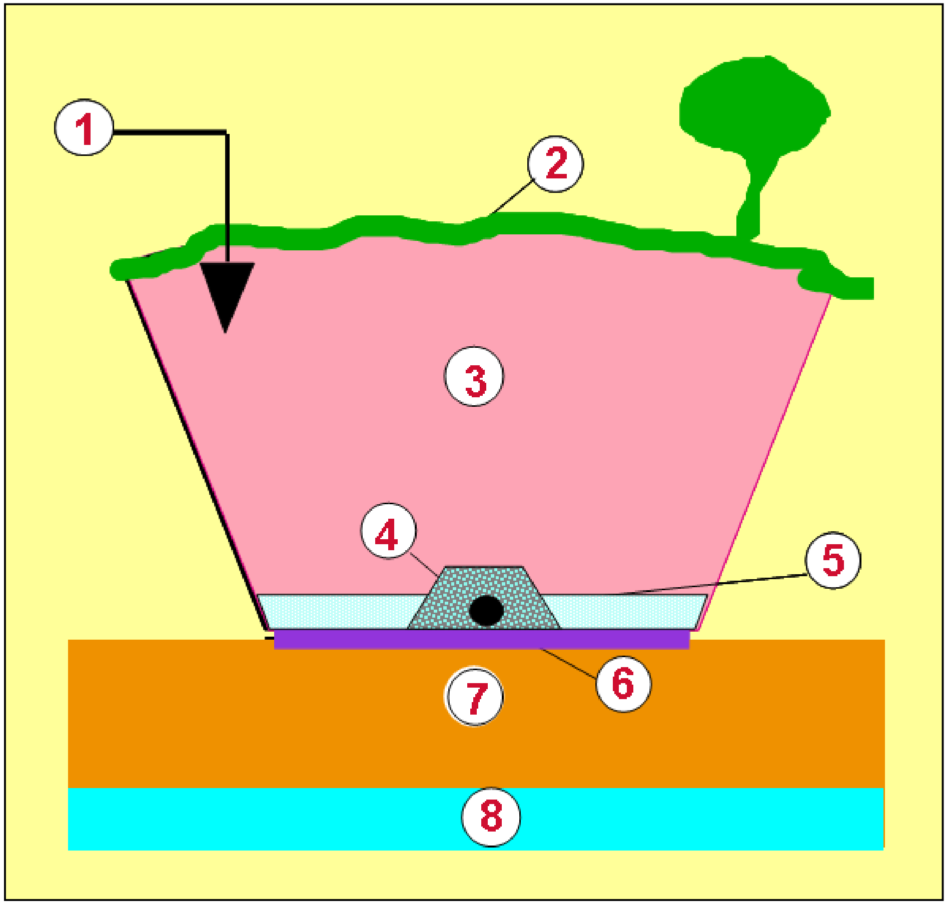
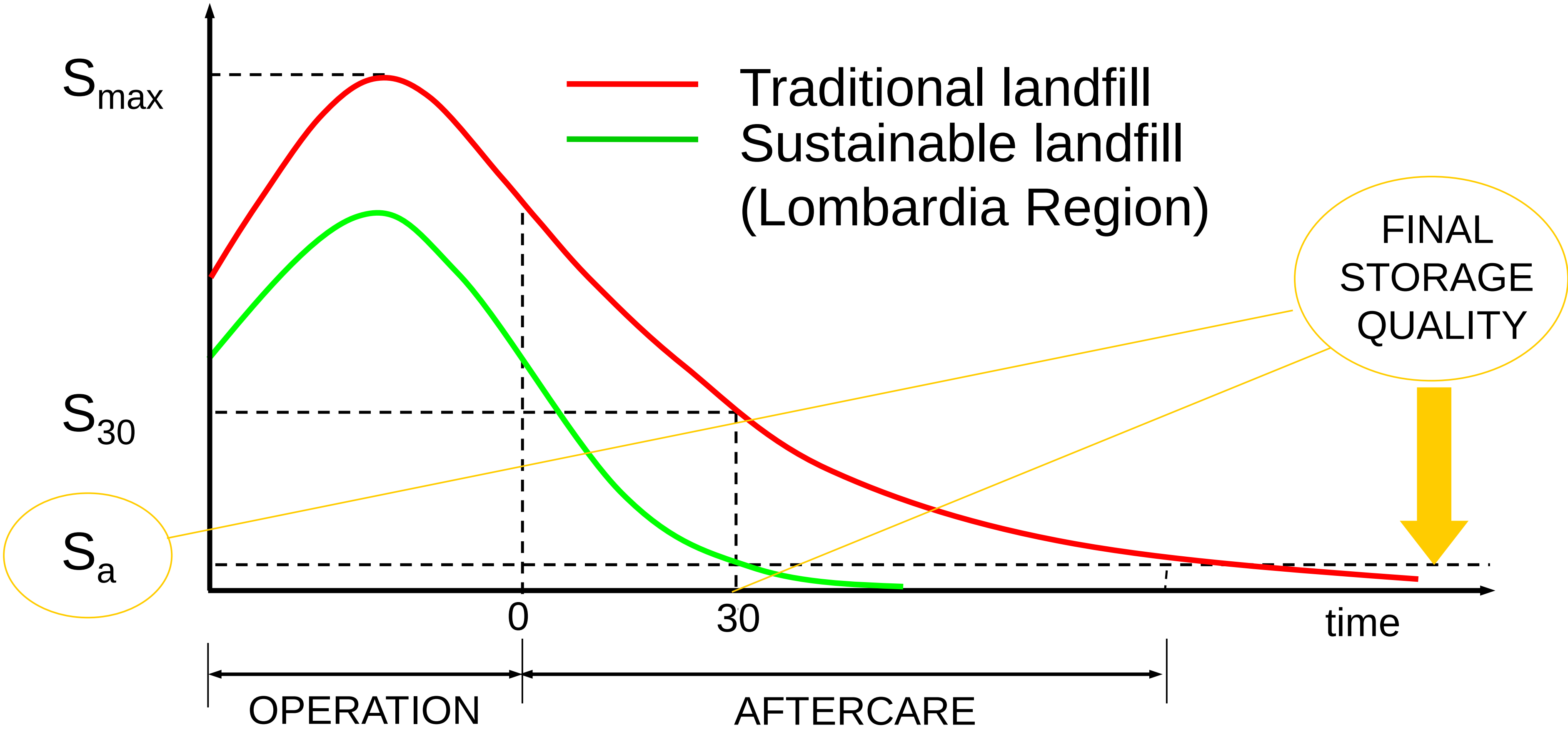
Facultative (semi-aerobic anaerobic) landfilling



