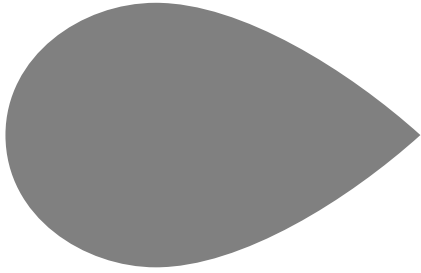


Moving Bed Technology for Small Communities

MBBR™ processes



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- Introduction
- Cases studied
 - Dimensioning
 - Investment costs
 - Operation costs
 - Ratios
 - Operation of MBBR plants
- Sludge Treatment
- Conclusions



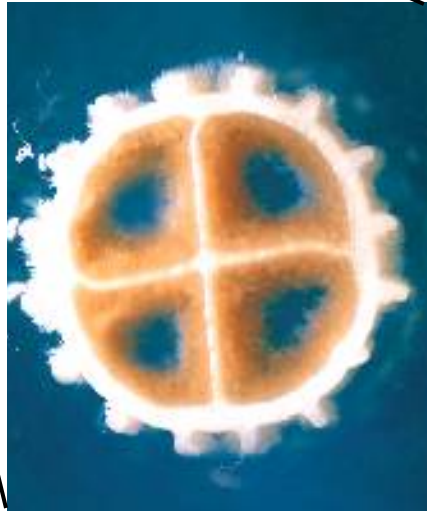
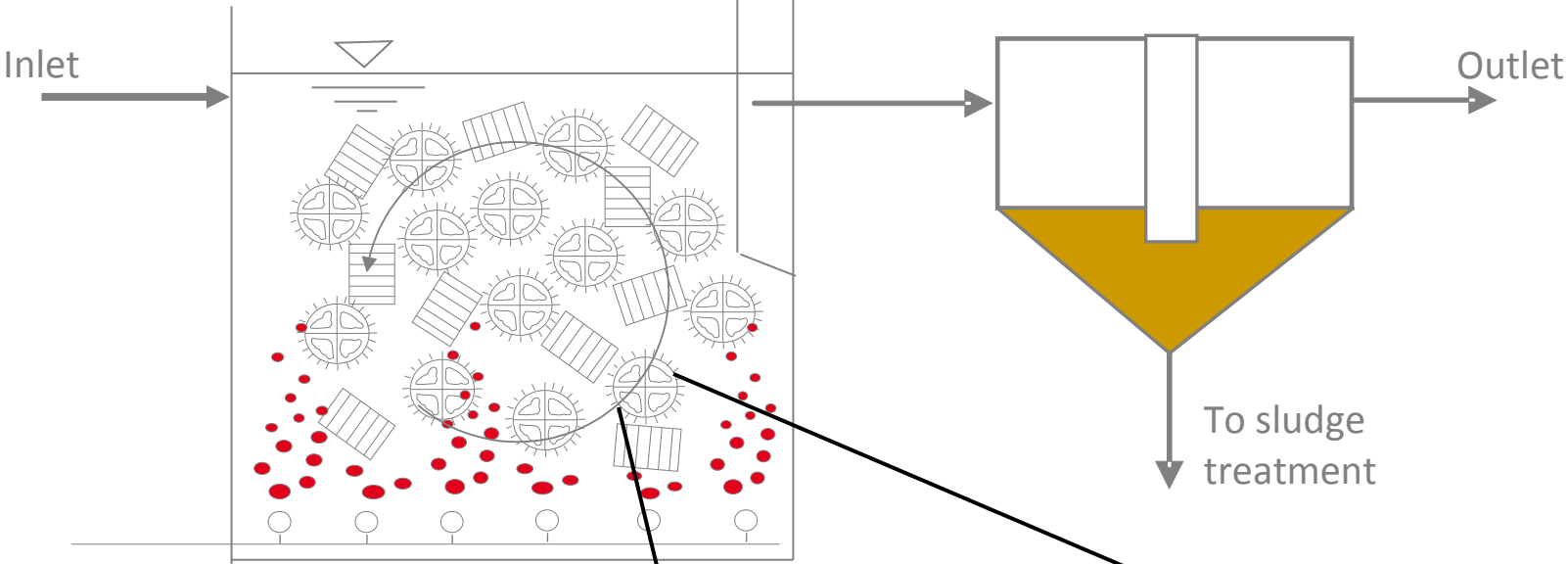
• Introduction

