CARIBSAN

WP3 Capacity building

Report on the webinar « Discovering treatment wetland technologies for wastewater treatment »

Version 3, 6 January 2021

Le projet CARIBSAN est cofinancé par le programme INTERREG Caraïbes au titre du Fonds Européen de Développement Régional, par l'Agence Française de Développement ainsi que les Offices de l'Eau Martinique et Guadeloupe.

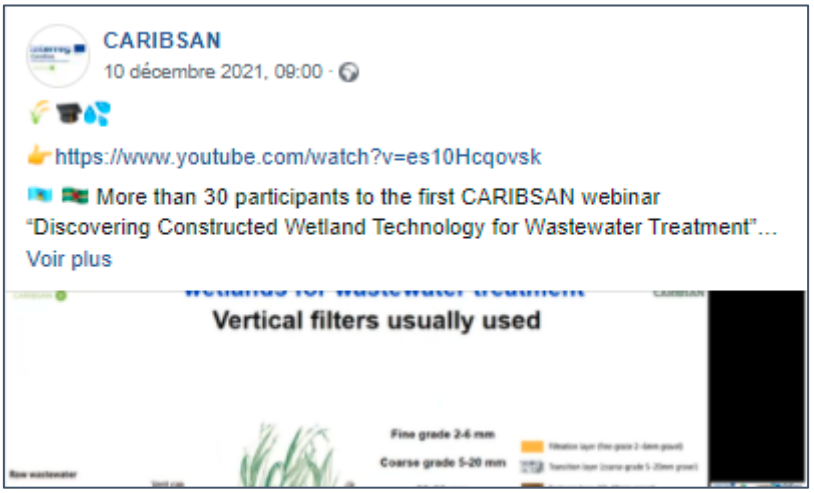
1. Context and objectives

This document is a summary of the first webinar organised in the framework of CARIBSAN project on constructed wetlands.

One of the main objective of CARIBSAN project is to promote constructed wetlands for wastewater treatment and disseminate knowledge on this technique to Caribbean actors. Work package 3 "Capacity building" of the project aims at providing technical training for local utilities on treatment wetlands and disseminating technical knowledge. In this framework, a first webinar ***« Discovering treatment wetland technologies for wastewater treatment »*** was organized on **Wednesday 8th December 2021** in collaboration with **CAWASA,** the regional organization of water utilities, which organizes already webinar for its members. This was the first webinar in a series of 3 which aims to familiarise sanitation actors of Caribbean region to treatment wetland for wastewater treatment.

The webinar was organised on **Zoom** and gathered up to **37 participants**. It consisted of a **one-hour presentation by experts and a 30-minute question and answer session. The recording of the webinar is available here: https://www.youtube.com/watch?v=es10Hcqovsk**

Invitations to the webinar were sent to CAWASA members. Communication was done before and after the event, as seen below.



2. Participants

The webinar was targeting English-speaking CAWASA members, mainly water utilities. The 37 participants represented 6 countries (Antigua and Barbuda, Barbados, Dominica, France, Saint Lucia, Trinidad and Tobago), as described in the list below. Two participants represented the Organisation of Eastern Caribbean States. Three people represented consultancies companies.

3. Questions/answers session

A lot of questions were asked by the participants. The table resumes the Q&A session.

Operation and maintenance	
What is the reason for the annual cutting of vegetation if the plants are part of the wetland? And then do we need to replant them? Is it pruning or trimming?	Removal of plants is necessary to avoid their decomposition on the surface of the system at their end of life, which could lead to clogging problems by increasing sludge production (sludge + vegetal). It is not necessary to replant, this happens spontaneously thanks to the roots and rhizomes in the filter.
You mentioned odour problems briefly. Is it a common issue or easy to control?	Odours are quite easy to control. In tropical climate (T= 25 – 30°C), odours can come mainly from the sewer itself (whatever the treatment technology) or from the batch feeding system. In that case, sizing of the system can be adapted to reduce residence times in the batch feeding system.
In a small housing complex that host about 300 persons, is daily maintenance required? If so what sort of activities are required and how many workers are needed to maintenance this type of system?	Operation and maintenance tasks are quite simple and do not require a high level of technical competencies. Maintenance is not needed daily, only twice a week (10 minutes for visual check, adjustment of the alimented system). Main other tasks are: cleaning of the pumping or batch-feeding system once a month, removing of weeds once a month, and plants cutting once a year.
What's about methane production and other gases from treatment wetlands (TW)?	We are looking for aerobic conditions in the TW and never anaerobic conditions. Thus, if the TW is well designed, there is not methane neither H_2S production.
Treatment performances	
What about effectiveness/performance during dry and wet seasons as experienced in the Caribbean?	The design is usually done for the worst period (period of higher flow). TW can accept up to the double of their nominal flow. If the flow during rainy events is higher than the double, the surface must be adapted. If the hydraulic flow is too low, risk of water stress for plants and competition with weeds. In that case, design can be adapted as well by recirculation (need of energy) or the implementation of a saturated zone at the bottom.
Are the treatment wetlands effective for oil and grease removal? And microplastics? What about the effect of toxic chemicals (such as ammonia, pesticides, etc..) on the biological components of the wetlands?	For classic domestic effluents with wastewater from restaurants or run-off from roads containing oil, there is not impact and the treatment can be done. If concentration are higher than normal (petroleum industry for example) very different design of TW must be envisaged. First available studies indicate the same performances on microplastics than for TSS (over 80%). If pesticides are in higher concentrations than usually in domestic WW (for example, water from cleaning of pesticide tank), it may kill the plants. In that case specific design adaptation must be done
Use of plants	
Apart from tolerance to anoxic and water stress, what are some of the properties of the suitable plant species in the Caribbean which make them effective for CW use?	In TW, plant play mainly a mechanical role (stem development passing through the deposit layer and allow maintaining permeability). To reach this mechanical role the development of the plant must be quite fast and homogeneous. This must be plants growing by rhizomes, local plants and not invasive, quite robust for competition