Raffaello Cossu, Luca Morello, Roberto Raga
University of Padova

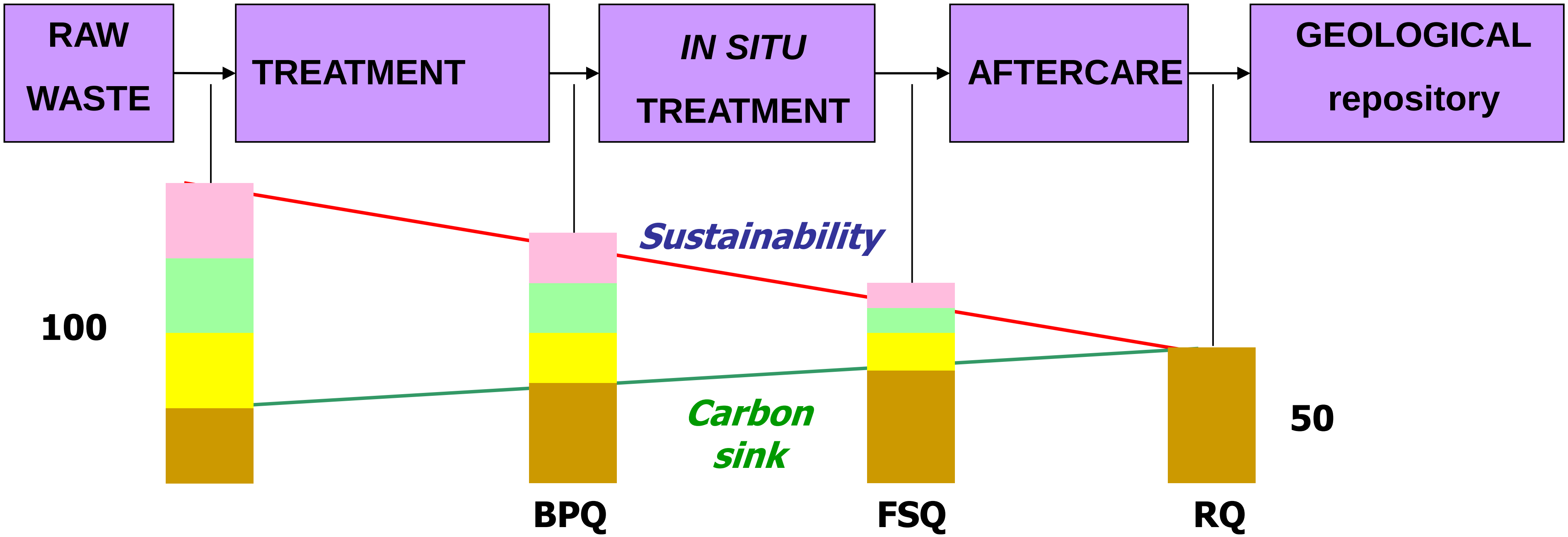
2. Equilibrium within 30 years



3. Table Values for defining FSQ

PARAMETERS	VALUES	PARAMETERS	VALUES
LEACHATE		CN^- (mg/l)	0,5
COD (mg/l)	1500	SO_4^{2-} (mg/l)	1000
BOD_5/COD	0,1	F^- (mg/l)	6
NH_4^+ (mgN/l)	50	$C_nH_n$tot	5
Al (mg/l)	1	C_6H_5OH	0,5
As (mg/l)	0,5	AOX	0,2
B (mg/l)	2	N-Organic solvents	0,1
Cd (mg/l)	0,02	Total chlorinated solvents	1
Cr (mg/l)	2	Phosfatic pesticides	0,1
Cr^{VI} (mg/l)	0,2	Total pesticides	0,05
Cu (mg/l)	1		
Fe (mg/l)	2	**BIOGAS**	
Hg (mg/l)	0,005	Methane (Nl CH_4/m^2/h)	0,5
Mn (mg/l)	2		
Ni (mg/l)	2	**WASTE**	
Pb (mg/l)	0,2	RI_4 (mgO_2/kg TS)	2
Sn (mg/l)	10	DRI (100 mgO2/kg VS/h)	100
Zn (mg/l)	3	GB_{21} (Nl LFG/kg TS)	5

