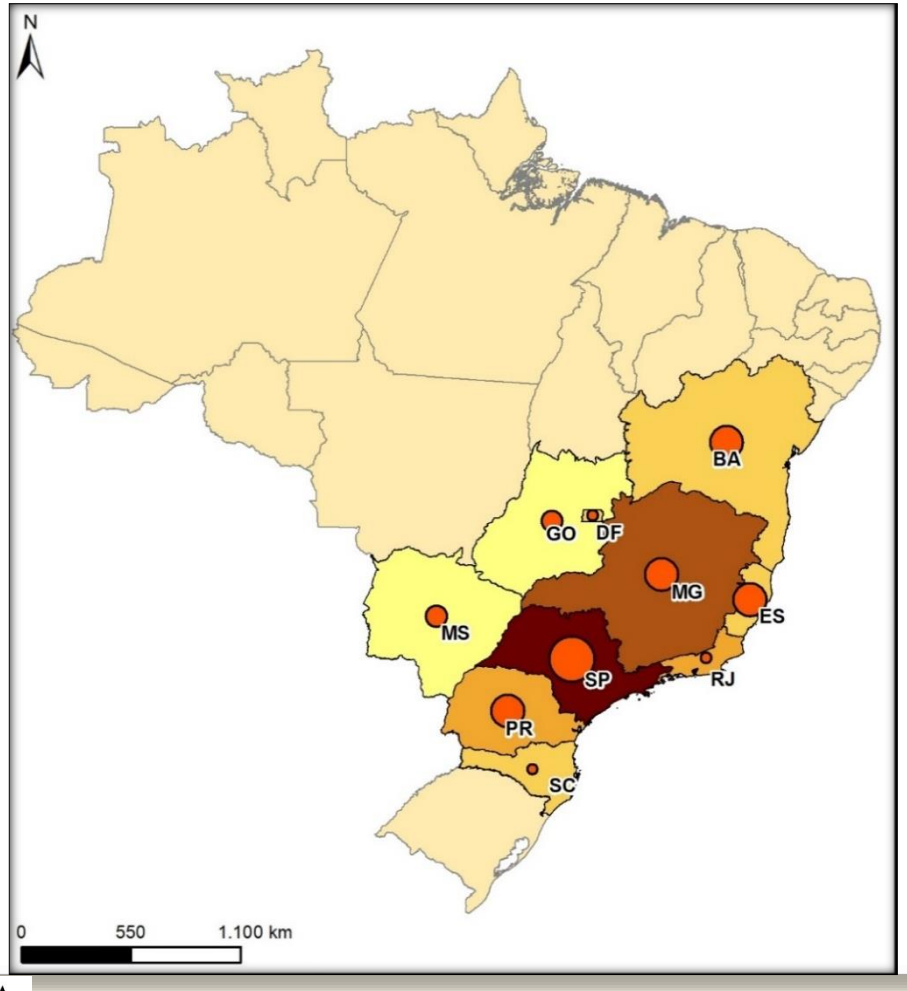
DESA UFMG

Acceptance of the anaerobic technology for domestic sewage treatment - updated Brazilian data

- Brazilian urban population (**152.6 M** inhabitants)
- Sample universe: **1439** STPs (**73.7 M** inhabitants)