	with other plants, and they must not store water in their leaves (to avoid mosquitoes). Their metabolism must insure their development during hydric stress (resting periods).
Have any studies been done on vegetation grown within this system to be used as feed stock that may be eaten by ruminant animals, if introduced in rural communities in the Caribbean or elsewhere?	Some studies where done in Africa where there is a need for feedstock. In France, it is not allowed because of the possible risk of transfer of human pathogens to animals.
Design and construction	
How the type of soil can affect the wetlands? Which process is used for selection of the wetland area? Since we live in different countries looking forward for the implementation of treatment wetlands, has an assessment/study being done concerning permeability of soil for the type of plant to use?	It must be reminded that we do not use natural soil to avoid clogging risks. We use specific materials (according to the materials locally available), generally sand and gravel, more stable over time, to constitute the system.
What is the typical overall installation cost per population equivalent (PE)[1]? **Roughly.**	It is hard to give values because it depends on various factors such as price of materials, price of man work, of land, etc. We observe generally that the smaller the system, the higher the cost per habitant. In terms of investment, TW systems are generally cheaper than activated sludge systems for WWTP up to 2,000 PE. Above that, activated sludge start to be more attractive. Concerning operating costs, TWs are almost 5 times cheaper than activated sludge (which requires more electromechanical equipment, energy, etc.). Consequently, taking into account investment and operation cost TW appear more economically interesting until 5,000 PE in European context.
Use of constructed wetlands in the Caribbean region	
Where are we in the development of the WWTP in the non French islands (Cuba, Dominica and Saint Lucia)? Where are we in the development of individual WWTP (<20 PE)? When will TW be authorized for individual treatment (<20PE)?	TW are used in France for more than 30 years. They are more and more applied in USA, Canada and China. In South America a lot of research is also being done. Regarding the use of TW for individual WWTP, in France, agreements have been done for temperate climate and studies are being done to obtain agreement in tropical climate.
What about land requirements, including size requirements per user?	In tropical climate: 0.8 – 1.5 m² of filter / population equivalent (PE)[1]. As an area near the system is needed to permit its operation and maintenance, the total ratio is around 2 – 2.5 m²/PE, according to design and the performances required. Possibility of intensified systems (not yet tested in tropical climate): < 1m² filter /PE with only one stage (total ratio 1.2 – 1.5 m²/PE)

[1] 1 population equivalent (P.E)= quantity of pollution emitted per person per day, 60 g of BOD_5/day

Do you know examples of reuse of treated waste water coming from the treatment wetland?	The majority of reuse cases are reuses in agriculture (Martinique, reuse of rum mill effluent to irrigate banana fields). Other countries: reuse for toilet flushing after disinfection process or reuse of effluents from car washing for car washing.

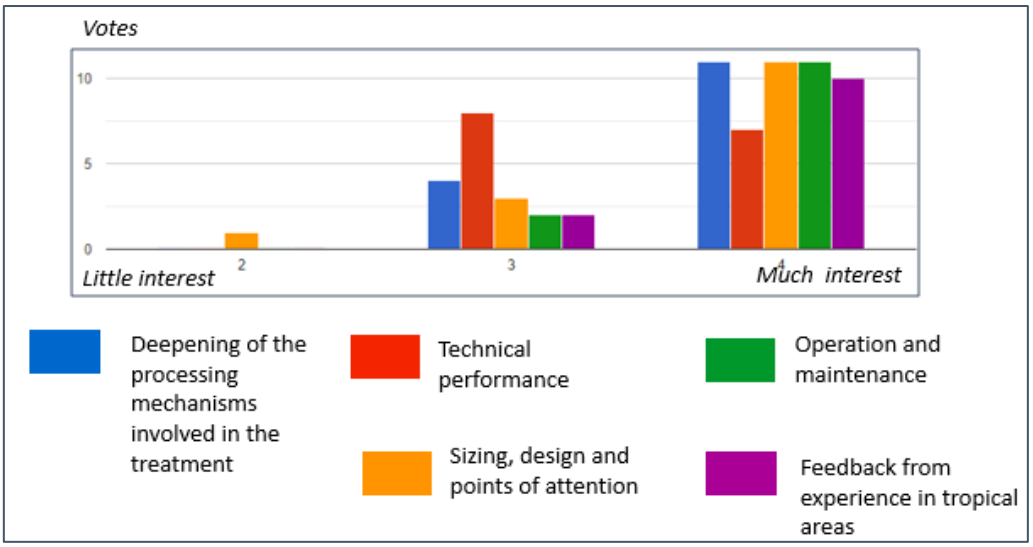
4. Summary of responses to the satisfaction survey

After the webinar, a satisfaction survey was sent to the participants in order to assess their satisfaction, the themes they would like to be covered for the next webinars and/or trainings, and other needs in the perspective of the future of the project. 15 replies have been received, representing the following countries and organisations:

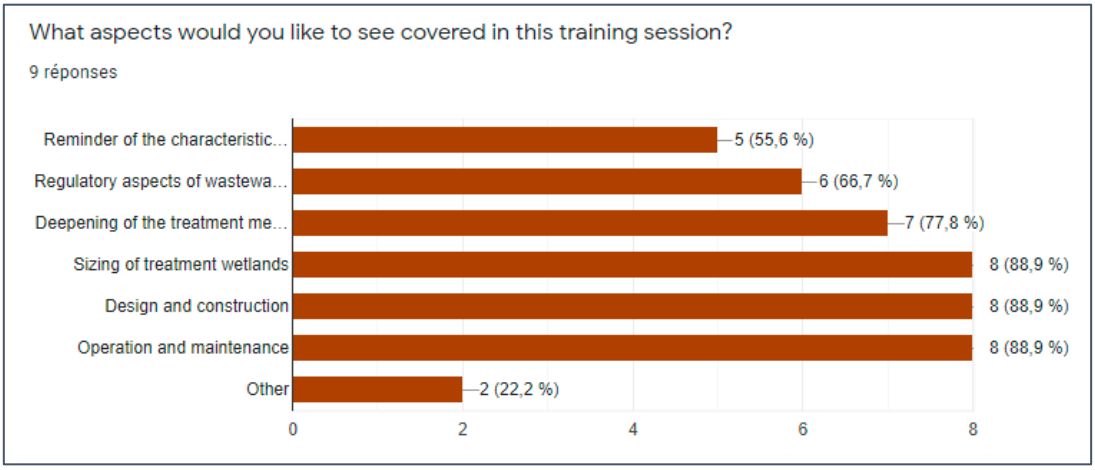
Number of replies	Country	Organisation
1	Antigua and Barbuda	Antigua Public Utilities Authority
1	Barbados	Barbados Water Authority
9	Dominica	DOWASCO
2	Trinidad and Tobago	WASA
2	Trinidad and Tobago	IG Training & Consultancy Ltd

Of the 15 respondents, 11 had heard of treatment wetlands for wastewater treatment prior to the webinar. All of them considered that this first webinar helped them to understand how treatment wetlands work (11 replied “yes” and 4 replied “somewhat yes”). According to the answers received, the 4 chapters of the presentation were appreciated, in particular the general presentation and the different applications of treatment wetlands, as well as the one about the mechanisms involved in the treatment process.