- *Plan Nacional de la Calidad de las Agua 2007-2015*: treatment of wastewater proceeding from small communities is one of the priorities. Technologies that provide an easy management and operation will prevail.
- *European Directive*: also sets out the requirements of “appropriate treatments”. CCAAs will determine the degree of purification to be achieved.
- This presentation lists various possible applications of the Moving Bed technology for small communities, for those cases where it can be advantageous over other possible solutions. Investment and operating costs have been estimated, too.



- The main issues underlying the choice of these applications instead of conventional biological processes have been:
 - Ease of operation,
 - Competitive investment and operating costs,
 - Flexibility for possible upgrading,
 - Volume reduction of the biological reactor,
 - Absence of filamentous bulking, and
 - Fast process recovery to inhibitions.
- Different solutions for sludge treatment are suggested, depending on:
 - Geography (proximity to large WWTP),
 - Treatment needs

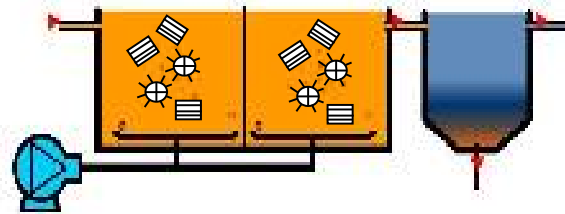
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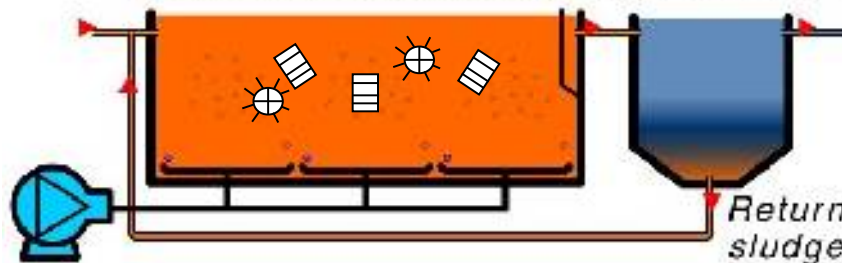
MBBR™ reactors



● MBBR™

Moving Bed Biofilm Reactor

Activated Sludge/ MBBR reactor



● HYBAS™

Hybrid Biofilm Activated Sludge

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Cases studied

	CASE 1		CASE 2		CASE 3
Q (m ³ /day)	300		300		400
Equivalent inhabitants	1,500		1,500		2,000
Technology	MBBR™		MBBR™ (DCN)		Hybas™
	(A)	(B)	(A)	(B)	(A)
Organic matter removal	yes	yes	yes	yes	yes
N removal	no	no	yes	yes	yes
P removal	no	no	Chemical (FeCl ₃)	Chemical (FeCl ₃)	Biological
Pretreatment	yes	yes	yes	yes	yes
Previous Imhoff	no	yes	no	yes	no
Primary clarifier	no	no	no	no	yes
Secondary clarifier	No chemicals	No chemicals	FeCl ₃	FeCl ₃	FeCl ₃



Wastewater characteristics

	Preatreated water	Imhoff outlet	Primary settler outlet	Biological outlet
COD (mg/l)	600	480	480	125
BOD (mg/l)	300	240	240	25
SS (mg/l)	350	210	210	35
TKN (mg/l)	50	50	45	14*
P total (mg/l)	8	7	7	2*
Temperature (°C)	15			
Average flow (m ³ /day)	300 (cases 1,2) – 400 (case 3)			
Peak flow (hydraulics) (m ³ /hour)	4 * Average flow			
Peak flow (aeration) (m ³ /hour)	1,5 * Average flow			

