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Ozone-enhanced granular sludge sequential biofilter for the treatment of mature municipal landfill leachates

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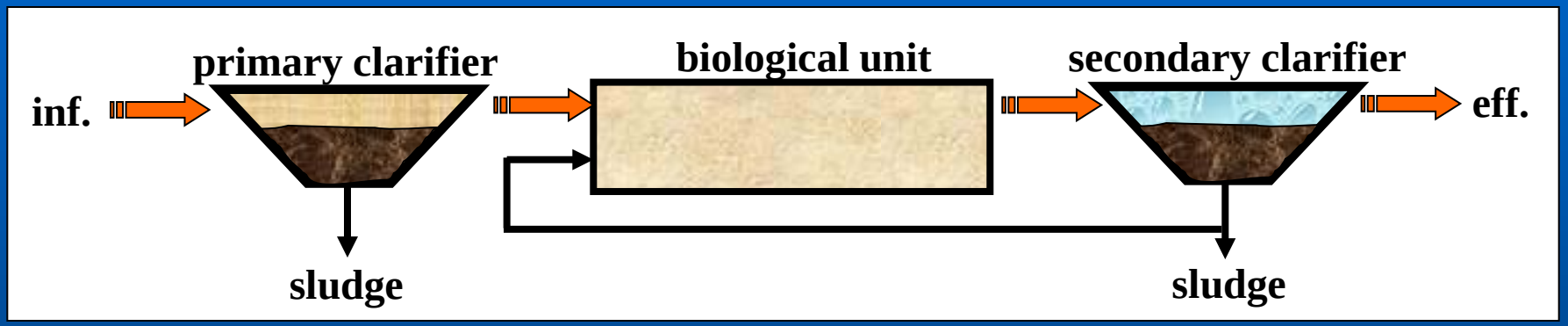
MAIN FEATURES OF CONVENTIONAL TREATMENT TECHNOLOGIES



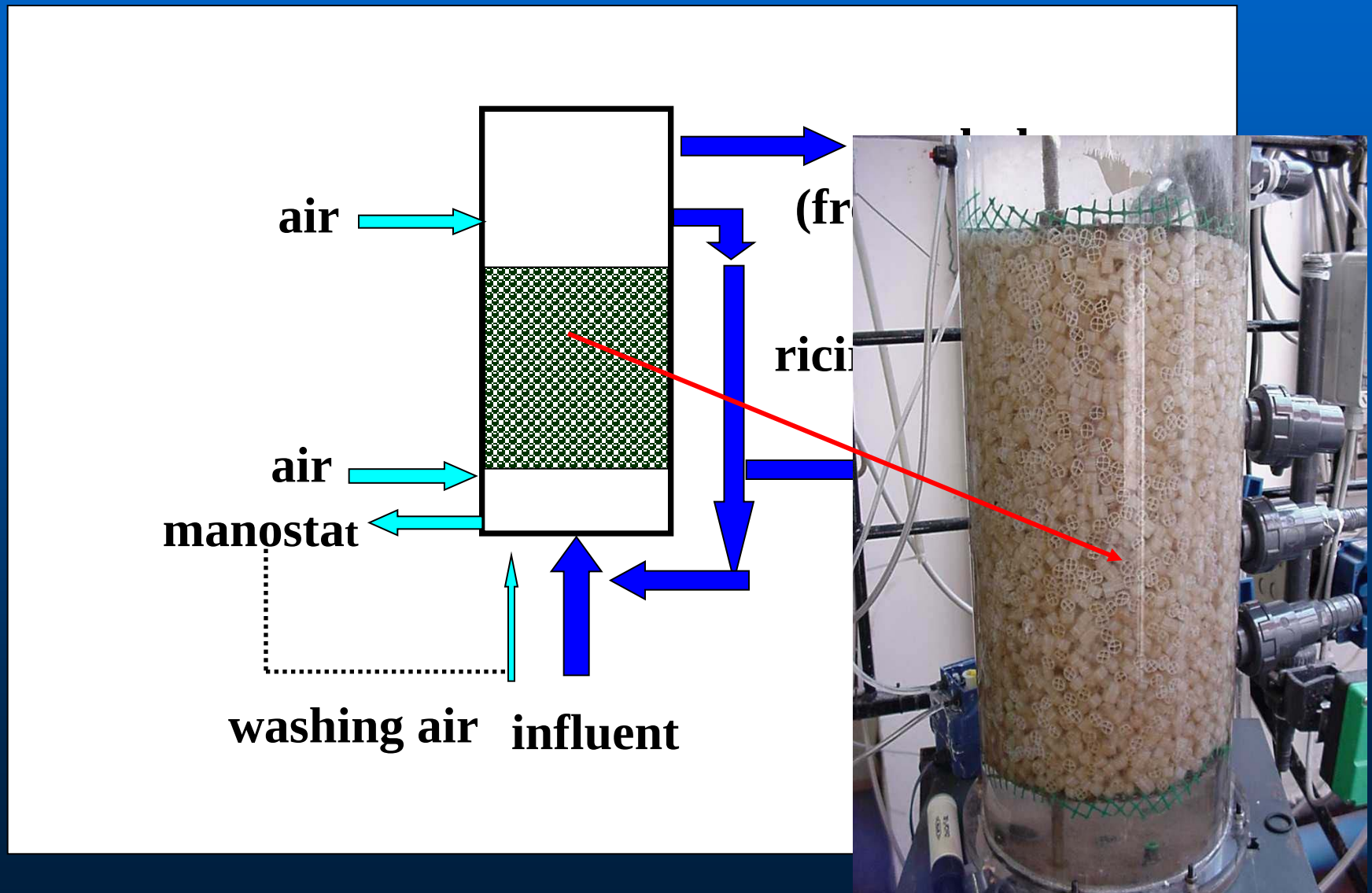
- low biomass settling velocity (< 1 m/h)
- low biomass concentration (4 kg/m^3)
- low volumetric conversion capacity (< 1 kgCOD/m^{3}d)
- large area requirement
- high sludge production (0.4 kg_{sludge}/$kgCOD_{removed}$)