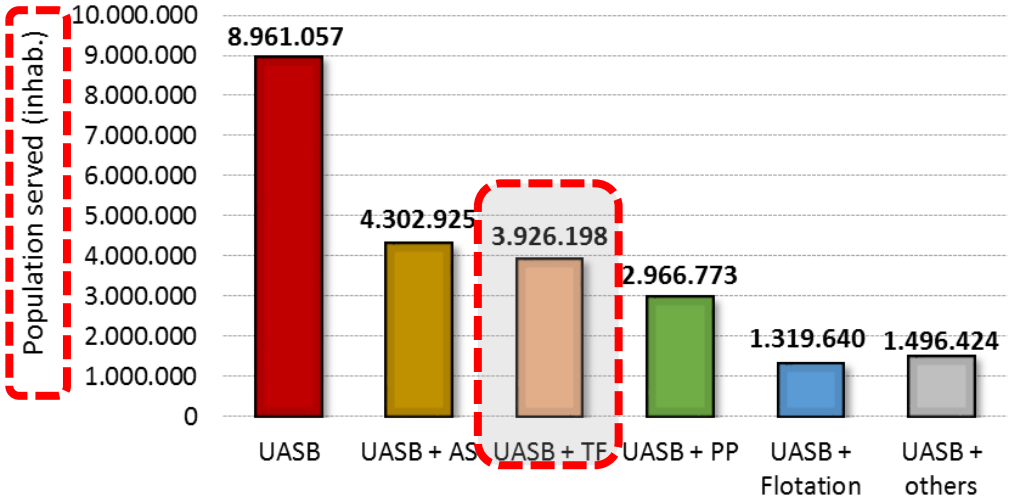


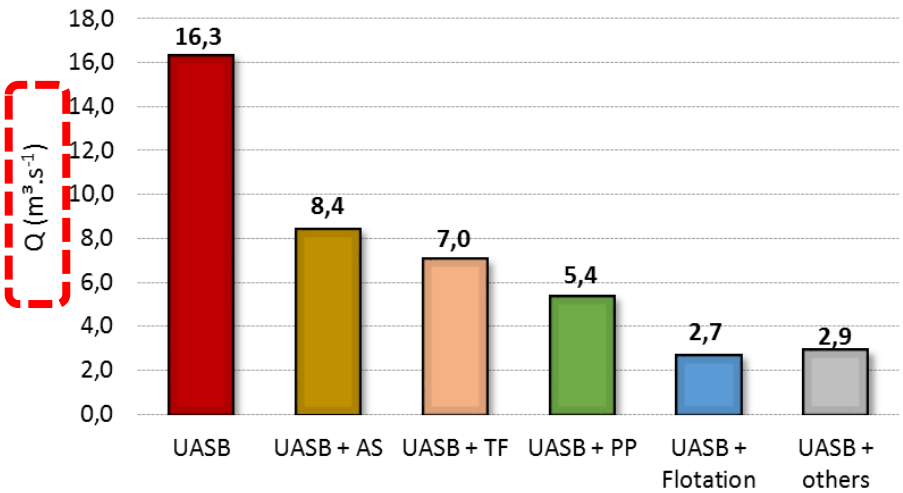
UASB reactors

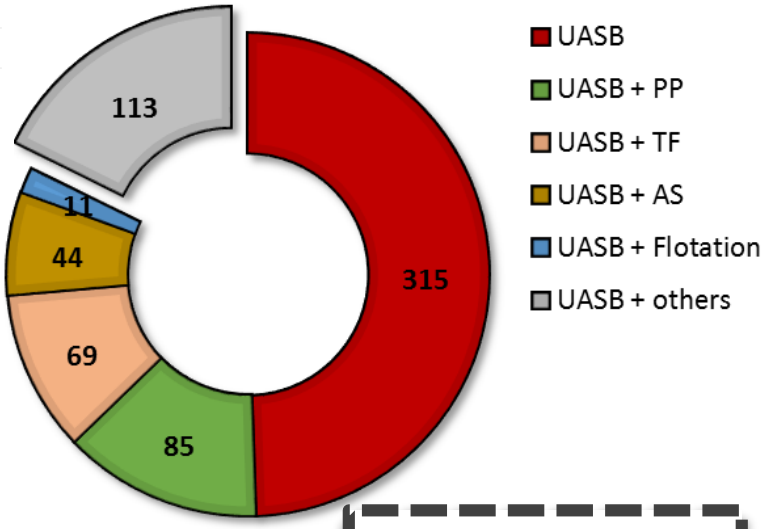
State	Treated sewage flow ($m^3.s^{-1}$)	Population served
DF	3,3	1.847.850
MG	11,8	6.532.306
SP	6,8	3.284.438
SC	1,5	780.559
RJ	1,7	447.327
ES	0,6	307.343
PR	12,4	6.894.283
BA	2,9	1.600.659
GO	0,6	306.972
MS	1,4	971.280
∑	**42,8**	**22.973.017**

UASB and post-treatment in Brazil

- **Sample universe: 1439 STPs (9 states + Federal District)**







637 STPs

Developing countries

- Enormous sanitation deficit
- Shortage of financial resources
- Lack of qualified personal for operation
- Need of low cost, sustainable and simplified sewage treatment systems

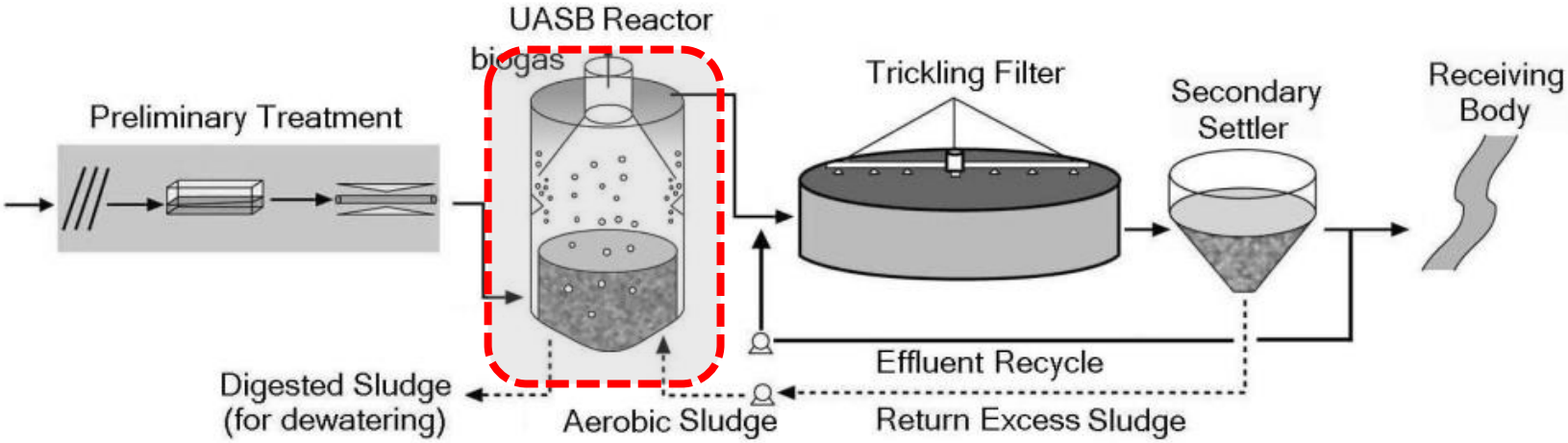
Combined **anaerobic + simple post-treatment** systems fit these criteria and can play a major role towards sustainable sewage treatment plants