Control of sustainability and element sink



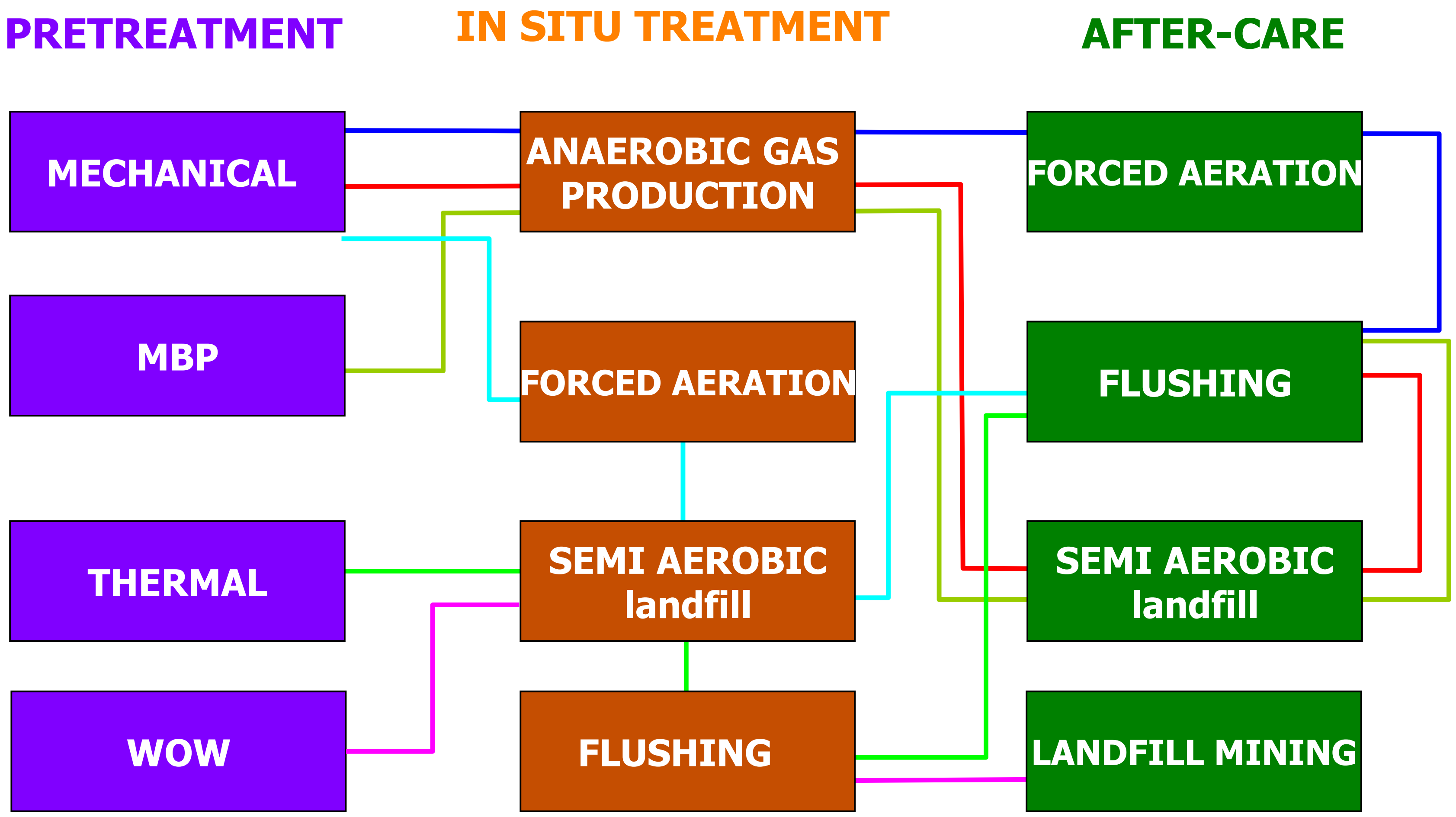
S_G= Gasified carbon *(CO_2, Methane)*

S_L= Leached carbon *(VFA, Carbohydrates, COD*

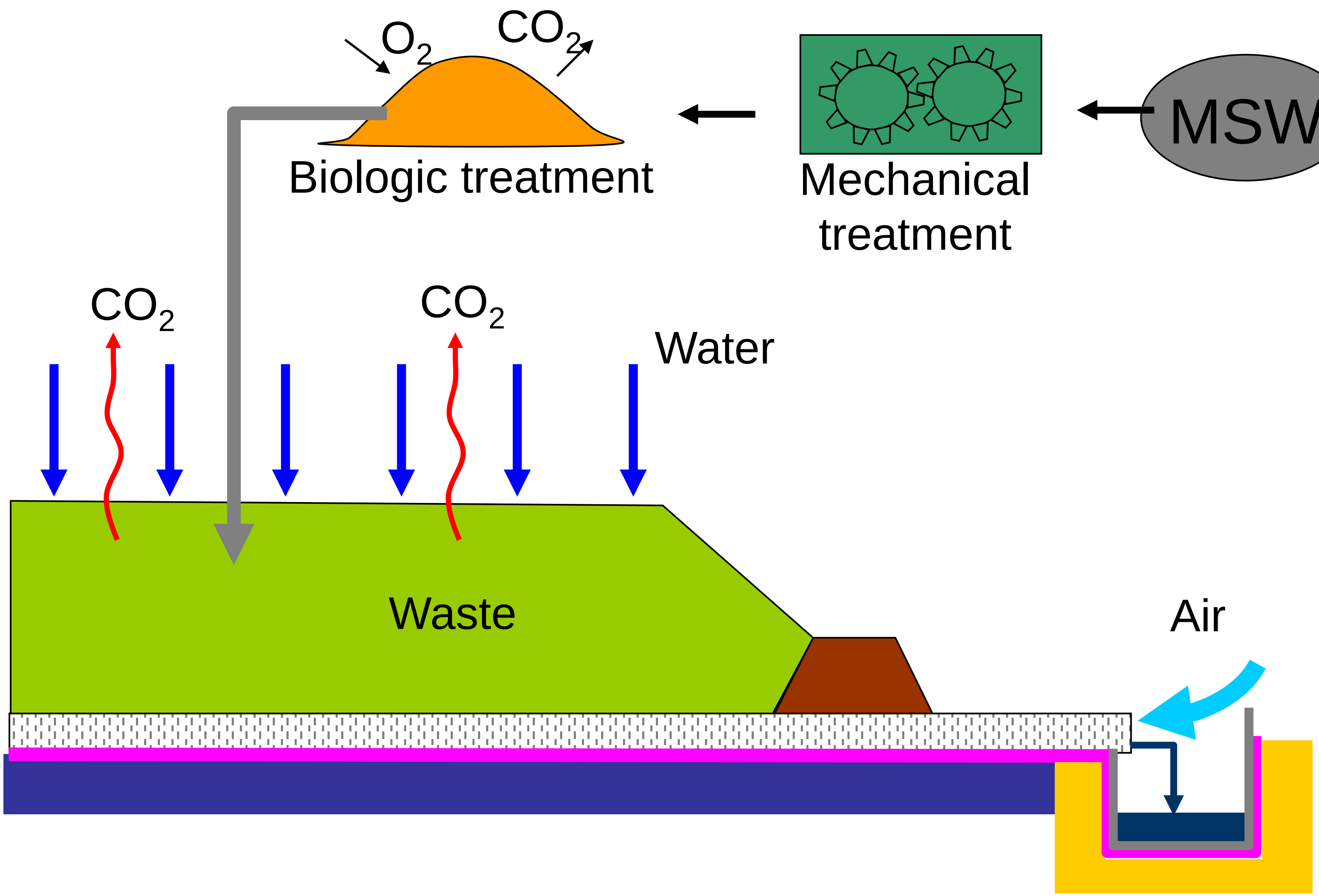
S_S= Degradable carbon *(cellulose, hemicellulose, fat)*