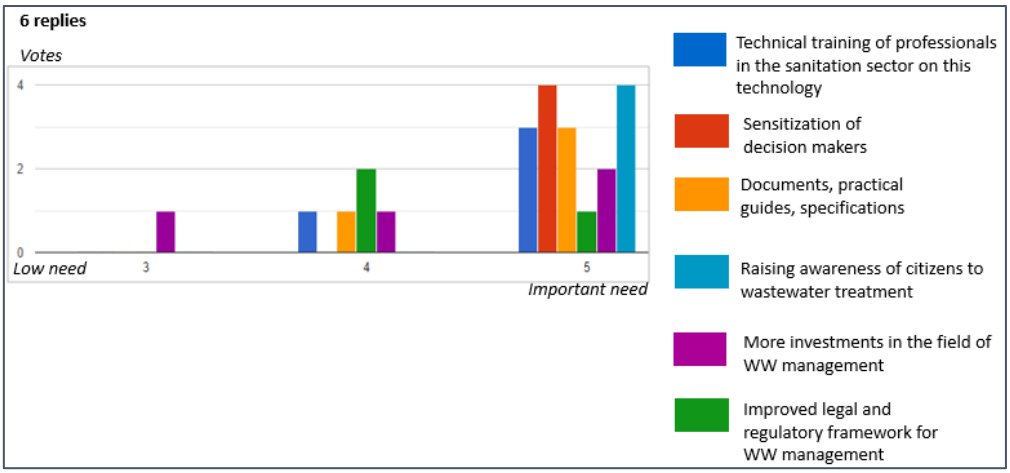
For the next webinar, the participants rated the aspects they would like to be covered as a priority. All the proposed themes are of interest to the participants as shown below, in particular operation and maintenance, processes and sizing and design of treatment wetland.



The results are the same for the participants from DOWASCO, who will benefit from a training session as CARIBSAN partner. This training session could address the following topics as a matter of priority: sizing, design and construction, operation and maintenance. Additionally, comparison with other wastewater treatment techniques and cost analysis would be welcomed.



Regarding the countries not included in this first phase of CARIBSAN project, 4 respondents (out of 6) from Antigua Public Utilities Authority, Barbados Water Authority, WASA and IG Training & Consultancy Ltd think that treatment wetlands could meet the treatment needs of their island. A participant form IG Training & Consultancy Ltd added that *"Due to its relatively low operation and maintenance cost, it is well suited for communities where the mechanical treatment works failed."* To deploy treatment wetlands on their territory, they evaluated their needs as shown below. Awareness raising of citizens and decision-makers seems to be a priority, followed by technical trainings and elaboration and documents and practical guides. Training needs in water and wastewater management, disaster management and emergency preparedness are mentioned.



5. Annex: Presentation

Discovering Treatment wetland technologies for wastewater treatment

CARIBSAN Project – WP3

Wednesday 8 December

2:00 – 3:30 PM (Paris), 9:00 – 10:30 AM (Saint Lucia)

Summary

- **General introduction**
  - Introduction to the CARIBSAN project (5min)
  - Treatment wetlands technologies presentation and applications (10min)
- **Mechanisms involved in Treatment wetlands for wastewater treatment** (15 min)
- **Adaptation for domestic WW treatment in tropical climate** (15 min)
- **Advantages and drawbacks of treatment wetlands** (15 min)
- **Questions/answers** (30 min)

Introduction to the CARIBSAN project

- 9 partners
- 1.7 million €
- 3 main components:
  - Preliminary studies for treatment wetlands implementation in 3 pilote zones
  - Capacity building
  - Communication and dissemination activities
- Duration : 2021 – 2022 + next phase foreseen

Objectives:

- Enhance Caribbean cooperation among actors on sanitation
- Promote constructed wetlands for wastewater treatment and disseminate knowledge on this technique
- Identify sites per country in order to implement constructed wetlands
- Prepare a next phase for their implementation

General introduction

Treatment wetlands technologies presentation and applications

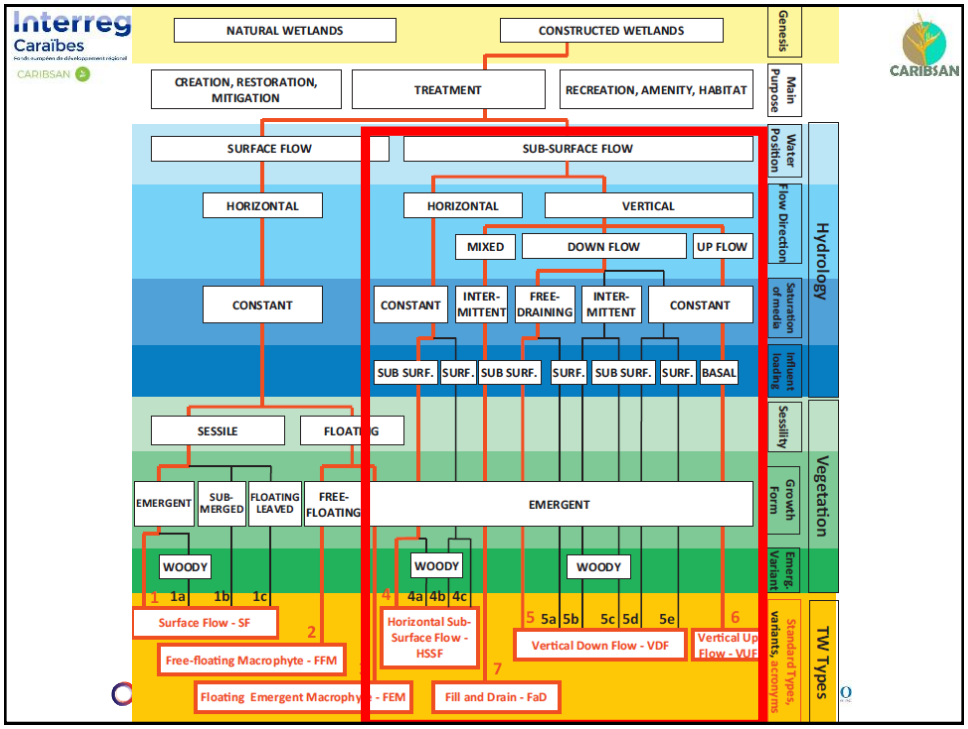
Treatment wetlands technologies presentation and applications

- What is a TW ?
  - An engineered wetland system designed to harness natural process for the purpose of improving water quality
  - Technically and operationally simple, but involving complex interactions between:
    - Water
    - Soil
    - Plants
    - Micro-organisms, and
    - The atmosphere

http://wio.iwaponline.com

ISBN: 9781780408774 (eBook)