Some alternatives:

- *UASB + Polishing Ponds*
- *UASB + Wetlands*
- ***UASB + Trickling Filters***

The idea behind the proposal

UASB + TF system

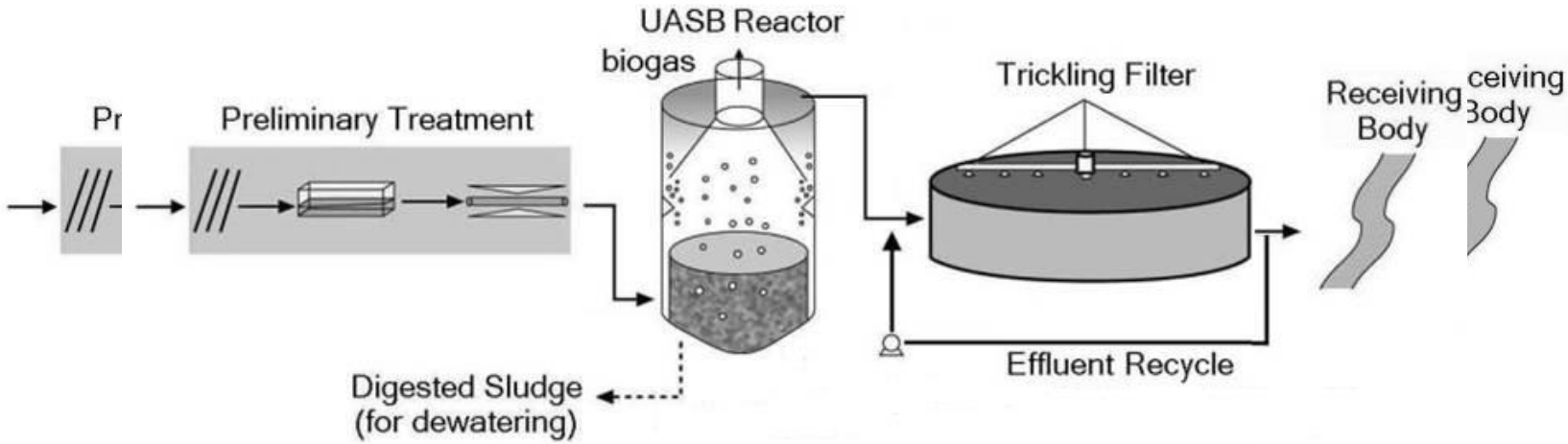


Central player

- Possibility of energy recovery
- Lower construction costs
- Lower O&M costs
- Simple to operate

The idea behind the proposal

UASB + SBTF system



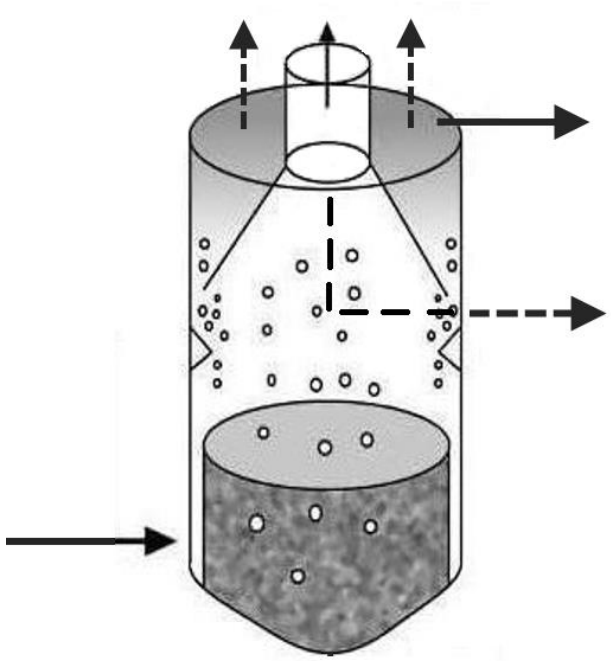
- Reduced sludge management
- Proper effluent quality
- Compactness (< 0,03 m²/inhab.)