X_S= Stable carbon *(lignin, humic substances, plastics)*

4. Tools and scenarios for achieving sustainability



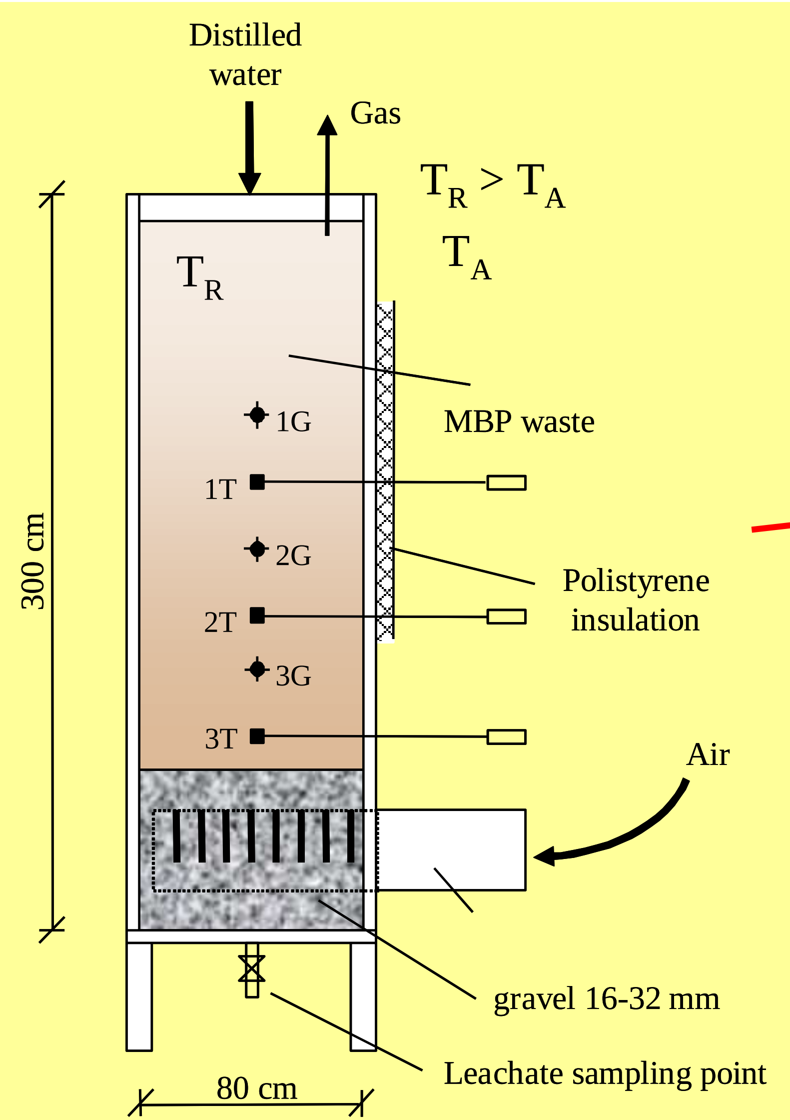
Semi aerobic landfill

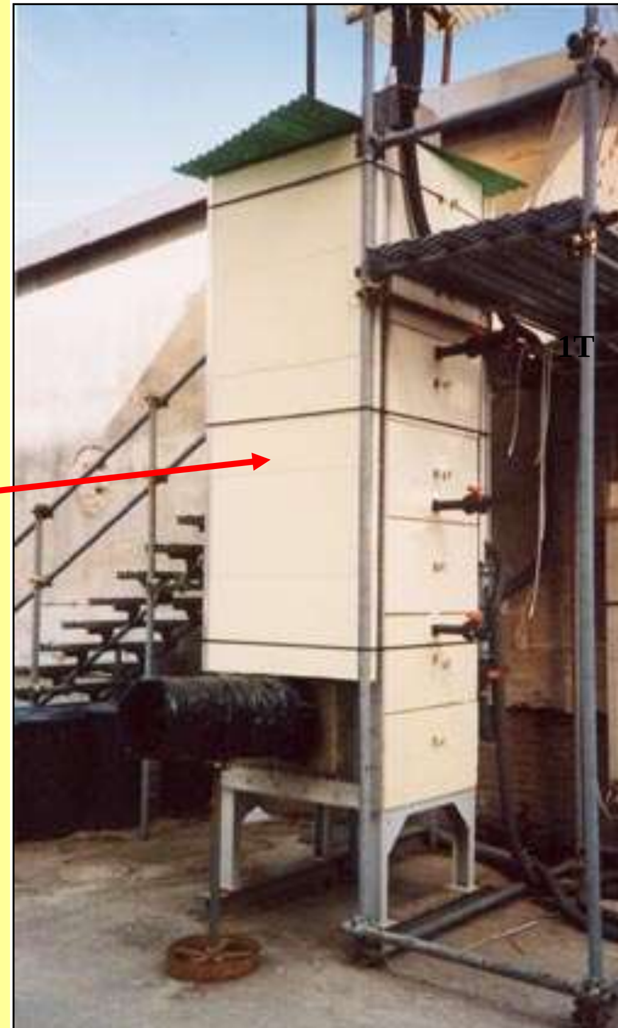


1 RUN: Testing of different models

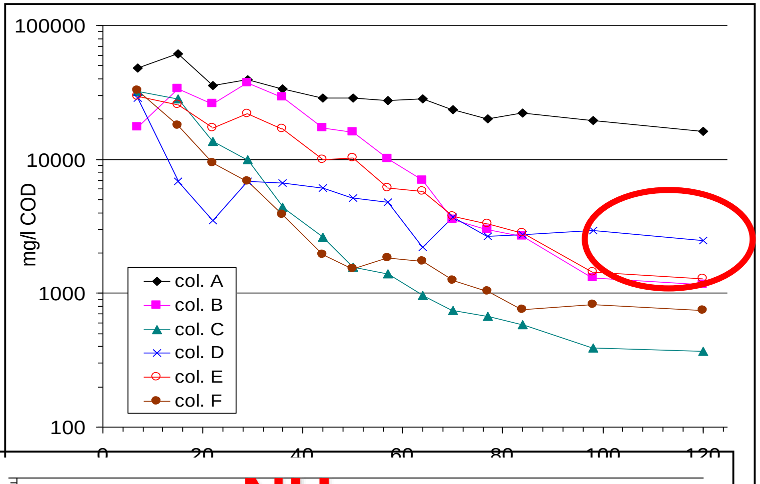
Six columns were installed in a thermoinsulated room

Column	Material	Operative Conditions	Landfill Concept
A	MSW	Anaerobic	Traditional landfill
B	MBP	Anaerobic	Pretreated landfill
C	MBP	Anaerobic with high water input	Flushing bioreactor
D	MBP	Aerobic - high air inflow	Aerated landfill
E	MBP	Aerobic - low and discontinuos air inflow	Semiaerobic landfill
F	MBP	Aerobic- low and discontinuos air inflow, high water input	PAF model

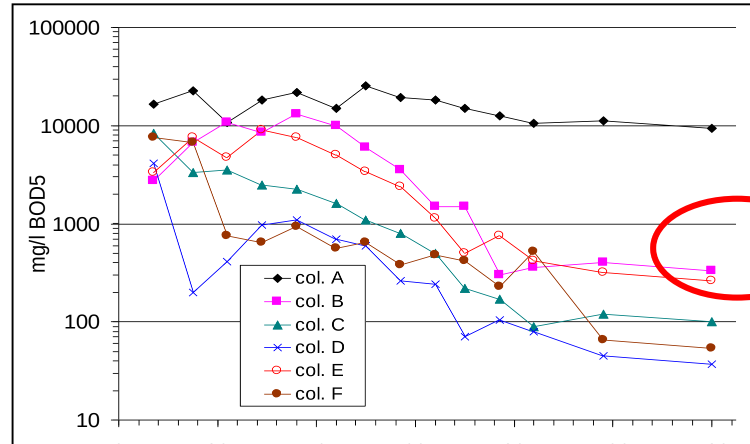

Distilled water
Gas
$T_R > T_A$
T_A
T_R
MBP waste
1G
1T
2G
2T
3G
3T
Polistyrene insulation
Air
gravel 16-32 mm
Leachate sampling point
300 cm
80 cm