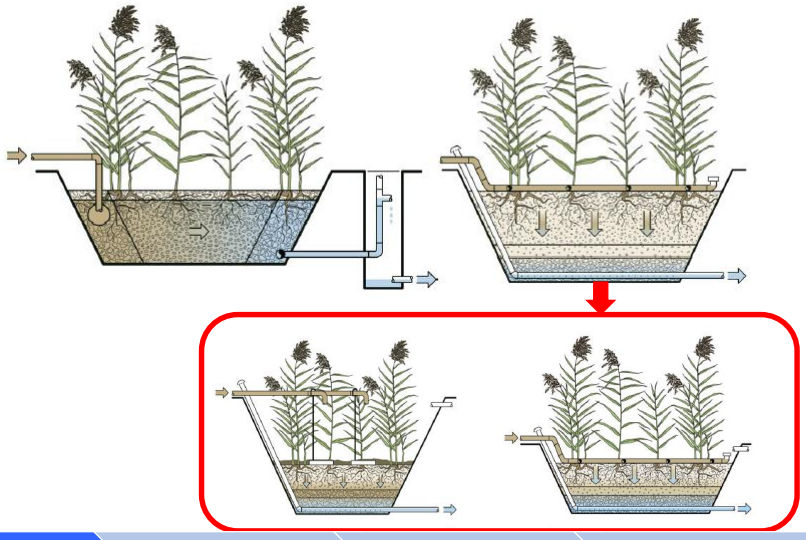
Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks



Treatment wetlands technologies presentation and applications

Horizontal subsurface flow TW

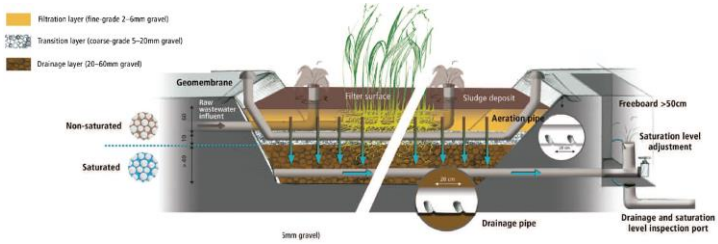
Vertical subsurface flow TW



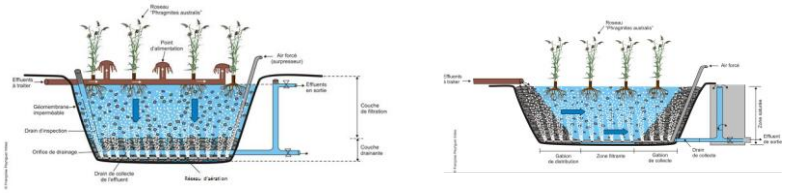
Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Treatment wetlands technologies presentation and applications

Design adaptations



Intensifications – forced aeration



Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

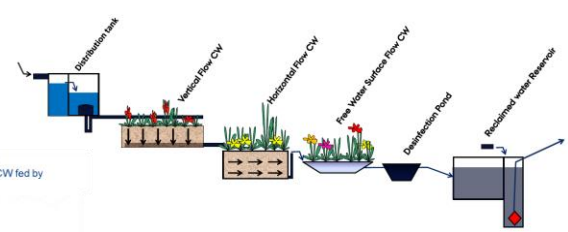
Treatment wetlands technologies presentation and applications

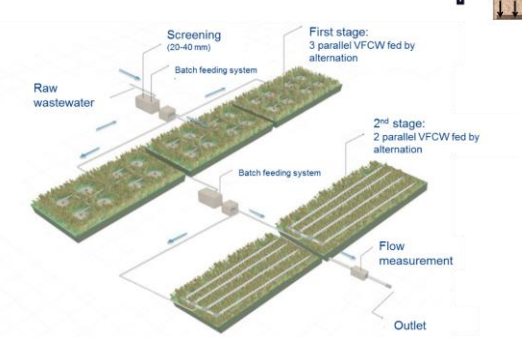
	Vertical unsaturated treatment wetlands	Saturated treatment wetlands
Surface	Surfacic loads	Simplified models $C_{out} = C^* + \frac{(C_{in} - C^*)}{\left(1 + k_V \cdot \frac{\tau}{N}\right)^N}$
	Clogging management	organic load limit to avoid clogging
Climate	Loads and number of filters	$k_T = k_{20}\theta^{(T-20)}$
Media	Particle size and depth	Particle size

Treatment wetlands technologies presentation and applications

According to local context (material available, land use, outlet requirement …):

- Combination of different treatment stages
- Use of recirculation
- Use of reactive materials
- …





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Treatment wetlands technologies presentation and applications

Domestic WW – from household

TSS : 98 %
BOD_5 : 99 %
COD : 94 %
KN : 97 %
TN : 50 – 70 %

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Treatment wetlands technologies presentation and applications

Domestic WW – from household
to big communities

Esthetic aspect is possible

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Treatment wetlands technologies presentation and applications

Sludge treatment

From activated sludge or septage


Danemark – activated sludge


France - septage

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Treatment wetlands technologies presentation and applications

Sludge treatment

From activated sludge or septage

Mayotte Island – activated sludge
5,000 PE

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Treatment wetlands technologies presentation and applications

Storm water – Combined Sewer Overflow (CSO)

France - CSO treatment – 1,500 m^3/d

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Treatment wetlands technologies presentation and applications

Industrial – agro food industries

Chemical industry – USA – Methanol - Benzene

Martinique Island – Rum distillery effluent – 250 m^3/d

https://www.terrerhum.org/

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Treatment wetlands technologies presentation and applications

Introduced into urban area for reuse purpose

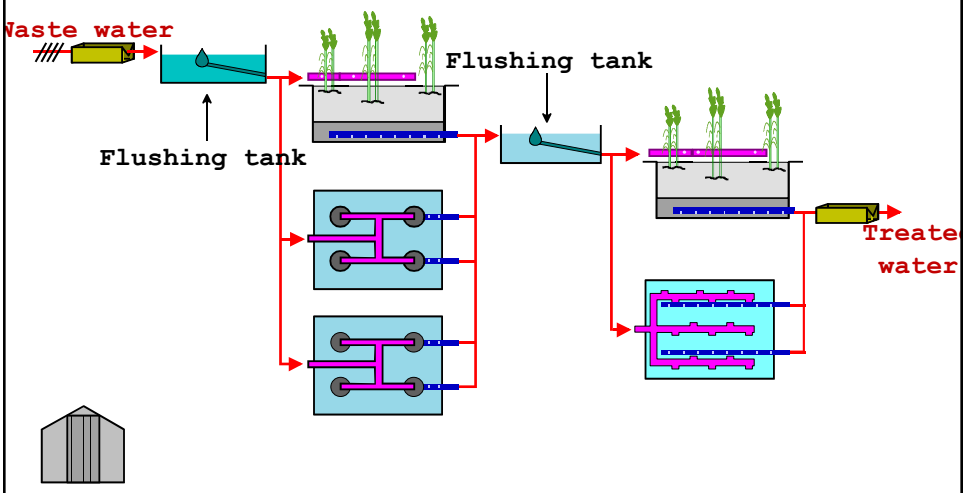
Treated WW reuse for toilet flushing

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Mechanisms involved in constructed wetlands for wastewater treatment