Parameter	Effluent ($mg.L^{-1}$)	Removal efficiency (%)
COD	< 100	80 – 85
BOD	< 40	85 – 90
TSS	< 40	75 – 80
NH_4^+	< 15	60 – 90
E. coli	< 1 E05 $MPN.100ml^{-1}$	> 4,0 log. units

Current Limitations and Constraints

Gas phase

- Waste gas
  - Can be collected and treated (ex. biofilter)



Liquid phase

- Residual carbon, ammonia and pathogens
  - Can be removed in the aerobic post-treatment of the liquid phase

Solid phase

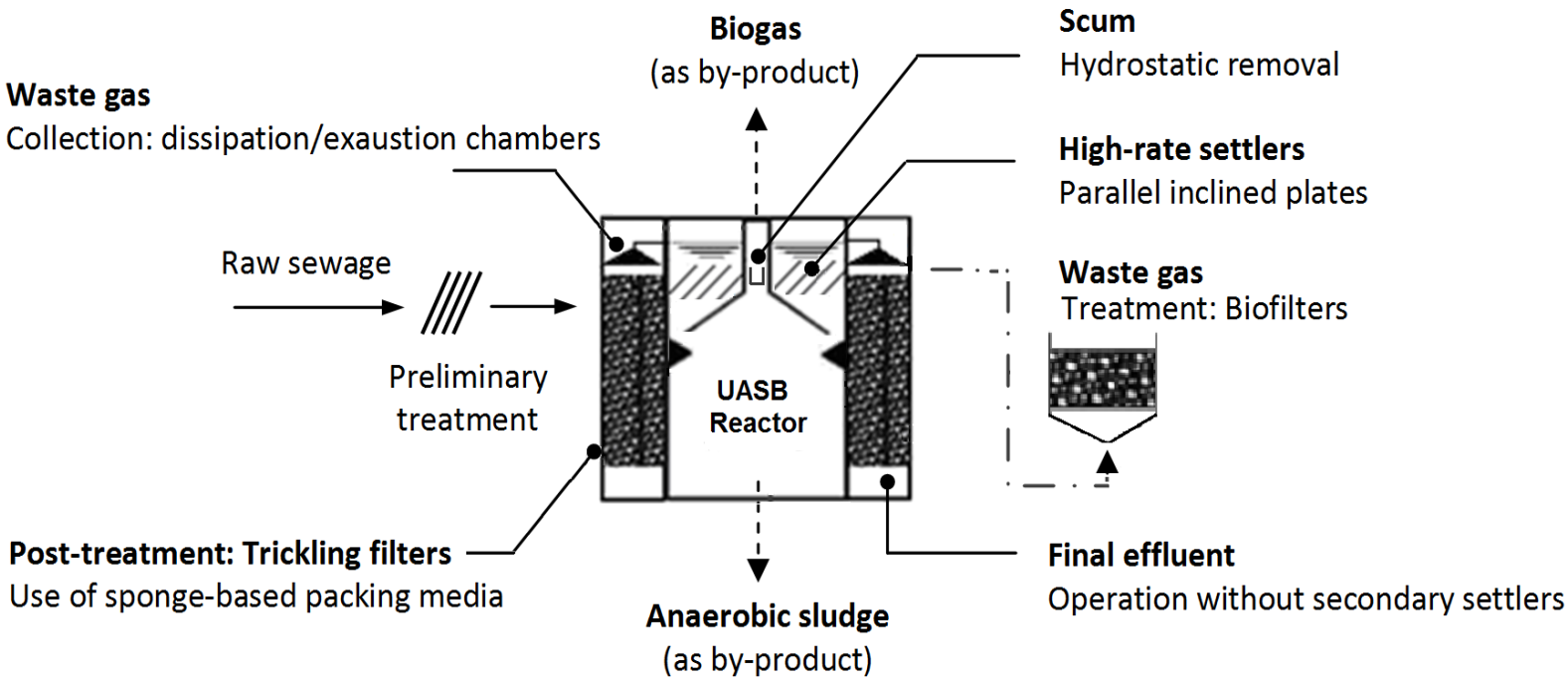
- Scum management
  - Can be controlled inside the TPS (ex. hydrostatic removal system)

Main objective

Present a compact sewage treatment system that incorporates technological improvements matching current constraints

- Effluent quality improvements with the use of **high rate settlers** in the anaerobic step followed by **sponge-bed tricking filters**
- Procedures for **scum management** using a **hydrostatic removal device**
- The use of a cost-effective **biofilter** for the treatment of **waste-gas**