1T

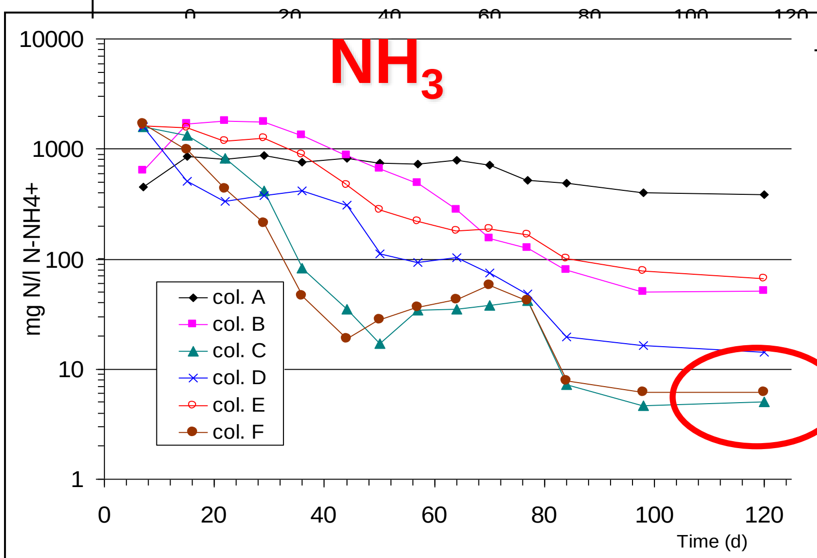
COD



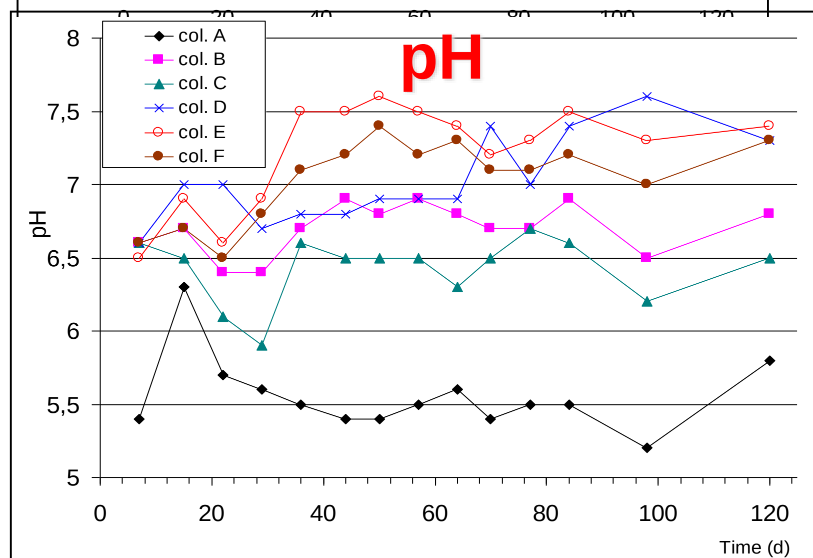
BOD

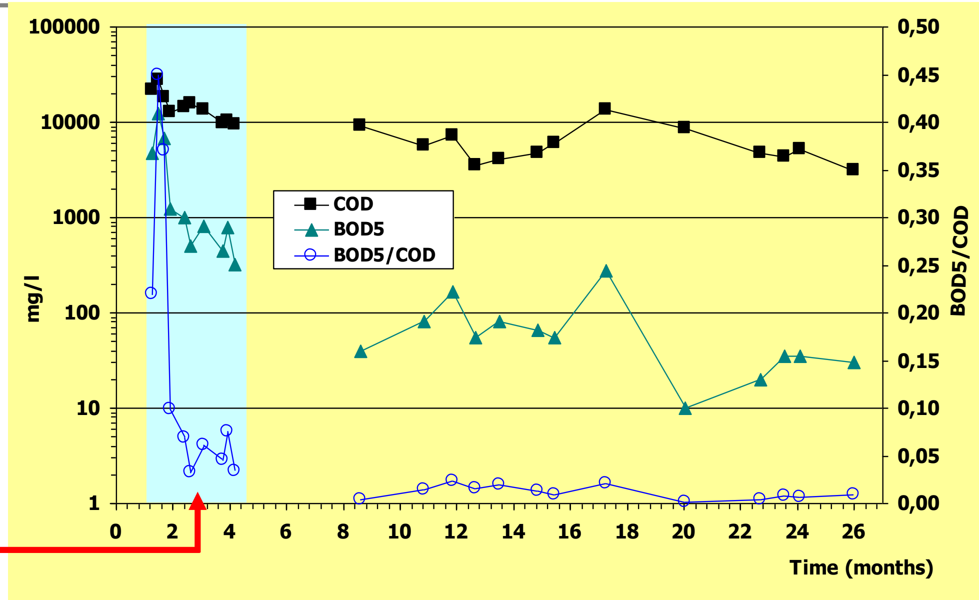


NH_3

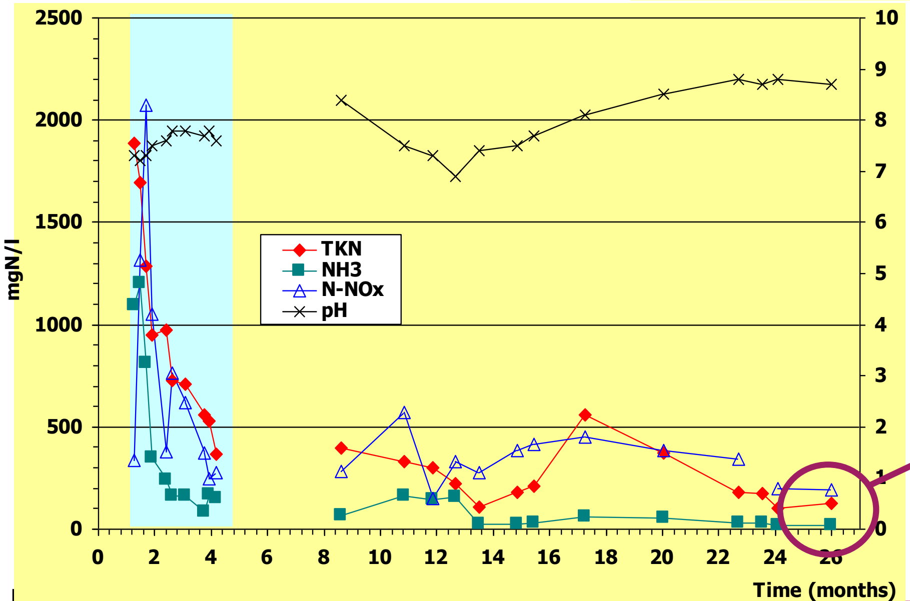


pH





Flushing



Final concentrations

BOD_5 = 30 mg/l

NH_3 = 19 mg/l

Residual emissions targets

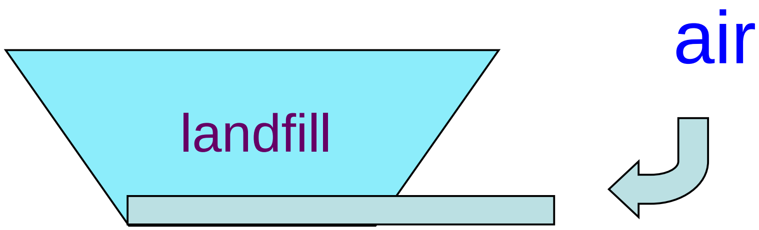
PARAMETERS	Traditional landfill	Enhanced landfill	Limits Water Discharge
BOD_5 , mg/l	5000	11	40
COD, mg/l	10000	1442	160
BOD_5 /COD	0,4	0,008	-
TVA, mgC/l	4000	106	-
TKN, mgN/l	3000	46	-
NH_3 , mgN/l	2500	6,3	15
Chloride mgCl/l	2500	1800	1200
Copper, mgCu/l	1,5	0,67	0,1
Lead, mgPb/l,	0,5	0,32	0,2