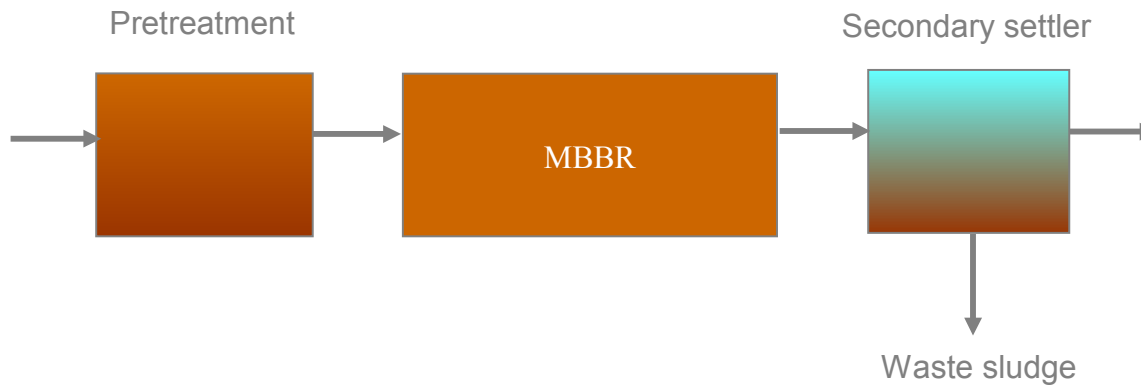
*CASES 2 and 3.

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• CASE 1: 1.500 e.i. Organic matter removal

$Q = 300 \text{ m}^3/\text{day}$.

(A) MBBR™ C No primary settler



Configuration:

Reactor volume:

MBBR C

80 m³

Carrier volume (K3):

41 m³ (51%)

HRT:

6,4 hours

SP:

104 kgTS/day

AOR_{25°C}:

4,2 kgO₂/h

AOR_{15°C}:

3,5 kgO₂/h

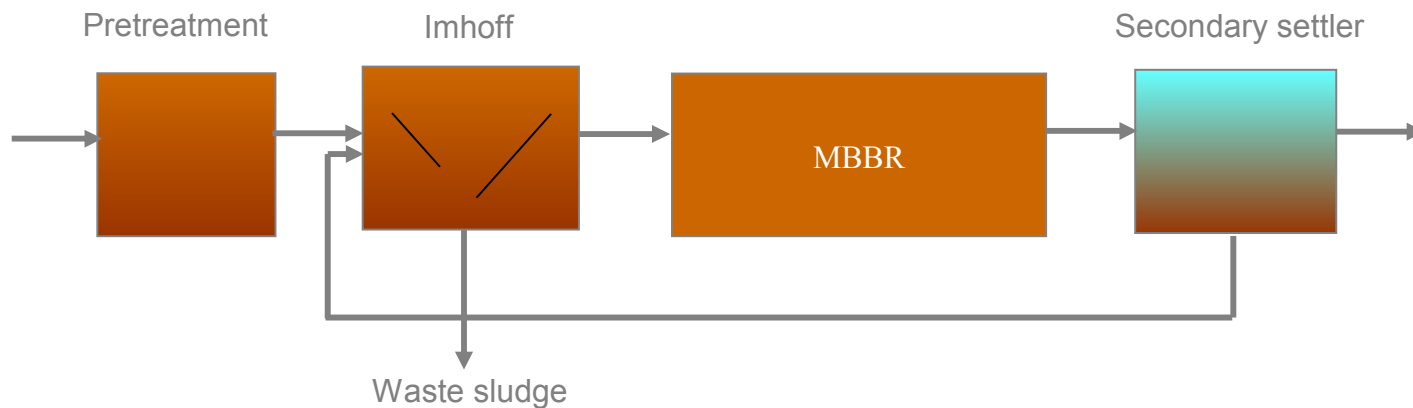
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• CASE 1: 1.500 e.i. Organic matter removal

$Q = \text{de } 300 \text{ m}^3/\text{day}.$

(B) MBBR™ C Previous Imhoff



Configuration:	MBBR C		
Reactor volume:	64	m^3	
Carrier volume (K3):	33	m^3	(52%)
HRT:	5,2	hours	
SP:	70	kgTS/day	
$\text{AOR}_{25^\circ\text{C}}$:	3,3	kgO_2/h	
$\text{AOR}_{15^\circ\text{C}}$:	2,8	kgO_2/h	