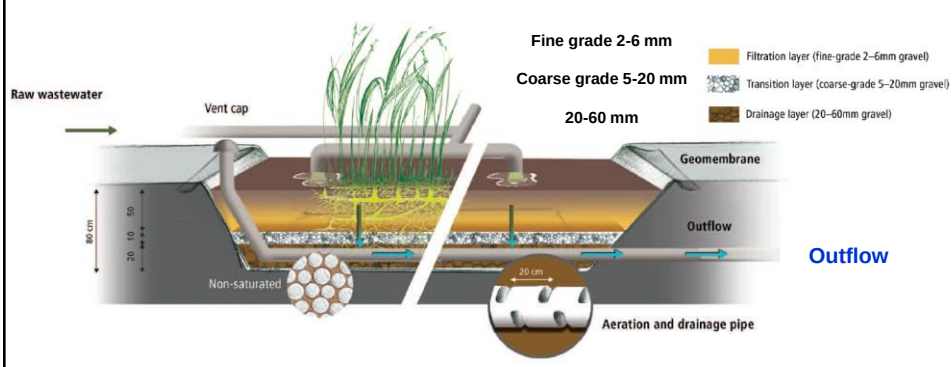
Mechanisms involved in constructed wetlands for wastewater treatment

Classical WWTP in metropolitan France



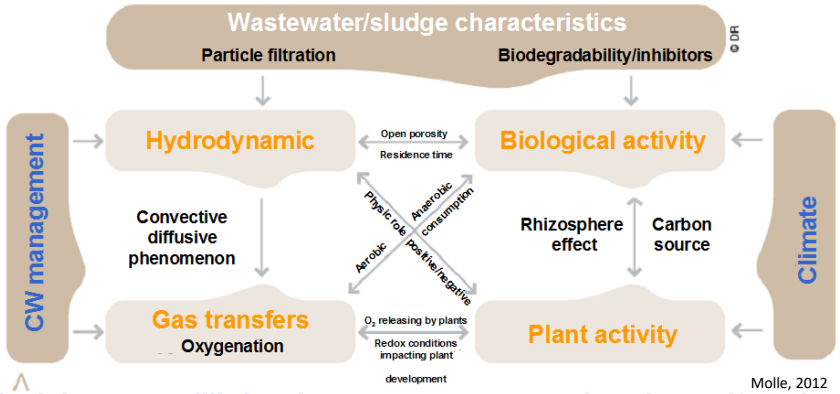
Mechanisms involved in constructed wetlands for wastewater treatment

Vertical filters usually used



Outflow

Mechanisms involved in constructed wetlands for wastewater treatment



Molle, 2012

Obtaining an equilibrium between processes, otherwise malfunctions

Adapting the design to external factors (climate, …)

Importance of operation tasks

Complex phenomenon and interactions

A lot of points to check during design

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Mechanisms involved in constructed wetlands for wastewater treatment

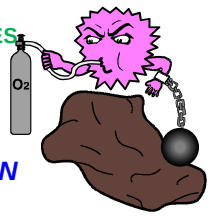
Evolution of vegetal growing

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Mechanisms involved in constructed wetlands for wastewater treatment

Batch feeding mode

UNFEEDING PHASES
Storage of water at the inlet



AERATION

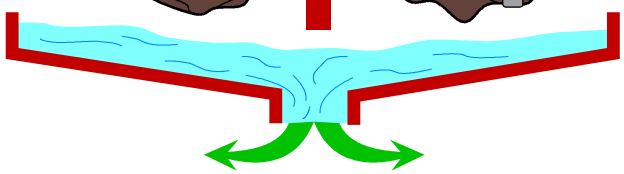
- Air incoming between sands grains

FEEDING PHASES
with high flowrate

HYDRAULIC

- Repartition by submersion
- Improvement of retention time and active surface

BIOFILM DEVELOPMENT



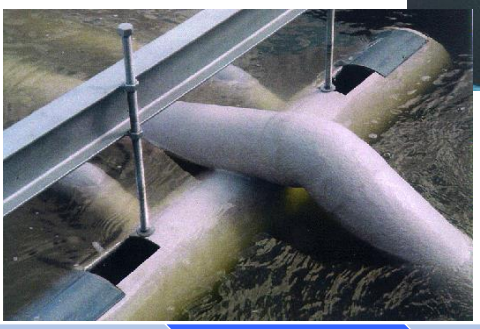
Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Mechanisms involved in constructed wetlands for wastewater treatment

Feeding by batches

- Siphon
- Pumps

If enough slope, no energy consumption



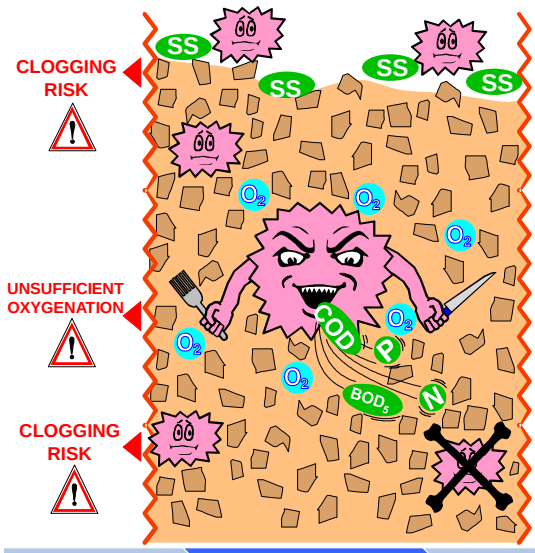
Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Mechanisms involved in constructed wetlands for wastewater treatment

Key points of treatment process

- Generally vertical flow
- Feeding by batches : homogenous water distribution, oxygen transfer
- Submersion (few cm) at each batch
- Aerobic
- Inlet of screened raw effluents
- Specific materials (gravels, sands)
- Filters in parallel : alternating periods of feeding (3,5 days) and resting (3,5 – 7 days), clogging prevention

Mechanisms involved in constructed wetlands for wastewater treatment



FILTRATION

ADSORPTION
ASSIMILATION
Eventual NITRIFICATION
Eventual DENITRIFICATION
Eventual DEPHOSPHATATION

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Mechanisms involved in constructed wetlands for wastewater treatment

Mechanisms	Active « media »	Removed parameters
Filtration	Fine gravels, coarse sands	SS
Adsorption	Biofilm, bacteria	Fine SS, BOD_5, COD, $NH4^+$
Aerobic assimilation		BOD_5, COD, N, P
Eventually, nitrification (if 2 stages in series)		N Kjeldahl, NH_4^+
Eventually, denitrification (if anoxia zone and enough organic C)		NO_3^-
Eventually, dephosphatation	If reactive material or coagulant addition	PO_4^{3-}
Maintaining permeability Plant uptake	Vegetal	Negligible Nutrients (N, P) : < 1 %