Bioreactor Landfills

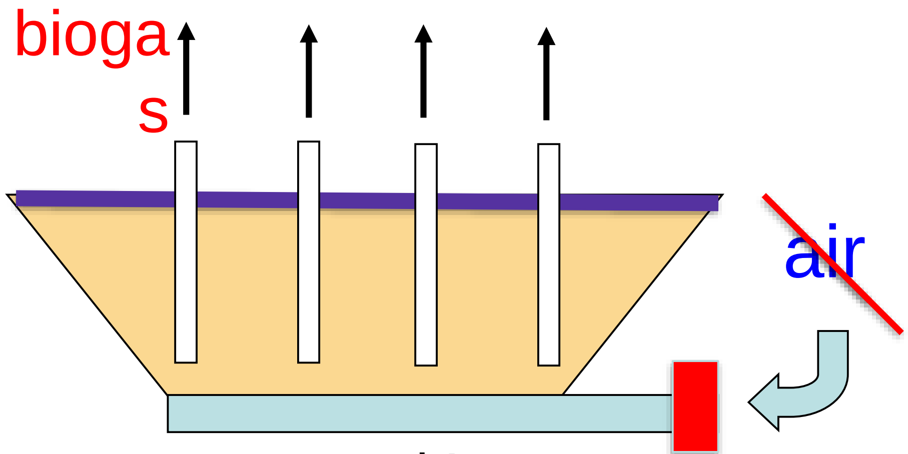
Type	Energetic Balance	Kinetics	Nitrogen	Main Persistent Elements	Techno-logical complexity
Anaerobic	Positive (methane production)	Slow	Persistence of NH_4^+	COD, NH_4^+, salinity, Metals	Low
Aerobic	Negative (Energy for aeration)	Fast	Nitro	salinity, Metals	Medium
Hybrid (anaerobic-aerobic)	Depends	Variable	Nitro-denitro	salinity, Metals	Medium
Hybrid (intermittent aeration)	Depends	Fast	Nitro-denitro	salinity, Metals	High
Hybrid (aerobic-anaerobic)	Positive (low initial energy for aeration)	Variable	Persistence of NH_4^+	COD, NH_4^+, salinity, Metals	High

SAnA concept

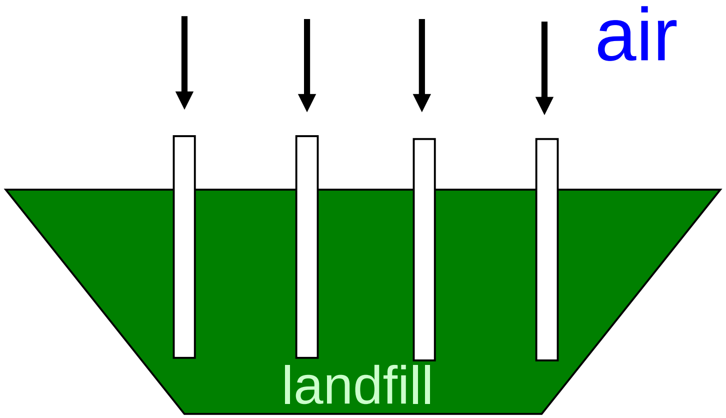
$T_{landfill} > T_{ambient}$



Semi-aerobic



Anaerobic



Forced aeration

Semi-Aerobic	Anaerobic	Aerated	Semi-Aerobic

SAnA


24.1

SANA Landfill

Advantages:

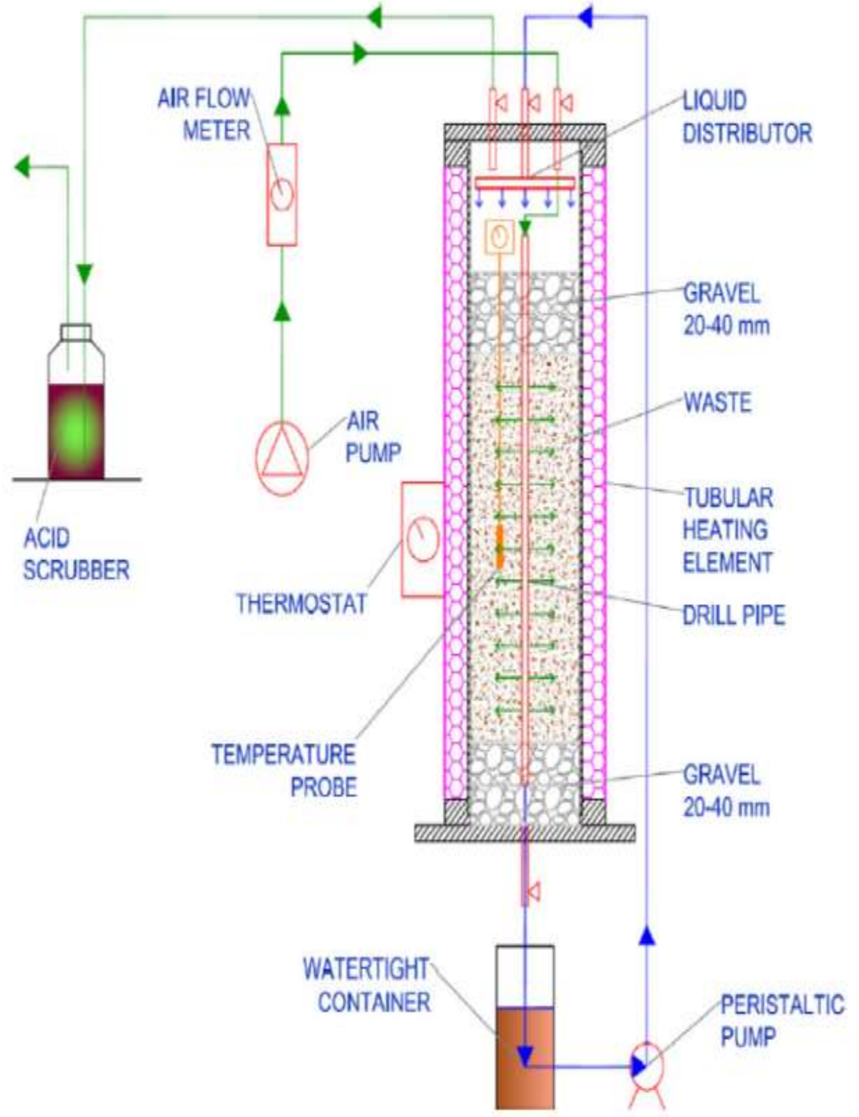
- Methane production and energy recover in anaerobic phase.
- Enhancement of methane production thanks to semi-aerobic pre-aeration of waste.
- Faster kinetics of reaction during anaerobic phase.
- Decomposition of hardly degradable organics during the aerobic phase.
- Nitrification and Denitrification during the aerobic phase.

Reasearch objectives

- ✓ Verify the effectiveness of pre-aeration for the enhancement of methane production in a following anaerobic phase (production rate, cumulative volume produced and lag phase).
- ✓ Establish the optimum parameters and the optimum aeration methodology for enhance methane production.
- ✓ Compare the methane potential production
- ✓ Verify the emission potential in leachate at the end of anaerobic phase.