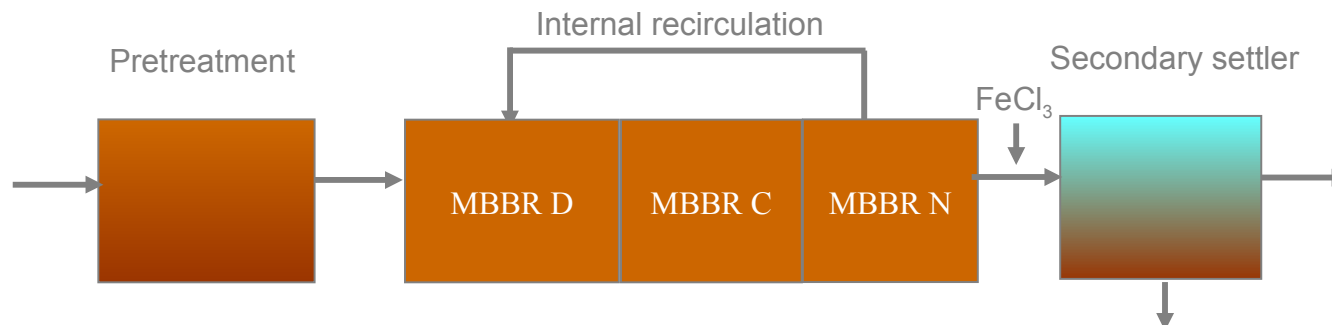
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● CASE 2: 1.500 e.i. Organic matter and nutrients removal

$Q = 300 \text{ m}^3/\text{day}$.

(A) MBBR™ DCN No primary settler



Configuration:	MBBR D-C-N			Waste sludge
D Reactor volume:	55	m ³	31 m ³ K1	(55%)
C Reactor volume:	39	m ³	25 m ³ K3	(65%)
N Reactor volume:	35	m ³	23 m ³ K3	(65%)
TOTAL volume:	129	m ³		
HRT:	10,3	hours		
Internal recirculation:	218	%		
SP:	106	kgTS/day		
AOR _{25°C} :	4,9	kgO ₂ /h		
AOR _{15°C} :	4,5	kgO ₂ /h		
FeCl ₃ :	0,6	l/h		

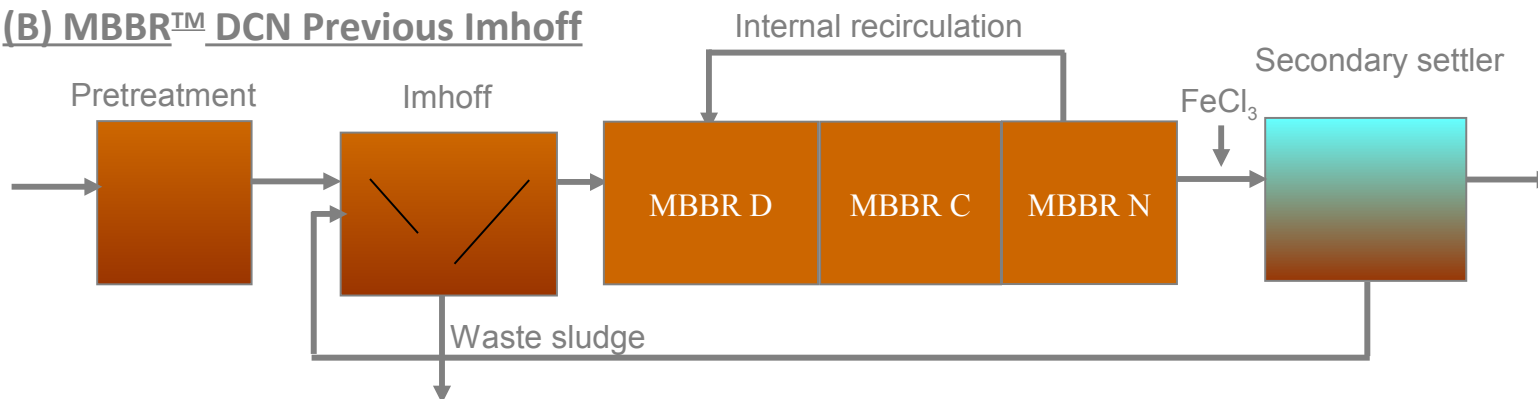
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● CASE 2: 1.500 e.i. Organic matter and nutrients removal

$Q = 300 \text{ m}^3/\text{day}$.