Mechanisms involved in constructed wetlands for wastewater treatment

Risks	Design and prevention of these risks
Clogging risks at the surface	Extended treatment Vertical flows Repartition of the inlet SS load on a big surface
	Vegetal stems
Clogging risk in depth	Resting periods Partial aerobic mineralization of biofilm
	Granulometry of fine gravels and coarse sands
Lack of oxygen Bad removal of organic matter and Kjeldahl nitrogen	Feeding by batches Oxygen between two batches
	Filters in parallel Resting periods Oxygen incoming in the filter

If good design, robustness, reliable, long WWTP life span (35 years in France)

Mechanisms involved in constructed wetlands for wastewater treatment

MAIN ROLE OF VEGETALS :

MAINTAINING OF PERMEABILITY at the surface

Introduction | **Mechanisms** | Adaptation in tropical climate | Advantages & drawbacks

Presentation of tropicalized systems for domestic wastewater treatment

Presentation of tropicalized systems for domestic wastewater treatment

- How to adapt the design in tropical climate ?

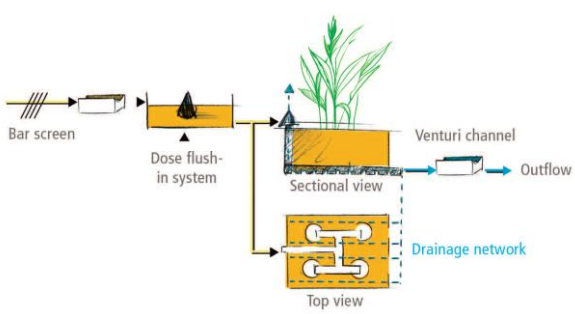
Climate →
- How can we reduce filter's surface ?
- How much filters in parallel ?

Material →
- Can we work without sand ?
- Are local material (volcanic) suitable ?

Plants →
- Which plants can replace Phragmites australis (mechanical role) ?

Presentation of tropicalized systems for domestic wastewater treatment

- Reduction of the number of filter



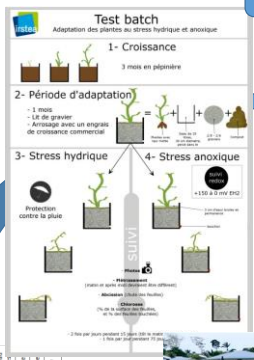
- maintain the robustness of the system to accept hydraulic overloads
- relying on the effect of tropical climate temperatures to manage clogging with a shorter resting period

Introduction | Mechanisms | Adaptation in tropical climate | Advantages & drawbacks

Presentation of tropicalized systems for domestic wastewater treatment

- Which local plants to use?

21 species



8 species

120 species

	Aux marais	Tige creuse (aérenchyme)	Rhizome	Système racinaire non ligneux	Développement rapide	Développement vigoureux	Mycorhiziens	Fructification (production de graines et dispersion)	Hauteur > 1m, diam. > 1 cm	Rôle de réservoir d'eau par parties aériennes	Toxicité (sève, feuille)	Espèce non protégée	Espèce non invasive
Phragmites australis	✓	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	x
Phragmites mauritanus	?	?	?	?	✓	?	✓	✓	?	?	✓	✓	✓
Canna indica	?	?	?	✓	✓	?	?	✓	✓	✓	✓	✓	✓
Heliconia Caribea	?	?	?	?	✓	?	?	✓	✓	✓	?	✓	✓
Heliconia psittacorum	✓	✓	✓	✓	✓	?	?	✓	✓	✓	?	✓	✓
Heliconia rostrata	?	?	?	?	✓	?	?	✓	✓	✓	✓	✓	✓
Alpinia purpurata	?	?	?	?	✓	?	?	✓	?	✓	✓	✓	✓
Cyperus papyrus L.	?	?	?	✓	✓	?	?	✓	?	✓	✓	✓	✓
Cyperus alopercuroides	?	?	?	✓	✓	?	?	✓	?	?	✓	✓	✓
Cyperus alternifolius	?	?	?	✓	✓	?	?	✓	?	?	✓	✓	✓
Cyperus luzulae	?	?	?	✓	✓	?	?	✓	?	x	✓	✓	✓
Schoenoplectus littoralis	✓	?	?	✓	✓	?	?	✓	?	✓	✓	✓	✓
Thysanolea maxima	✓	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓
Tripsacum laxum	?	?	✓	✓	✓	?	x	✓	✓	✓	✓	✓	✓
Pennisetum purpureum	?	?	?	✓	✓	?	?	✓	✓	✓	✓	✓	x

Presentation of tropicalized systems for domestic wastewater treatment

- Which local plants to use?

Heliconia psittacorum	*Canna indica, canna glauca*	*Cyperus alternifolius/involucratus*
Heliconiaceae family, Zingiberales order	Cannaceae family, Zingiberales order	Cyperaceae family, Poales order
		
Very even growth, progressive colonization of the entire filter bed	Slight tendency to tuft Slow colonization of the entire filter bed	Fast growth but slow colonization of the entire filter bed Tufting
Moderate strand density: up to 250 stems/m²	Moderate strand density: up to 250 stems/m²	Very high strand density: up to 600 stems/m²
Very very competitive against adventives	Very very competitive against adventives	Very competitive against adventives
Needs help to establish: weeding out adventives for a 3-month periods, once or twice per month Annual harvesting, before the tropical cyclone season	Needs help to establish: weeding out adventives for a 3-month periods, once or twice per month Annual harvesting, before the tropical cyclone season	Does not need help for nursery plants to establish harvesting every 6 months to thin out dead stems and encourage colonization of the entire filter bed
Notes and comment There are 1,200-odd cultivars, leading to chronically uneven growth (even inside the same filter beds!). Opt for the smallest cultivars. Genetic overlap with the banana tree creates plant health risks if the CW is sited within 1 km of a banana plantation	Note and comment *Canna indica* in both Guadeloupe and Martinique suffered caterpillar invasions from December to March. The plants are not decimated, but they are weakened.	

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Which plants are needed for a French vertical-flow constructed wetland under a tropical climate?