SBBGR
(Sequencing Batch Biofilter Granular Reactor)

Mean features of SBBGR technology are:

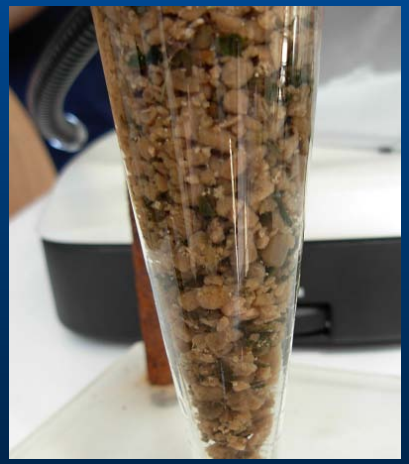
- **high biomass concentrations (up to 40 kg/m^3);**
- **high conversion capacities (up to 4 kg COD/m^{3}d);**
- **low foot-print (no secondary clarifier);**
- **low sludge production (up to 5-6 times lower);**
- **possibility of integrating biological degradation and chemical oxidation for treating biorefractory wastewater.**

WHAT'S SBBGR TECHNOLOGY?

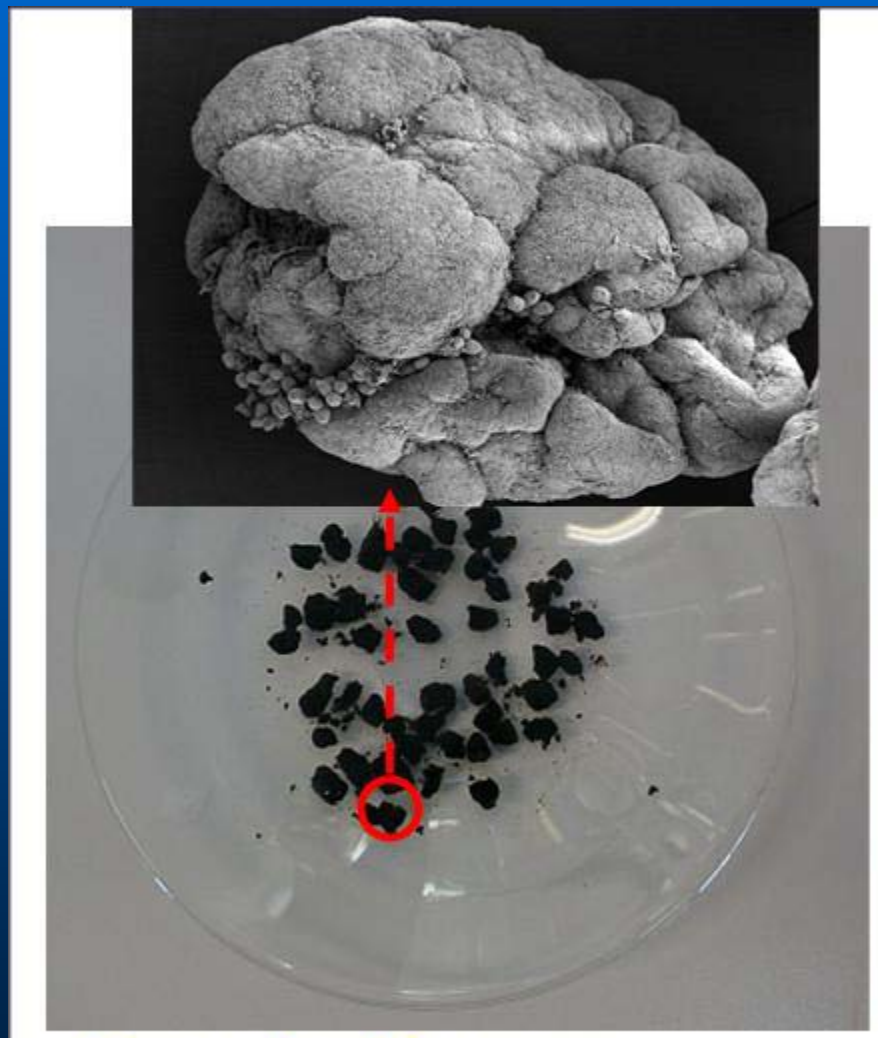