Materials and methods

Waste sample:
18 kg MSW
Density: 0.5 kg/L
Humidity maintained
at 55-60%
Leachate Recirculation
Leachate extraction =
Water input =
200 ml/week

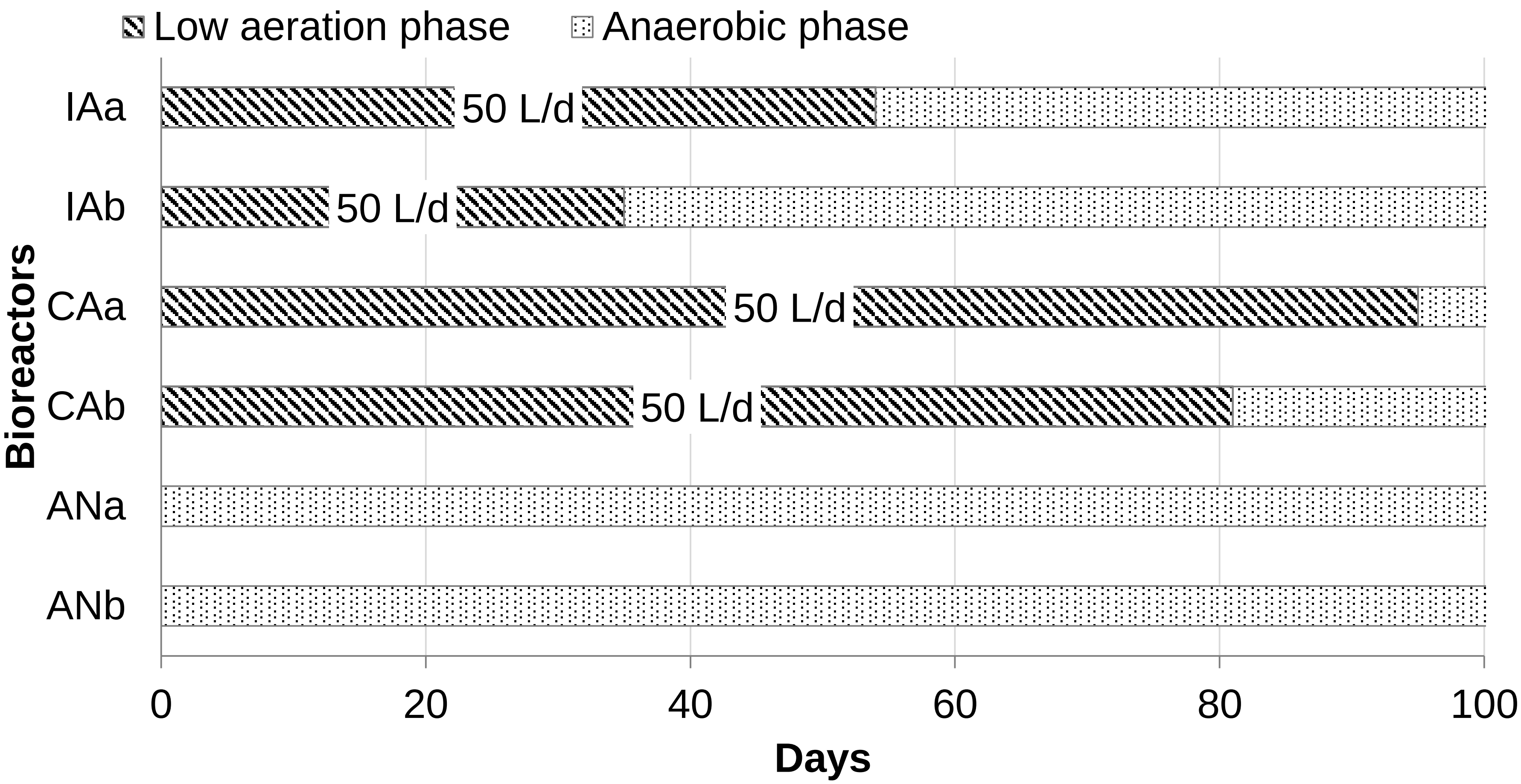


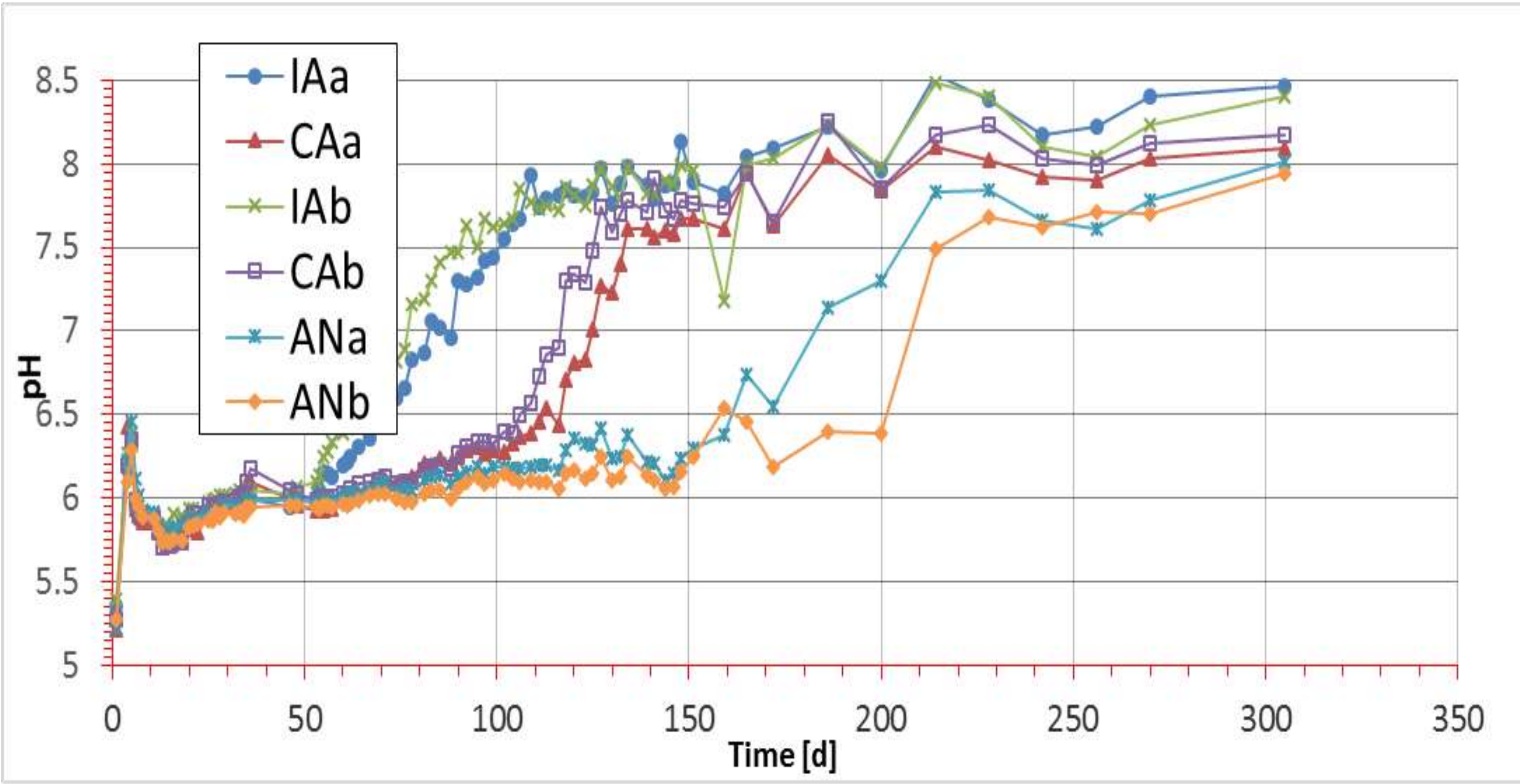
Aeration → Decreas e VFA → Increase pH → Optimum conditions for methanogens → Increased and faster methane generation