R. Lombard Latune, O. Laporte-Daube, N. Fina, S. Peyrat, L. Pelus and P. Molle

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Interreg Caraïbes
CARIBSAN

Presentation of tropicalized systems for domestic wastewater treatment

CARIBSAN

- Design and performances

Name	Department	Capacity	Technology	Commissioned	Number of performance monitoring	Mean load rate (% nominal load)	
						Organic	Hydraulic
Hachenoua	Mayotte	110 EH	1 stage : 2 CW NS 80 cm filtration layer	April 2006	16	53 %	65 %
Bois d'Opale 1	Guyane	300 EH	1 stage : 2 CW NS 0 and 100% recirculation	May 2010	9	33 %	139 %
Bois d'Opale 2	Guyane	480 EH	1 stage : 2 CW NS 100% recirculation	March 2012	13	29 %	169 %
Mansarde Rancée	Martinique	1 000 EH	1st stage : 2 x 3 NS/S 2nd stage : 2 x 2 NS CW	January 2014	3	10 %	16 %
Taupinière	Martinique	900 EH	1st stage : 2 x 2 NS/S CW 2nd stage : Low-load TF	November 2014	31	84 %	98 %
Les Mangles	Guadeloupe	120 EH	1 stage : 2 NS/S CW	October 2015	17	4 %	15 %
Champ d'Ylang 2	Mayotte	190 EH	1 stage: 2 NS CW 30cm filtration layer	November 2015	7	81 %	105 %

NS: non-saturated; NS/S: non-saturated/saturated; TF: trickling filter.

Load rates calculated for applied loads of 350 g COD/m²/d and a flush of 0.37 m/d, which equates to a sizing ratio of 0.8 m²/PE

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CARIBSAN

- Design and performances

Name	Department	Capaci
Hachenoua	Mayotte	110 EI
Bois d'Opale 1	Guyane	300 EI
Bois d'Opale 2	Guyane	480 EI
Mansarde Rancée	Martinique	1 000 E
Taupinière	Martinique	900 EH
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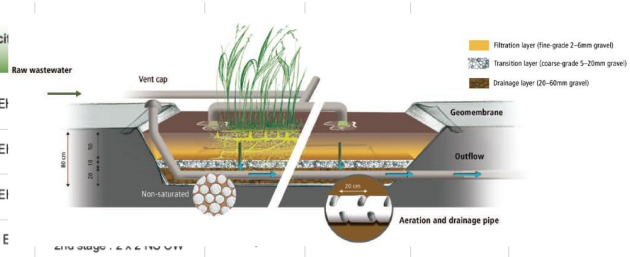

NS: non-saturated; NS/S: non-saturated/

Load rates calculated for applied loads c
which equates to a sizing ratio of 0.8 m

One stage Vertical Flow TW with 2 filters in parallel

Different filtration layer depth with our without recirculation

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Presentation of tropicalized systems for domestic wastewater treatment

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- Design and performances

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Bois d'Opale 1	Guyane						
Bois d'Opale 2	Guyane						
Mansarde Rancée	Martinique						
Taupinière	Martinique	900 EH	1st stage : 2 x 2 NS/S CW 2nd stage : Low load TF	November 2014	31	84 %	98 %
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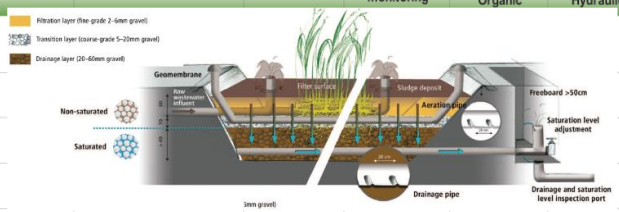

NS: non-saturated; NS/S: non-satura

Load rates calculated for applied loa
which equates to a sizing ratio of 0.8

1st stage unsaturated/saturated with two filter in parallel

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CARIBSAN

- Design and performances

Name	Department	Capacity					
Hachenoua	Mayotte	110 EH					
Bois d'Opale 1	Guyane	300 EH					
Bois d'Opale 2	Guyane	480 EH					
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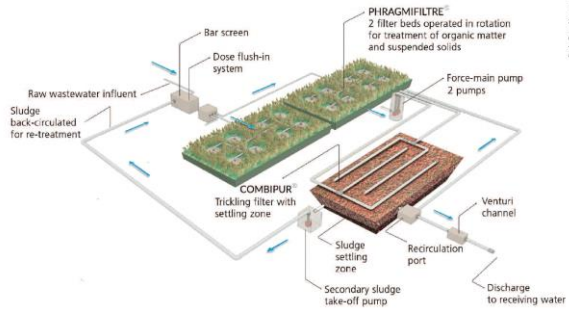
Les Mangles	Guadeloupe	120 EH	1 stage : 2 NS/S CW	October 2015	17	4 %	15 %
Champ d'Ylang 2	Mayotte	190 EH	1 stage: 2 NS CW 30cm filtration layer	November 2015	7	81 %	105 %



NS: non-saturated; NS/S: non-saturated/satu

Load rates calculated for applied loads of 35
which equates to a sizing ratio of 0.8 m²/PE

Simplified Trickling filter with a decantation zone

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Presentation of tropicalized systems for domestic wastewater treatment

CARIBSAN

- Design and performances

Similar performances of unsaturated VFTW than in temperate climate for COD, BOD, TSS

Better nitrification - Almost complete nitrification using 80 cm of gravel and recirculation

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French vertical-flow constructed wetland design: adaptations for tropical climates

P. Molle, R. Lombard Latune, C. Riegel, G. Lacombe, D. Esser and L. Mangeot

Quality (mg/L)	80 cm			Removal rates (%)		
	0 %	< 125 %	> 125 %	0 %	< 125 %	> 125 %
COD	71	61	44	91	93	91
BOD_5	33	23	8,6	91	94	
TSS	26	37	16	91	93	95
KN	10	5	4	90	93	95

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Presentation of tropicalized systems for domestic wastewater treatment

CARIBSAN

- Design and performances

Can accept high hydraulic overloads (storm event) and typhons

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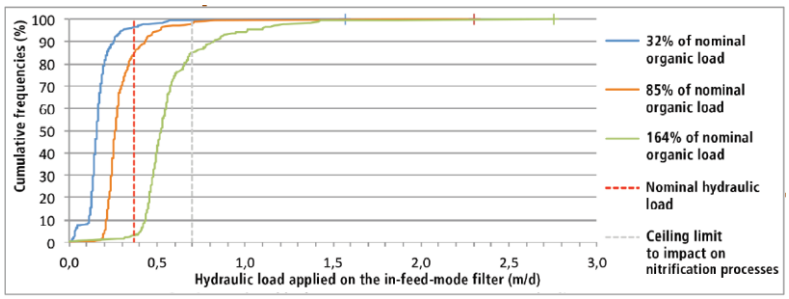
Resilience and reliability of compact vertical-flow treatment wetlands designed for tropical climates

R. Lombard-Latune [a,*], L. Pelus [b], N. Fina [c], F. L'Etang [d], B. Le Guennec [e], P. Molle [a]



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Presentation of tropicalized systems for domestic wastewater treatment

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- Which system for which constraints?