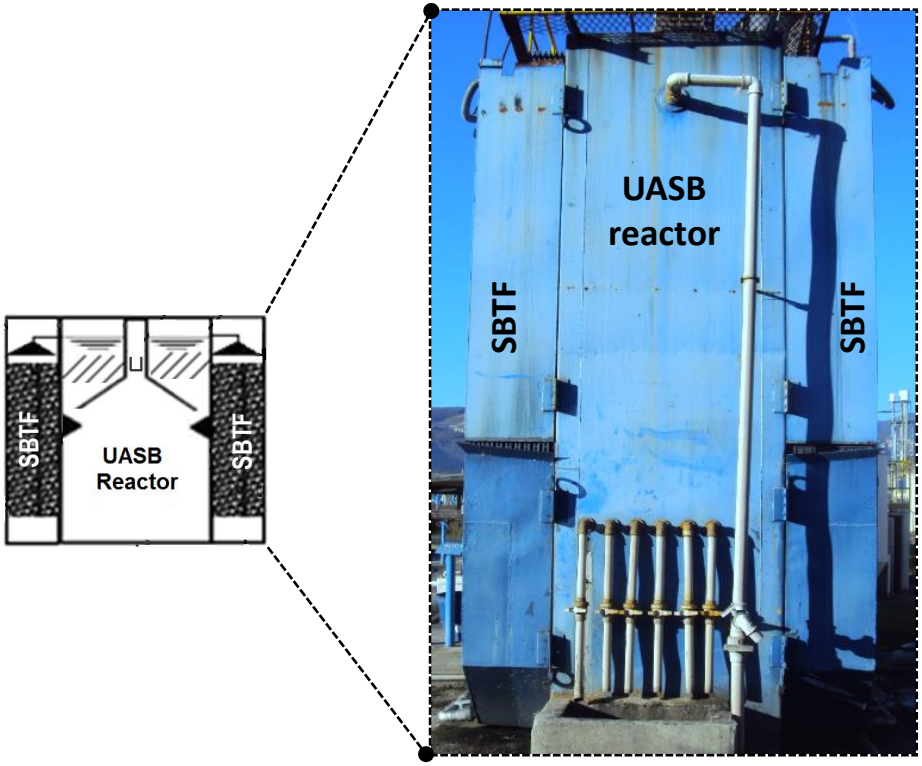
Material and Methods



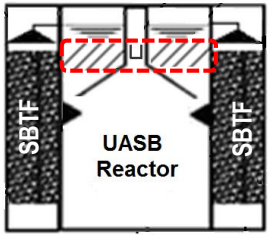
Characteristics	unit	UASB reactor	SBTF	Dissipation chamber	Biofilter
Average flow	$m^3.d^{-1}$	45.7	13.8	45.7	0.3 - 1.5
Useful height	m	4.5	3.5	1.0	1.0
Useful volume	m^3	16.8	4.4[2]	0.008	0.008
Organic loading rate	$kgCOD.m^{-3}.d^{-1}$	1.4	0.8	-	-
Hydraulic loading rate	$m^3.m^{-2}.d^{-1}$	13.0	11.5	1448.3	-
Retention time	h	8.6	3.0	-	0.12 – 0,71

Material and Methods

- Improvements for the treatment of the **liquid phase**: UASB and TF effluent quality



High rate settler
(lamella plates)



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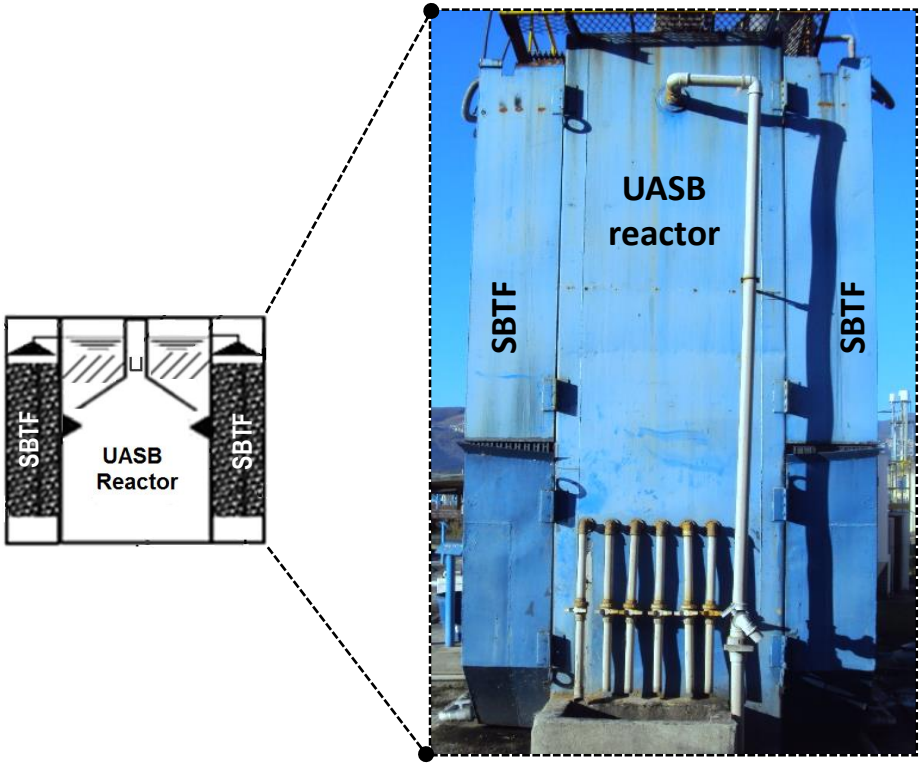
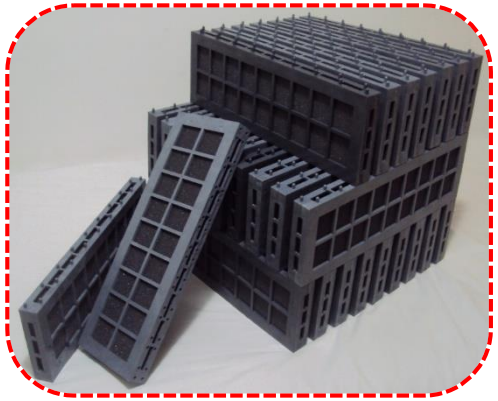
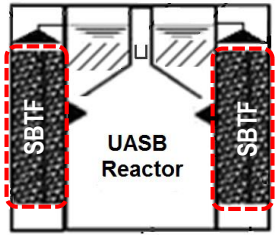
Material and Methods