(B) MBBR™ DCN Previous Imhoff



Configuration:

		MBBR D-C-N		
D Reactor volume:	61	m ³	34 m ³ K1	(55%)
C Reactor volume:	27	m ³	17 m ³ K3	(65%)
N Reactor volume:	33	m ³	22 m ³ K3	(65%)
TOTAL volume:	121	m ³		
HRT:	9,7	hours		
Internal recirculation:	240	%		
SP:	72	kgTS/day		
AOR _{25°C} :	4,1	kgO ₂ /h		
AOR _{15°C} :	3,8	kgO ₂ /h		
FeCl ₃ :	0,5	l/h		

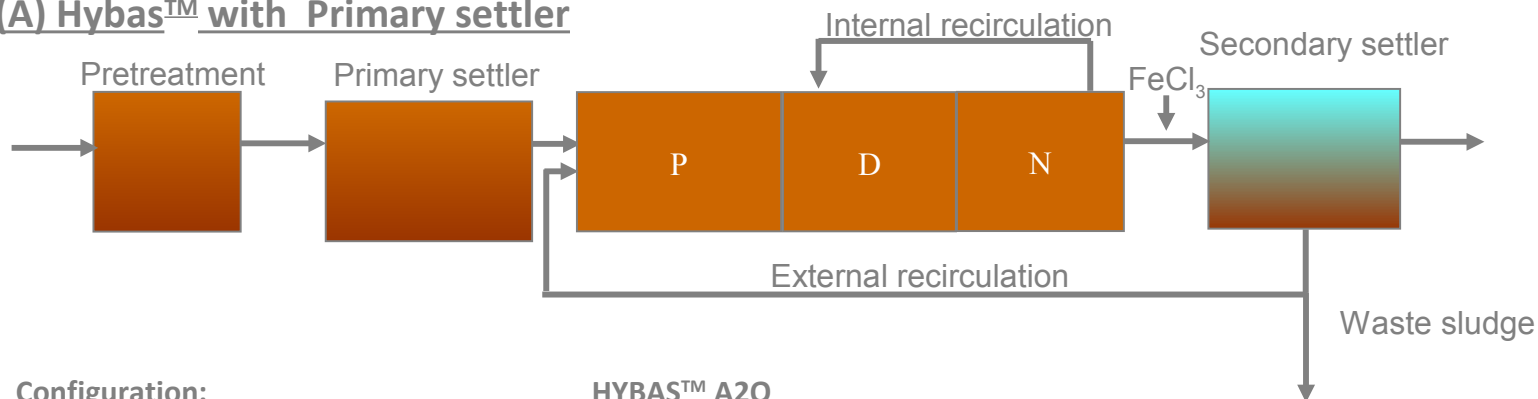
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• CASE 3: 2.000 e.i. Organic matter and nutrients removal

Q = de 400 m³/day.

(A) Hybas™ with Primary settler



Configuration:	HYBAS™ A2O			
Anaerobic Reactor volume:	25	m ³		
Anoxic Reactor volume:	36	m ³		
Aerobic Reactor volume:	64	m ³	22 m ³ K3	(34%)
TOTAL volume:	125	m ³		
HRT:	7,5	hours		
Internal recirculation:	101	%		
External recirculation:	100	%		
SP:	83	kgTS/day		
AOR _{25°C} :	5,5	kgO ₂ /h		
AOR _{15°C} :	4,8	kgO ₂ /h		
FeCl ₃ :	0,3	l/h		



• Investment costs

- Deposits for biological reactors:
 - CASE 1A: Polyester
 - CASES 1B, 2 and 3: Bolted steel tanks
- Aeration grids and outlet sieves:
 - Construction and installation
- Plastic media:
 - Price including transportation to the WWTP
- Equipment:
 - Level controller
 - DOmeters
 - Flowmeters
 - Mixers
 - Inlet and internal recirculation pumps
 - Blowers