GRANULAR BIOMASS IN A SBBGR

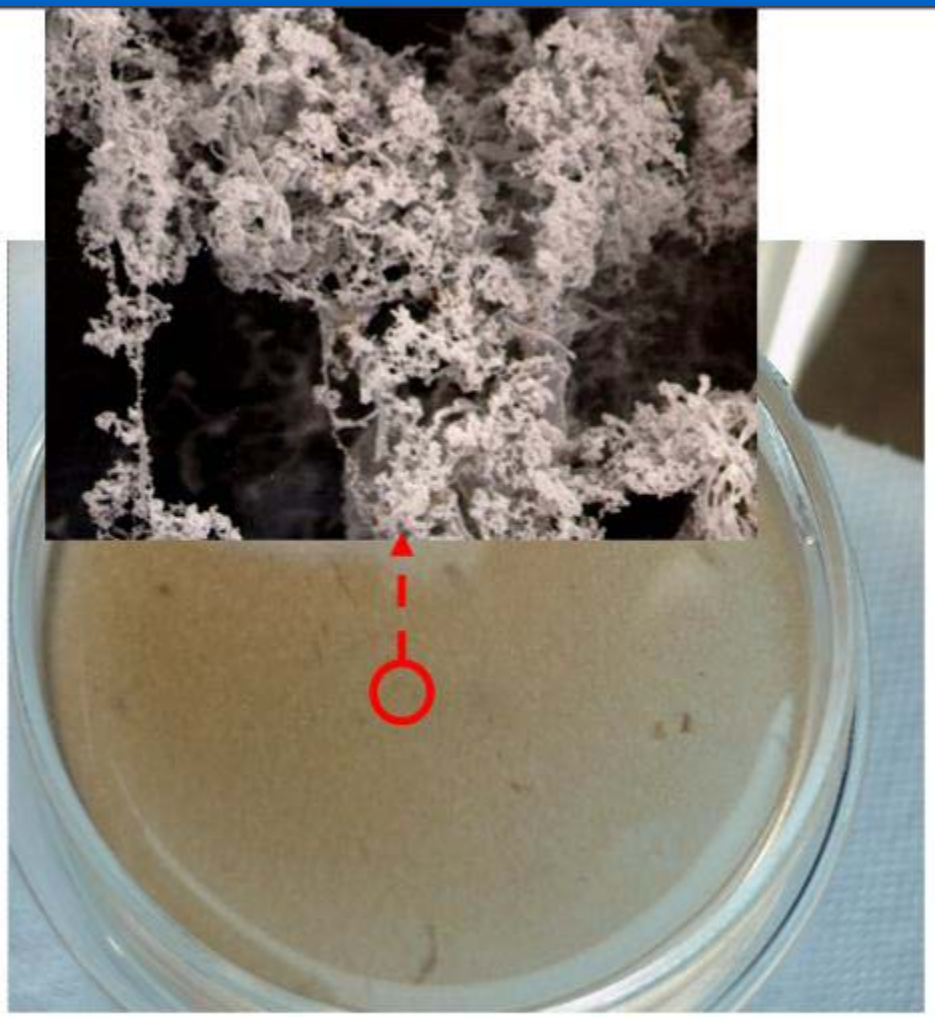
1 cm



GRANULAR BIOMASS IN A SBBGR



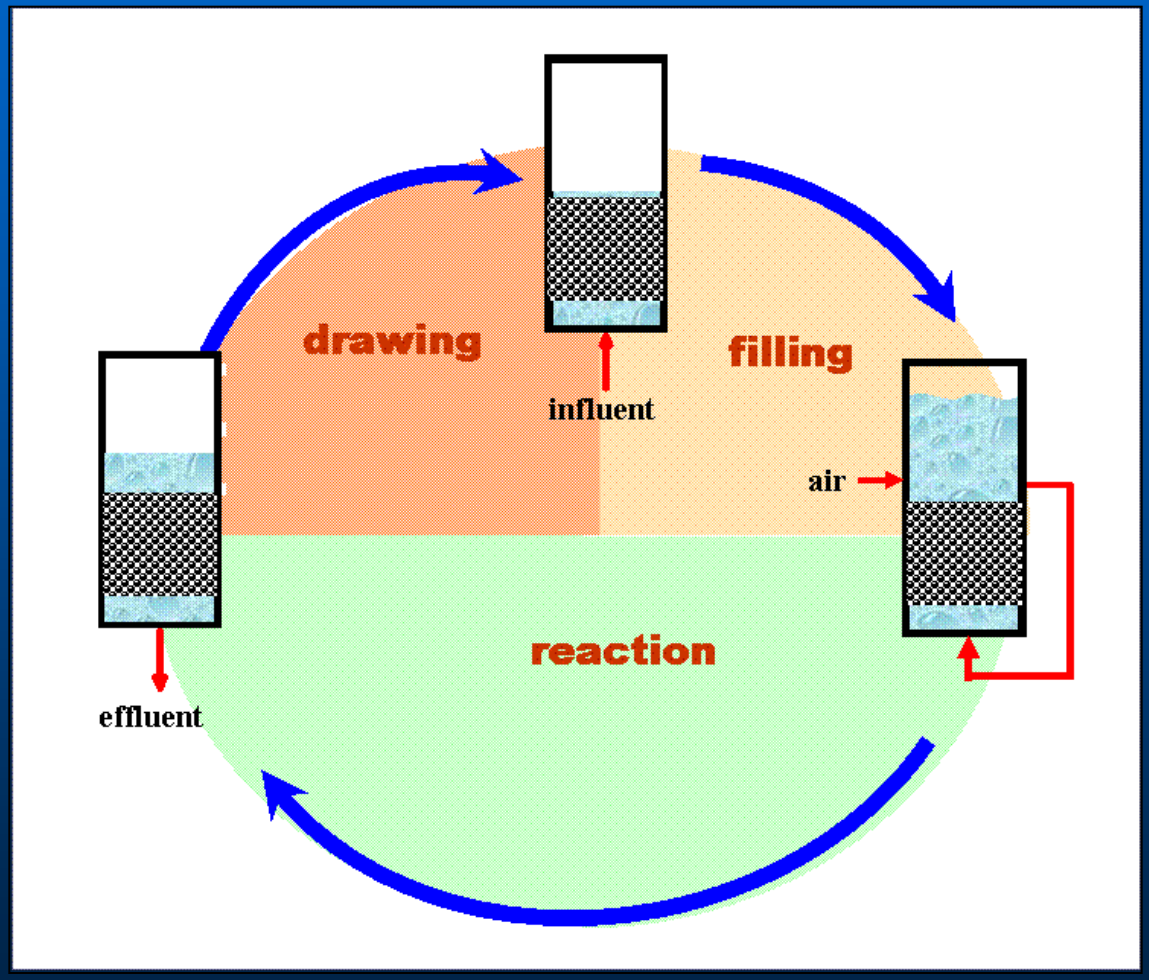
Granular biomass



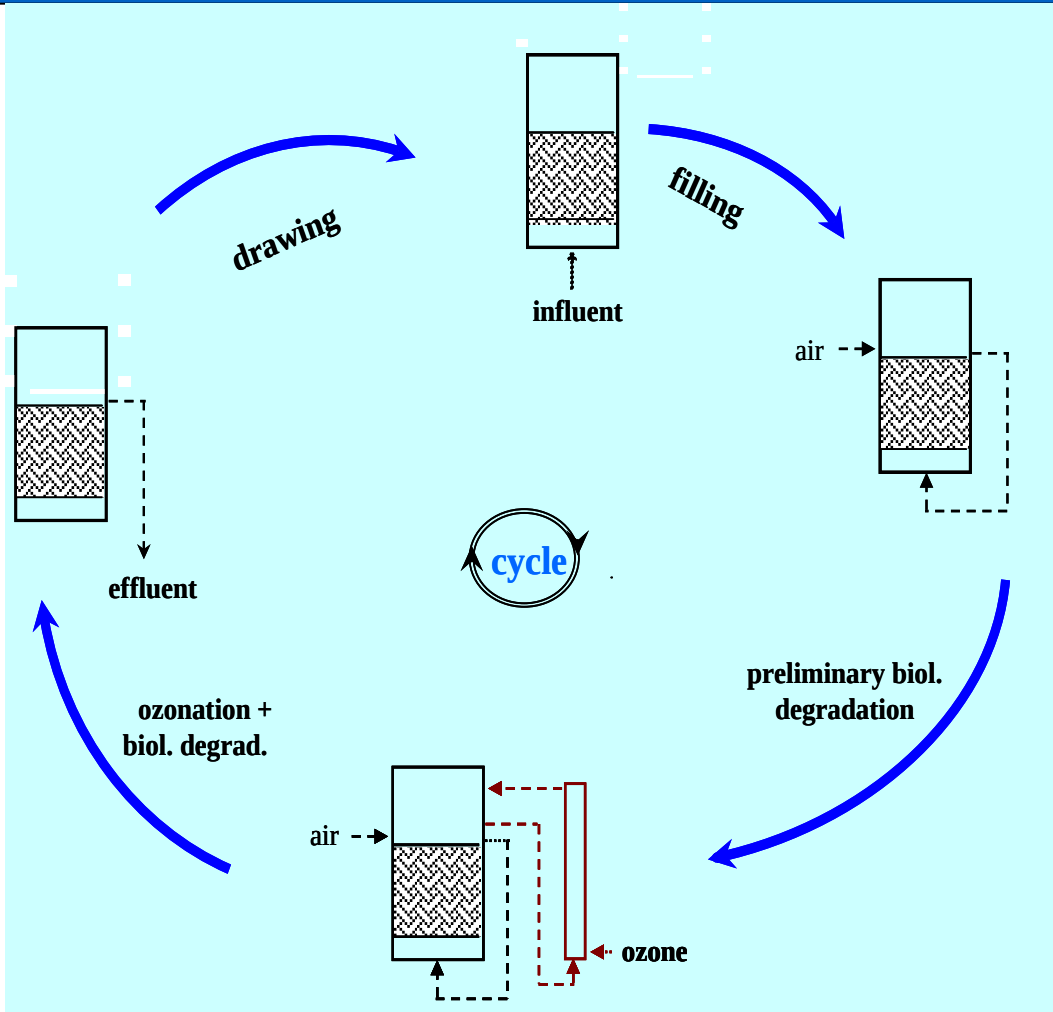
Activated sludge

GRANULAR BIOMASS IN A SBBGR

HOW DOES SBBGR WORK?