- Improvements for the treatment of the **liquid phase**: <u>UASB and TF effluent quality</u>





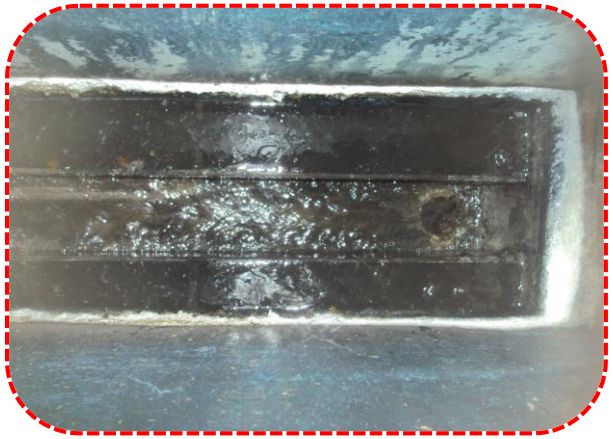
Self-structured packing media

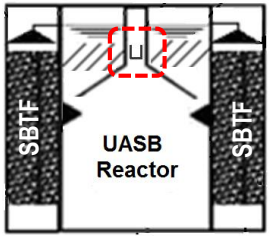


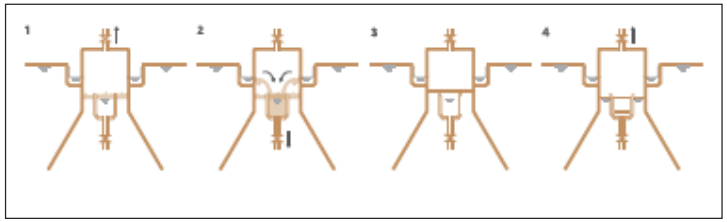
Centre for Research and Training in Sanitation (*CePTS*)

Material and Methods

- Improvements for the treatment of the **solid phase**: <u>scum management</u>





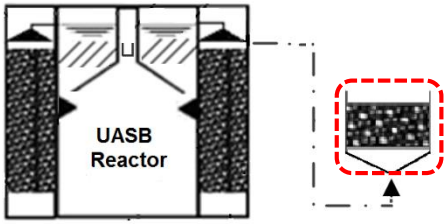


Hydrostatic scum removal device

Centre for Research and Training in Sanitation
(*CePTS*)