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Investment costs

Investment costs (€)					
	CASE 1		CASE 2		CASE 3
	A	B	A	B	
Biological reactors	14.400	14.000	28.000	28.000	28.000
Grids and sieves	2.900	2.440	7.115	6.310	4.144
Plastic media	17.220	13.860	31.200	28.800	9.240
Equipment	10.145	10.107	35.033	33.020	32.717
TOTAL	44.665	40.407	101.348	96.130	74.101
€/ e.i.	29,8	26,9	67,6	64,1	37,0

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Operating costs

- Energy consumption of:
 - Inlet and internal recirculation pumps
 - Blowers (average air consumption)
 - Mixers
- FeCl₃ consumption (average flow)

	CASE 1		CASE 2		CASE 3
	A	B	A	B	
Operation power (kw)	9,2	8	12,6	10,8	14,1
FeCl ₃ (l/day)			4,5	4,5	4,5

Operation costs (€/year)					
	CASE 1		CASE 2		CASE 3
	A	B	A	B	
FeCl ₃			936	838	427
Energy cost	7.253	6.308	9.933	8.515	11.116
TOTAL	7.253	6.308	10.869	9.353	11.543

FeCl₃: 4,5 €/l

kwh: 0,09 €/kwh

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Some ratios

	CASE 1		CASE 2		CASE 3
	A	B	A	B	
kg DM bio sludge / e.i., day	0,069	0,047	0,071	0,048	0,044
kg DM bio sludge / kgBOD removed	1,26	1,085	1,28	1,12	1,01
kwh / e.i., day	0,15	0,13	0,20	0,173	0,169
kwh / m ³	0,74	0,64	1,01	0,864	0,846
kwh / kgBOD removed	2,68	2,98	3,67	4,01	3,93
Investment € / e.i.	29,8	26,9	67,6	64,1	37,0
Operation € / e.i.,day	0,013	0,011	0,020	0,017	0,016

- BOD removed in the primary settler or Imhoff has not been taken into account
- CASES 1 A and 2 A higher SP, because primary sludge is included
- CASES 2 and 3, higher kwh due to nitrification
- Investment costs are also higher when nutrient removal is included. Moreover, CASES 2 need more filling media than CASE 3.
- Operation costs only include energy and FeCl₃ consumption; staff costs have not been considered.



• **Operation of MBBR™ plants**

- Operation of MBBR™ biological step is extremely simple.
- Attention required by this kind of treatment in small plants is much lower than that of pretreatment, sludge management or sewage maintenance steps.
- Few things need to be checked:
 - DO level in aerobic reactors,
 - agitation of the media,
 - presence of colour, smell or foam, etc.
- Operation of Hybas™ also requires to control:
 - MLSS concentration,
 - SVI,
 - DO level in aerobic reactors,
 - Agitation of media



• **Operation of MBBR™ plants**

- In both cases, operation tasks may include:
 - Cleaning reactor walls,
 - Sporadic cleaning of outlet sieves
- Electromechanical maintenance of equipment is similar to other treatments :
 - DO probes and other online meters
 - Blowers
 - Pumps
 - Flowmeters, etc.



• **Sludge treatment**

- **Storage and transportation:**

- Sludge could be trucked to a WWTP for further treatment. A deposit will be needed to store the settled or thickened sludge, so that it could be vacuumed for its transportation.
- Due to the short SRT of MBBR reactors, sludge has higher content of VS.
- Thus, in anaerobic digestion CH_4 production will be higher than that obtained with sludge coming from conventional treatments.
- Self-sustaining thermophilic aerobic digestion (ATAD) can be an alternative to anaerobic digestion used in larger plants. In this case T will be easier maintained due the higher volatile fraction of biological sludge.

- **Digestion in primary Imhoff tanks:**

In cases 1B and 2B an Imhoff tank has been included prior to the biological treatment, where both primary and secondary sludge is partially digested.



● CONCLUSIONS

- High rates of COD and N removal
- Easy to operate
- Small footprint required
- Possibility to use existing reactors for upgrading
- Robust against toxic compounds and load variations (no washout of biomass)
- Higher nitrification rates even at low temperatures compared to suspended biomass processes
- Slightly stabilized sludge. Higher potential for biogas production
- Competitive investment costs.
- Slightly higher operation costs (higher energy consumption but lower maintenance requirements)

THANK YOU FOR YOUR ATTENTION

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for Small Communities

MBBR™ processes



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