CW variants	Standalone electricity (excluding topography constraints)	Combined sewer	Intermittent activity	Footprint of the treatment infrastructure	Minimum guaranteed treatment performances: % removal (threshold concentrations, mg/L)				Pathogen die-off (UV module disinfection)
					COD	TSS	TKN	TN	
2 FPV NS with 30 cm of first filtration layer	✓	✓	✗	0.8 m²/PE	75 % (125 mg/L)	80 % (50 mg/L)	60 % (40 mg/L)	20 % (60 mg/L)	✗
2 FPV NS with 30 cm of first filtration layer + recirculation	✗	✓ (daily flush < 70 cm)	✓ (can hike the electricity bill)	0.8 m²/PE	75 % (125 mg/L)	85 % (30mg/L)	60 % (40 mg/L)	20 % (60 mg/L)	✗
2 FPV NS/S with 30 cm of first filtration layer	✓	✓	✓	0.8 m²/PE	85 % (125 mg/L)	90 % (25 mg/L)	60 % (40 mg/L)	50 % (50 mg/L)	✓

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Presentation of tropicalized systems for domestic wastewater treatment

CARIBSAN

- Which system for which constraints?

CW variants	Standalone electricity (excluding topography constraints)	Combined sewer	Intermittent activity	Footprint of the treatment infrastructure	Minimum guaranteed treatment performances: % removal (threshold concentrations, mg/L)				Pathogen die-off (UV module disinfection)
					COD	TSS	TKN	TN	
2 FPV NS with 80 cm of first filtration layer	✓	✓	✓ possible with recirculation	0.8 m²/PE	90 % (100 mg/L)	90 % (25 mg/L)	80 % (15 mg/L)	20 % (60 mg/L)	✓
2 FPV NS/S stage + NS stage	✓	✓	✓ possible with recirculation (hydric stress on the second stage)	1.6 m²/PE	90 % (75 mg/L)	95 % (15 mg/L)	90 % (6 mg/L)	70 % (35 mg/L)	✓
2 FPV NS/S stage + TF stage	✗	✓	✓	0.9 m²/PE	90 % (75 mg/L)	95 % (15 mg/L)	90 % (6 mg/L)	70 % (35 mg/L)	✓
2 FPV NS stage + HF stage	✓	✓	✓	1.8 m²/PE	85 % (125 mg/L)	90 % (25 mg/L)	70 % (20 mg/L)	70 % (35 mg/L)	✓

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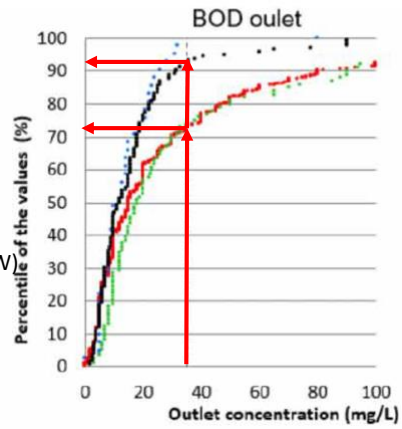
Presentation of tropicalized systems for domestic wastewater treatment

- Better robustness than conventional systems

- Activated Sludge (AS)
- Rotating Biological Contactor (RBC)
- Ponds systems (FP)
- Vertical Flow TW (VFTW)



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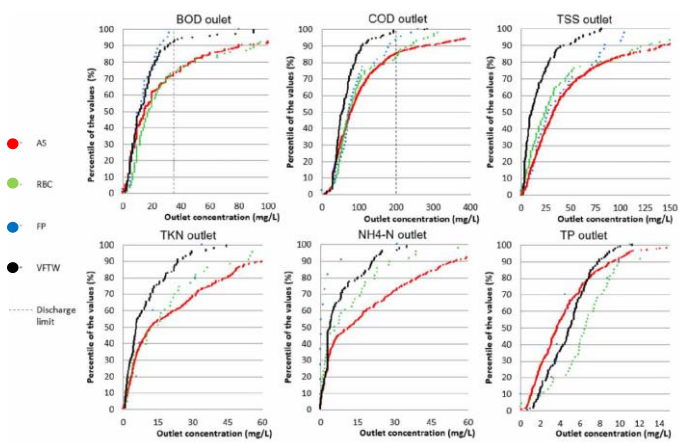
Presentation of tropicalized systems for domestic wastewater treatment

- Better robustness than conventional systems



Performance and reliability comparison of French vertical flow treatment wetlands with other decentralized wastewater treatment technologies in tropical climates

Rémi Lombard-Latune, Florent Leriquier, Chafatayne Oucacha, Lucas Pelus, Gérald Lacombe, Bernard Le Guennec and Pascal Molle

Introduction | Mechanisms

Presentation of tropicalized systems for domestic wastewater treatment

- Better robustness than conventional systems

https://www.researchgate.net/project/Sanitation-systems-in-tropical-climate

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Advantages and drawbacks of constructed wetlands

Drawbacks of constructed wetlands

- Required surface for an extended treatment (but possibility of less than 1 m^2/P.Eq.)
- Annual cutting of vegetal and removal, especially for highest surfaces
- Removal of weeds, especially during first years (especially in case of too low hydraulic load)
- Natural slope of the ground, if no use of energy is requested
- Risk of undesirable fauna (snakes ? …)
- Availability of fine gravels, coarse and fine sands (necessity to adapt the design in tropical area)
- High investment cost for high WWTPs capacity (less competitive in comparison with activated sludge, …)
- Finding available endemic vegetal and local adapted material (sands, gravels)

Advantages of constructed wetlands

- Good removal of suspended solids and organic matter (BOD_5 < 25 mg/l, COD < 75 - 125 mg/l, SS < 15 - 50 mg/l)
- Possibilities of nitrification (NTK < 6 – 40 mg/l), denitrification (NT < 35 mg/l), dephosphatation (PT < 2 mg/l)
- Able to treat raw waste water. No primary treatment, neither primary sludge
- Minimal sludge management. Extraction every 15-20 years or more. Decreasing of sludge production. Sludge reuse in agriculture
- Easy to operate :
  - Filters rotation 1 to 2 times / week
  - Weeds removal
  - Annual cutting of vegetal
  - None or few electromechanical equipment

Advantages of constructed wetlands

- None or low energy consumption
- Capacity to accept organic and hydraulic loads variation. Case of little WWTPs
- Nature-based solutions
- Tropical climate favorable to endemic vegetal growth
- Possibilities to treat other types of wastewater : agricultural, industrial, rainy, … waste waters. Sludge
- Lower investment cost for little WWTPs in comparison to other treatments
- Operation costs

Questions/answers