Material and Methods

- **Gas phase**: <u>waste gas treatment</u>



Biofilters

Composted leaves

60%

+ 40%

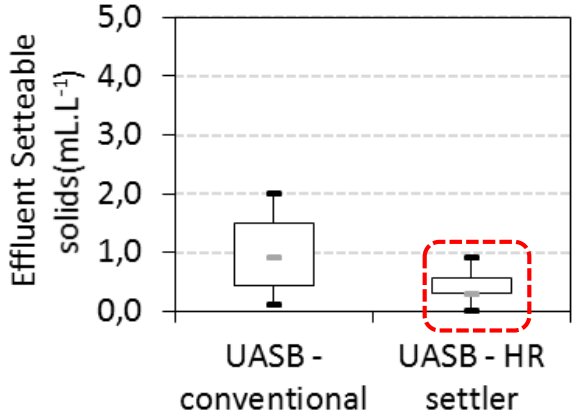
Blast furnace slag

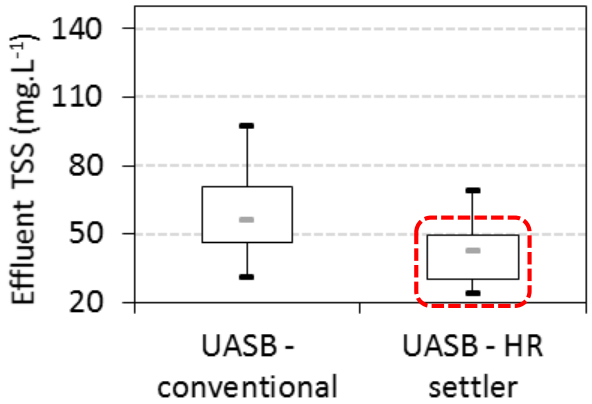
Expanded vermiculite

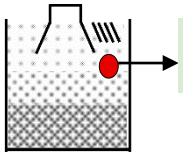
<u>Biobob®</u>

Results

- Technological improvements regarding UASB reactors: **HR settler**







TS < 0,5%

Anaerobic sludge management: **key factor**

- ➢ Effluent TSS concentrations was **30% lower** with the use of high rate settlers.
- ➢ **Smaller data variability** with the use of high rate settlers was observed, even operating the system under a typical full-scale STP flow regime.

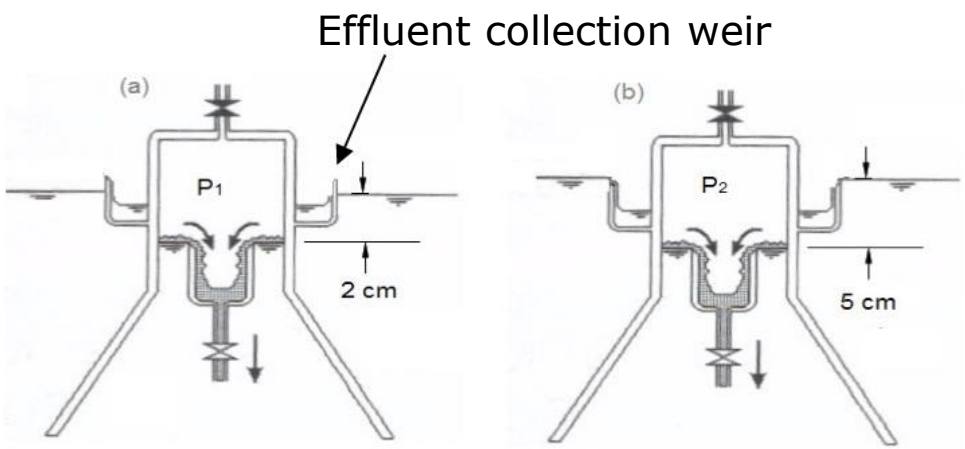
12% decrease of total COD effluent concentration

Results

- Technological improvements regarding UASB reactors: **scum management**

➢ Scum accumulation coefficient varied between 5.0 and 12.3 $gTS.kgCOD^{-1}_{applied}$: importance of a **proper sludge management**

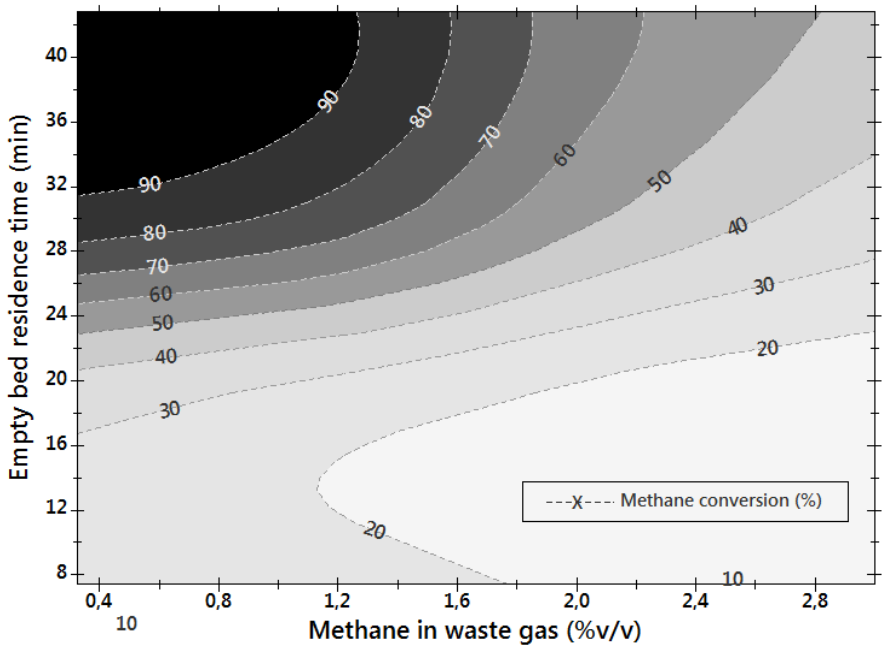
➢ Best discharge routine:
- frequency of discharge of 5 $days.week^{-1}$
- level of scum between 2 and 5 cm below the edge of the collection weir



Scum volume corresponded to only **0.05%** of the sewage volume treated during two consecutive operations of scum discharge