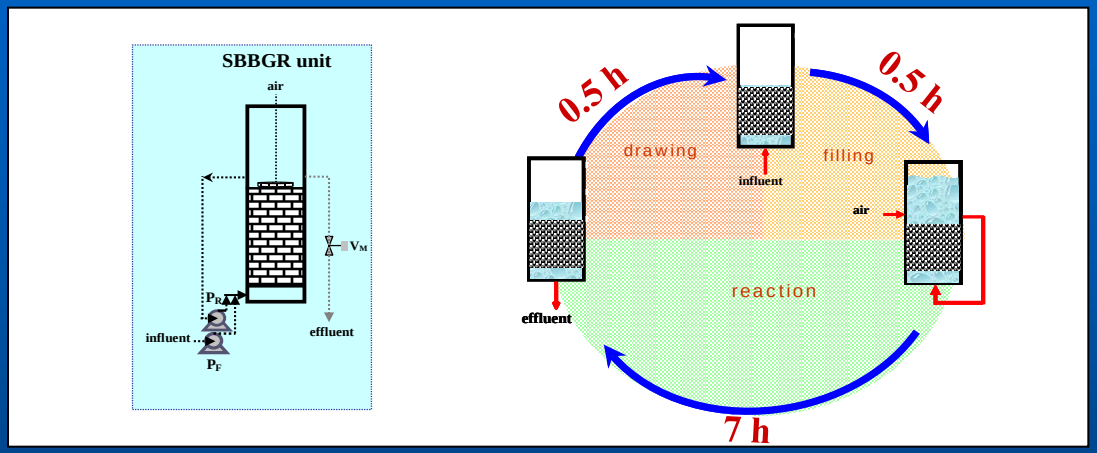
SBBGR INTEGRATED WITH OZONATION



MUNICIPAL LANDFILL LEACHATE COMPOSITION – 1

Parameter	Value range	Parameter	Value range
COD	8.0 – 10.8 g/L	Sulphates	4 – 6 g/L
BOD_5/COD	0.15 – 0.2	Sodium	5 – 7 g/L
DOC	2.5 – 3.3 g/L	Potassium	1.5 – 2 g/L
NH_4-N	2.9 – 3.1 g/L	Magnesium	150 – 300 mg/L
pH	7.8 – 8.2	Pb	< 0.1 mg/L
P_{tot}	10 – 30 mg/L	Ni	2 – 4 mg/L
TSS	120 – 390 mg/L	Mn	0.1 – 0.4 mg/L
VSS	100 – 260 mg/L	Fe	5 – 7.5 mg/L
Chlorides	3.0 – 6.0 g/l	Zn	0.4 – 0.7 mg/L
Conductibility	20 – 30 mS/cm	Cu	0.04 – 0.2 mg/L

LANDFILL LEACHATE TREATMENT BY SBBGR FOR CARBON REMOVAL

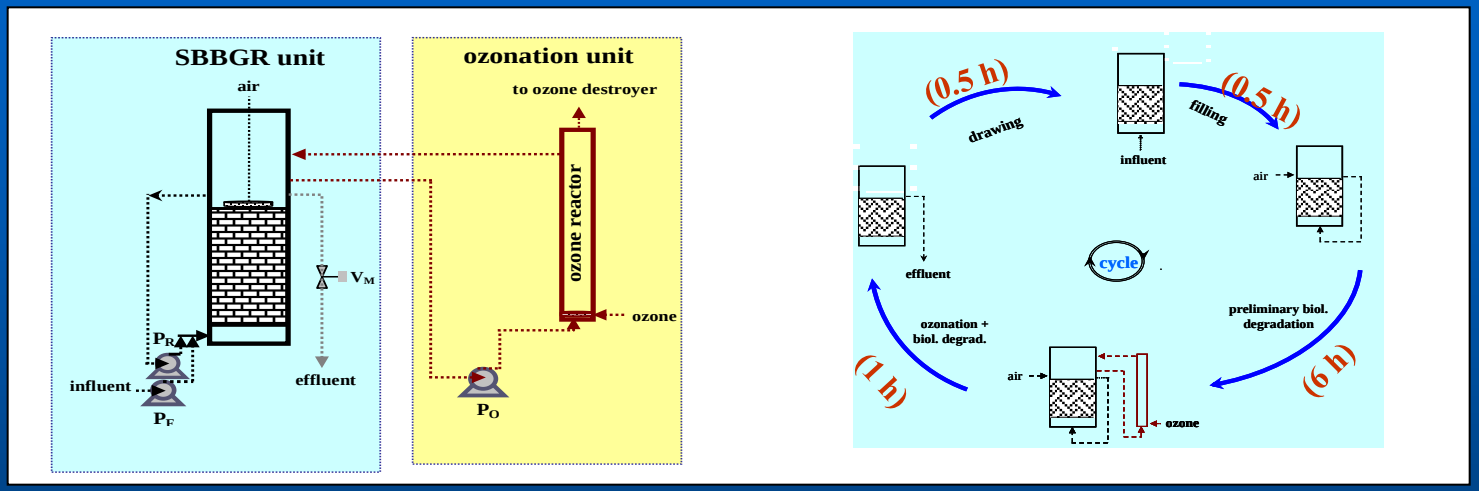


Process performance (OLR: 3-4 kg COD/m³·d)