Results

- Technological improvements regarding UASB reactors: **biofilters (waste gas)**

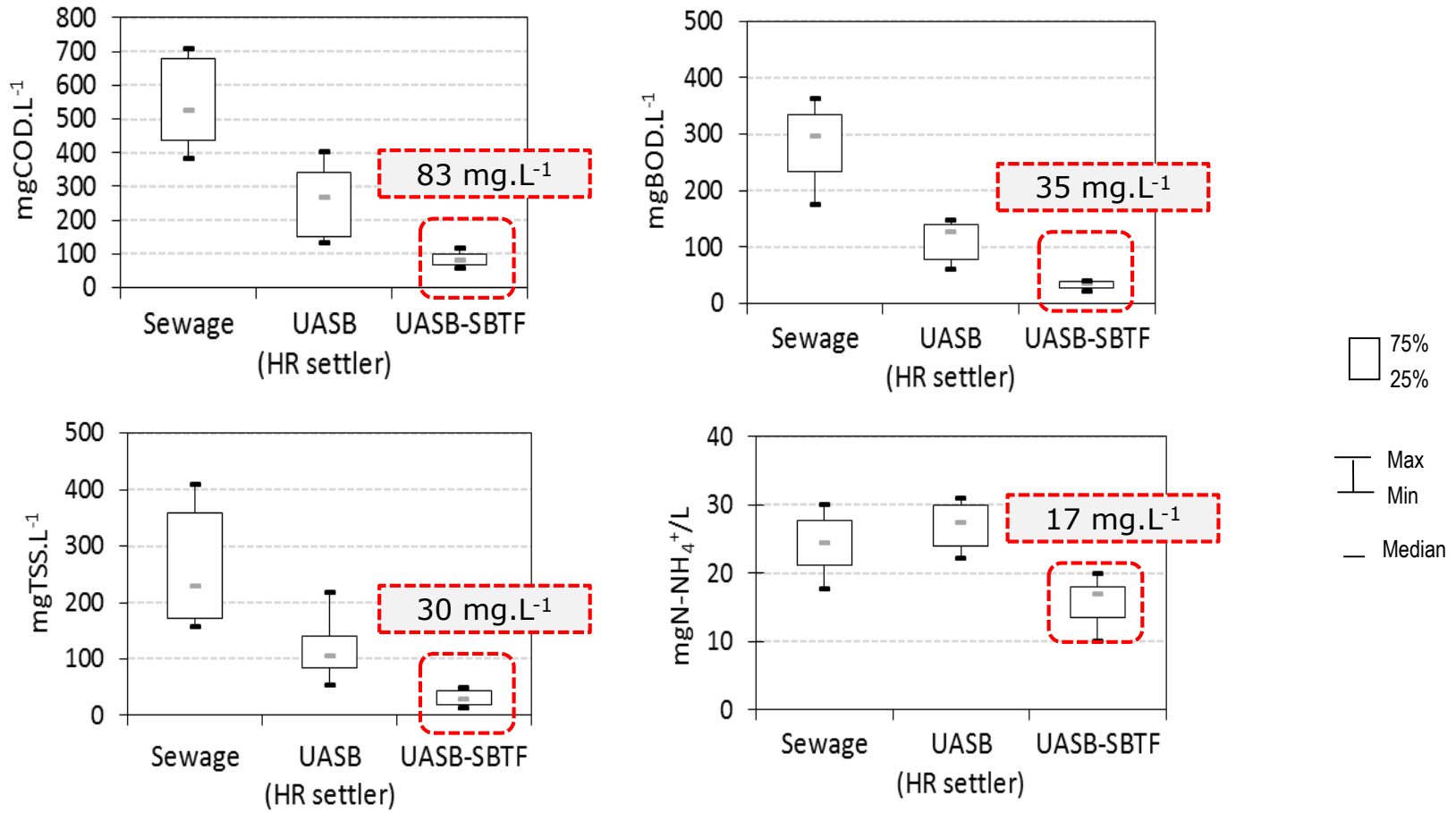


Potential use of **composted leaves** and **expanded vermiculite** for the treatment of waste gas from UASB reactors treating domestic sewage

➢ The CH_4 conversions decreased gradually (from above 90% to below 10%) with the increase of the CH_4 inlet concentration and decrease of the **EBRT**

Results

- Technological improvements regarding SBTF



- Total coliforms and *Escherichia coli* removals: 4.3 and 3.5 log units, respectively

Final Remarks

- The operation of the UASB reactor with **high rate settlers** and the use of a **sponge-bed trickling filter** without final clarifier post-UASB reactor can lead to the production of a final effluent that can consistently comply with the discharge standards adopted in developing countries.

- The use of a **hydrostatic scum removal** device has shown promising and effective results, requiring a minimal level of operation and expertise.

Final Remarks

- The use of **desorption chambers** followed by **biofilters** for collection and treatment of dissolved gases present in the effluent of UASB reactors seems to be appropriate for a decentralized system applied to developing countries, although further research is needed for the simultaneous treatment of CH_4 and H_2S.

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Thank you for your kind attention

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