	COD	DOC	BOD_5	TSS	Surf.	Col.
Inf. (mg/L)	8,700	2,700	1,400	370	65	
Eff. (mg/L)	4,500	1,750	3	40	6.5	
Rem. eff. (%)	48	35	100	89	90	2

sludge production < 0.05 kg dry sludge/kg COD removed

LEACHATE TREATMENT BY SBBGR INTEGRATED WITH OZONATION FOR CARBON REMOVAL



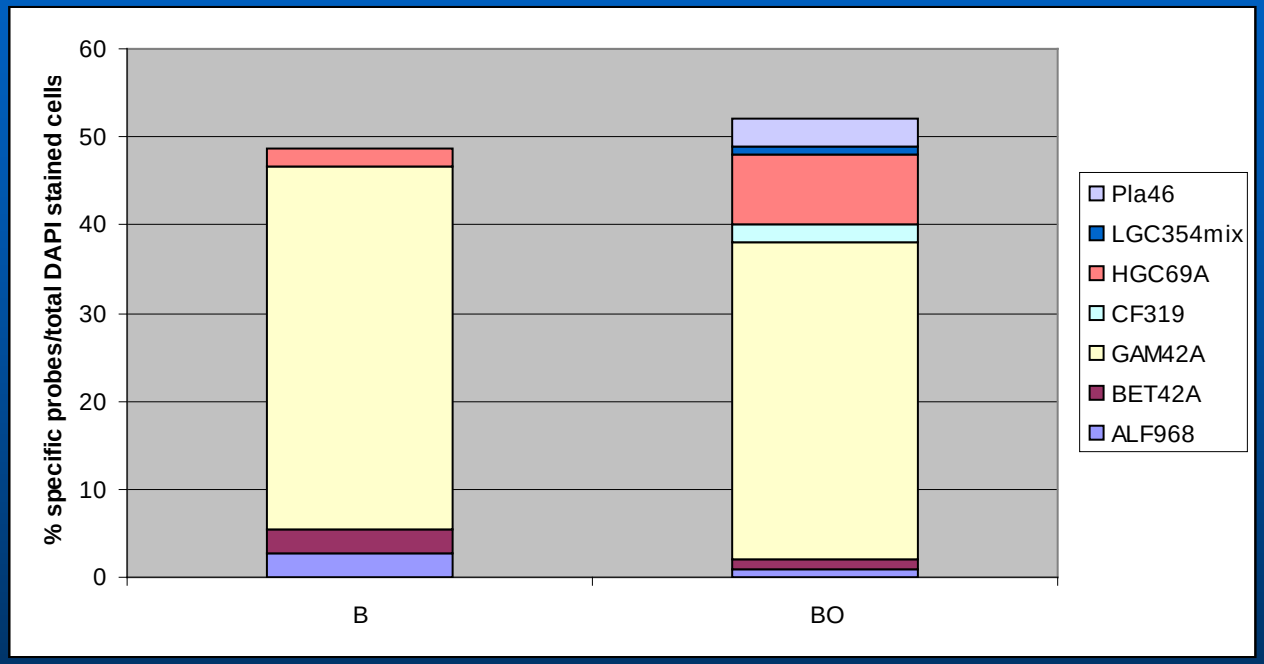
Process performance

(OLR: 3-4 kg COD/m^3·d; ozone dose: 2 kgO_3/m^3_{inf})

	COD	DOC	Surf	TSS	Col
Inf. (mg/L)	**8,000**	**2,450**	**65**	**370**	
Eff. (mg/L)	**160**	**145**	**1**	**20**	
Rem. eff. (%)	**98**	**94**	**98**	**95**	**98**

LEACHATE TREATMENT BY SBBGR INTEGRATED WITH OZONATION FOR CARBON REMOVAL

BIOMASS ACTIVITY AND COMPOSITION



Legenda:

ALF968: *Alphaproteobacteria*

Bet42a: Betaproteobacteria

GAM42A: *Gammaproteobacteria*

CF319: *Cythophaga-Flexibacter-Bacteroides*

HGC69a: *Actinomycetes*

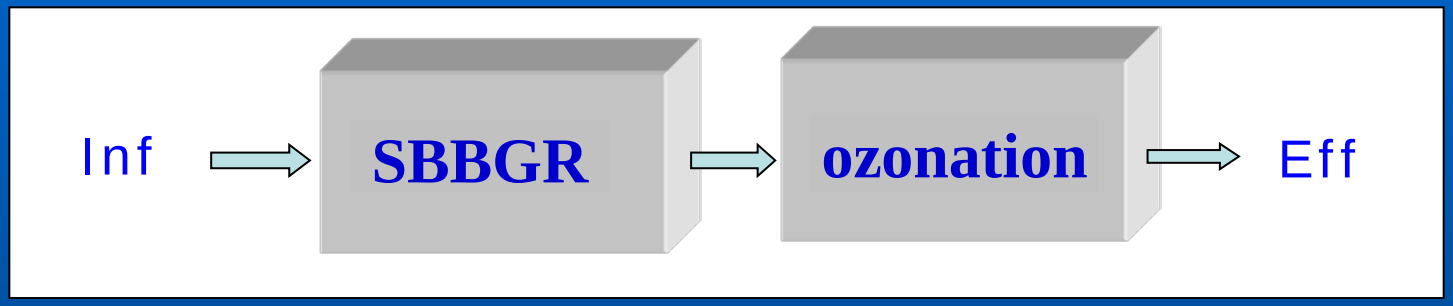
LGC354mix: *Firmicutes*

Pla46: Planctomycetes

B= biological degradation alone

B+O= biological degradation integrated with ozonation

LANDFILL LEACHATE TREATMENT BY SBBGR COMBINED WITH OZONE FOR CARBON REMOVAL



Process performance

(OLR: 3-4 kg COD/m^3·d; ozone dose: 2 kgO_3/m^3_{inf})

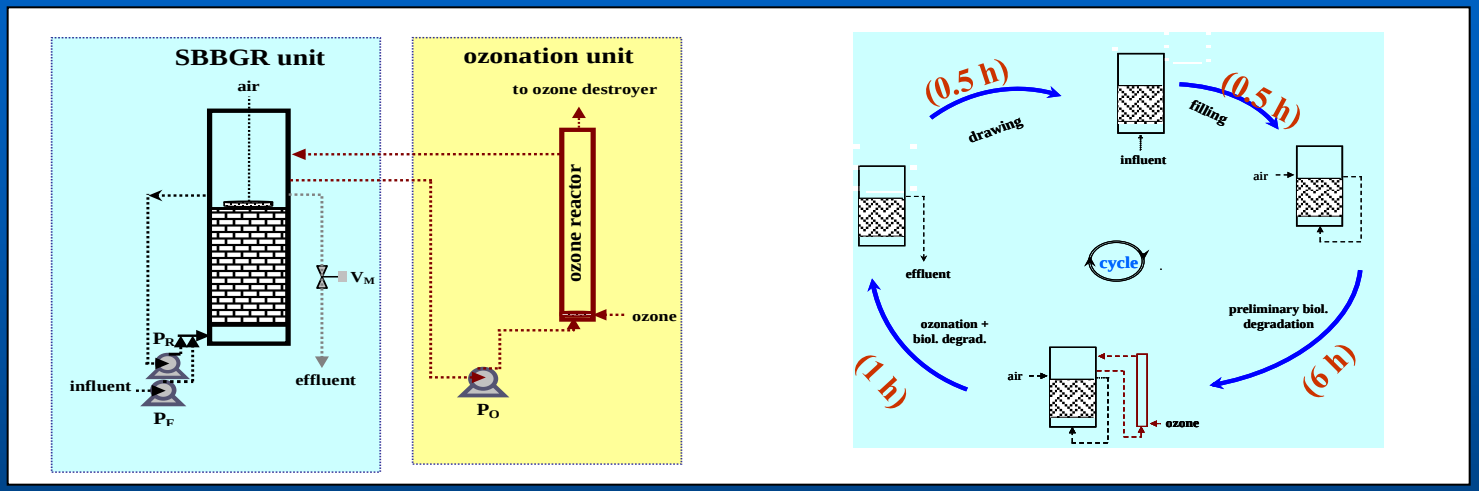
	COD	DOC	TSS	Surf.	Col.
Inf. (mg/L)	8,700	2,700	370	65	
Eff. (mg/L)	3,220	1,410	30	4.5	
Rem. eff. (%)	63	48	92	93	98

OPERATING COSTS

	Energy demand ($kWh/m^3_{inf.}$)	Operating costs ($€/m^3_{inf.}$)
Biological unit (i.e., SBBGR)	**6.0**	**0.63**
Fill. and recirc. oper.	1.5	0.11
Air supply	4.5	0.32
Sludge treatment and disposal		0.20
Ozonation unit	**24**	**3.38**
ozone production, transfer and removal	24	1.68
oxygen demand		1.70
		~ 4

energy cost: 0.07 €/ kWh

LEACHATE TREATMENT BY SBBGR INTEGRATED WITH OZONATION FOR CARBON REMOVAL



Process performance

(OLR: 3-4 kg COD/m^3·d; ozone dose: 0.5 kgO$_3$/m$^3_{inf}$)

	COD	DOC	Surf	TSS	Col
Inf. (mg/L)	8,000	2,450	65	370	
Eff. (mg/L)	490	380	2	30	
Rem. eff. (%)	94	85	97	92	95

OPERATING COSTS

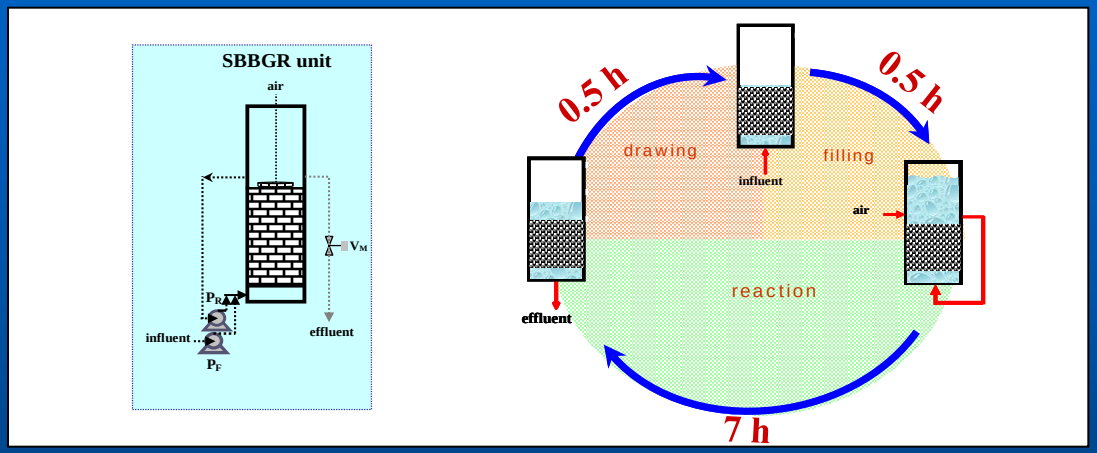
	Energy demand ($kWh/m^3_{inf.}$)	Operating costs ($€/m^3_{inf.}$)
Biological unit (i.e., SBBGR)	**5.9**	**0.62**
Fill. and recirc. oper.	1.5	0.11
Air supply	4.4	0.31
Sludge treatment and disposal		0.20
Ozonation unit	**6**	**0.87**
ozone production, transfer and removal	6	0.42
oxygen demand		0.45
		~ 1.5

energy cost: 0.07 €/ kWh

MUNICIPAL LANDFILL LEACHATE COMPOSITION – 2

Parameter	Value range	Parameter	Value range
COD	2.8 – 3.6 g/L	Sulphates	1.0 – 1.5 g/L
BOD_5/COD	0.2 – 0.3	Sodium	1.5 – 2.0 g/L
DOC	0.9 – 1.2 g/L	Potassium	1.2 – 1.6 g/L
NH_4-N	1.5 – 2.0 g/L	Magnesium	0.2 – 0.4 g/L
pH	7.8 – 8.3	Cr	< 0.1 mg/L
P_{tot}	4 – 6 mg/L	Ni	0.5 – 1 mg/L
TSS	150 – 300 mg/L	Mn	< 0.02 mg/L
VSS	120 – 230 mg/L	Fe	1 – 1.5 mg/L
Chlorides	3.0 – 4.0 g/l	Zn	< 0.01 mg/L
Conductibility	16 – 22 mS/cm	Cu	0.01 – 0.2 mg/L

LANDFILL LEACHATE TREATMENT BY SBBGR FOR N & C REMOVAL



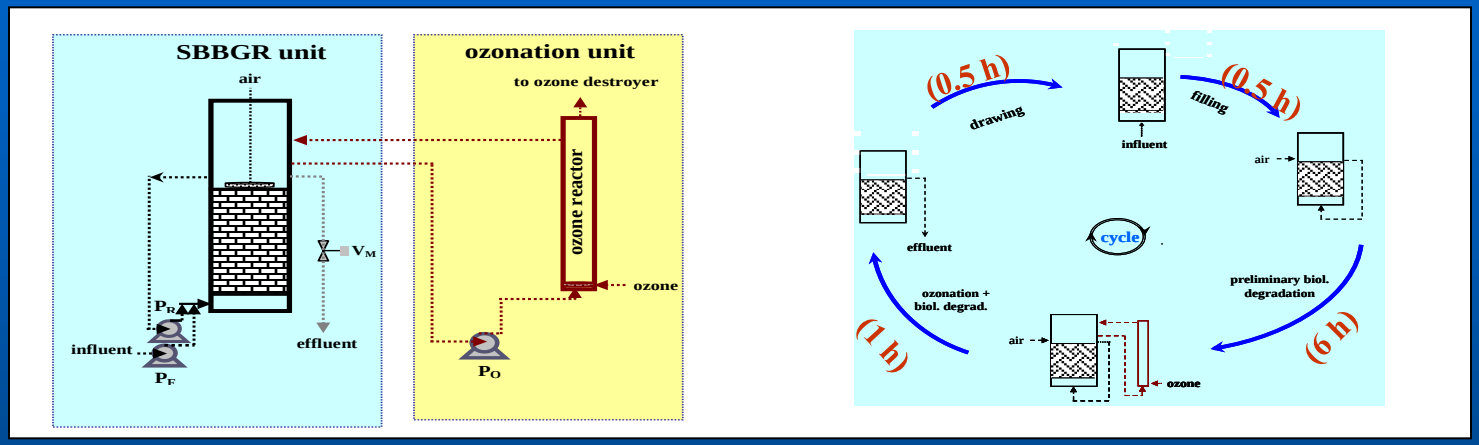
Process performance (OLR: 0.5 - 0.7 kg COD/m³·d)

	COD	DOC	BOD_5	NH_4-N	NO_x-N	TSS	Surf.	Col.
Inf. (mg/L)	9,500*	3,950	3,800	1,680		220	18	
Eff. (mg/L)	1,500	770	15	8	6	45	9	
Rem. eff. (%)	84	81	100	99	99	80	50	52

* 3,500 (leachate) + 6,000 (external source)

sludge production < 0.05 kg dry sludge/kg COD removed

LEACHATE TREATMENT BY SBBGR INTEGRATED WITH OZONATION FOR N & C REMOVAL



Process performance

(OLR: 0.5-0.7 kg COD/m^3·d; ozone dose: 0.4 kgO_3/m^3_{inf})

	COD	DOC	NH_4-N	NO_x-N	TSS	Surf.	Col.
Inf. (mg/L)	9,500*	3,950	1,680		220	18	
Eff. (mg/L)	485	290	2	8	30	1.5	
Rem. eff. (%)	95	93	100	99	86	92	95

* 3,500 (leachate) + 6,000 (external source)

OPERATING COSTS

	Energy demand ($kWh/m^3_{inf.}$)	Operating costs ($€/m^3_{inf.}$)
Biological unit (i.e., SBBGR)	**12**	**4.54**
Fill. and recirc. oper.	5.5	0.39
Air supply	6.5	0.45
External carbon source		3.5
Sludge treatment and disposal		0.20
Ozonation unit	**4.8**	**0.7**
ozone production, transfer and removal	4.8	0.34
oxygen demand		0.36
		5.2

energy cost: 0.07 €/ kWh

SCALE-UP OF THE PROCESS


SBBGR


ozone injector


ozone generator


ozone reactor

Acknowledgment

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