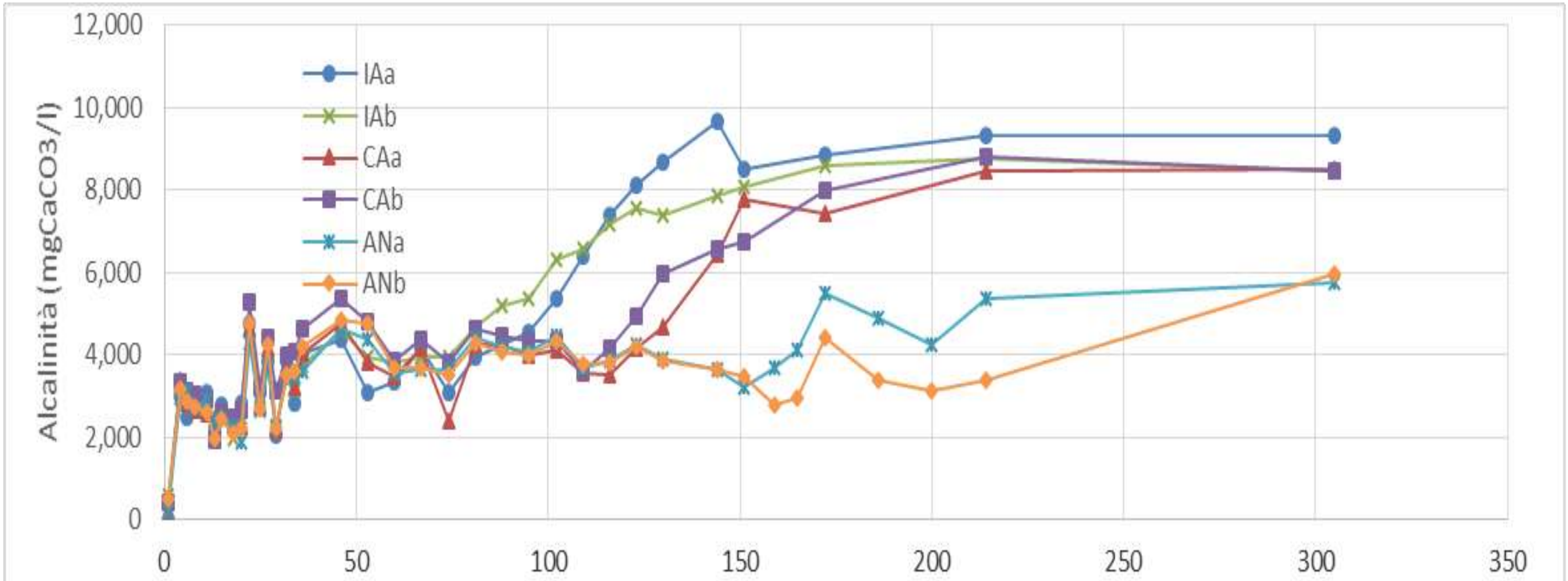
For stopping the aeration and start the methanogenic phase, the optimums parameters for methanogens must be reached.

Parameter	Values Range
Temperature (°C)	35-45
pH	6.5 – 8.2
Alkalinity ($mgCaCO_3/L$)	1000-5000
Volatile Fatty Acids ($mgCH_3COOH/L$)	< 6000

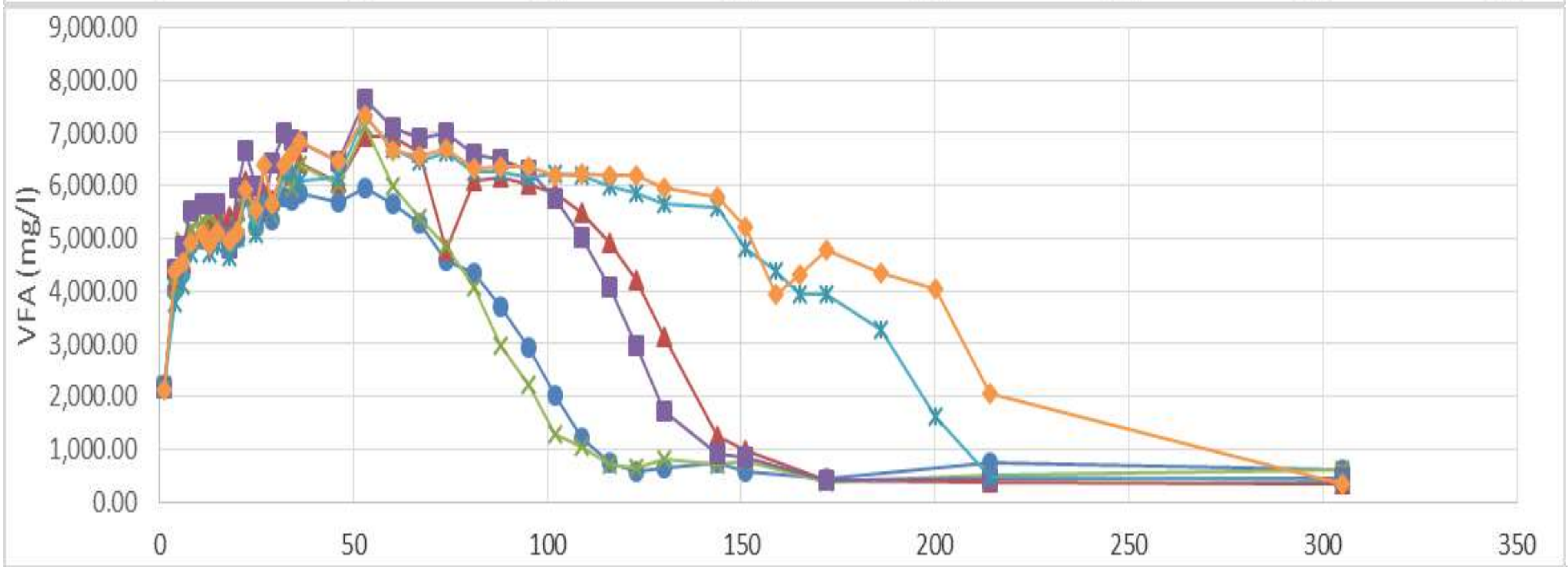
Pre-aeration programme



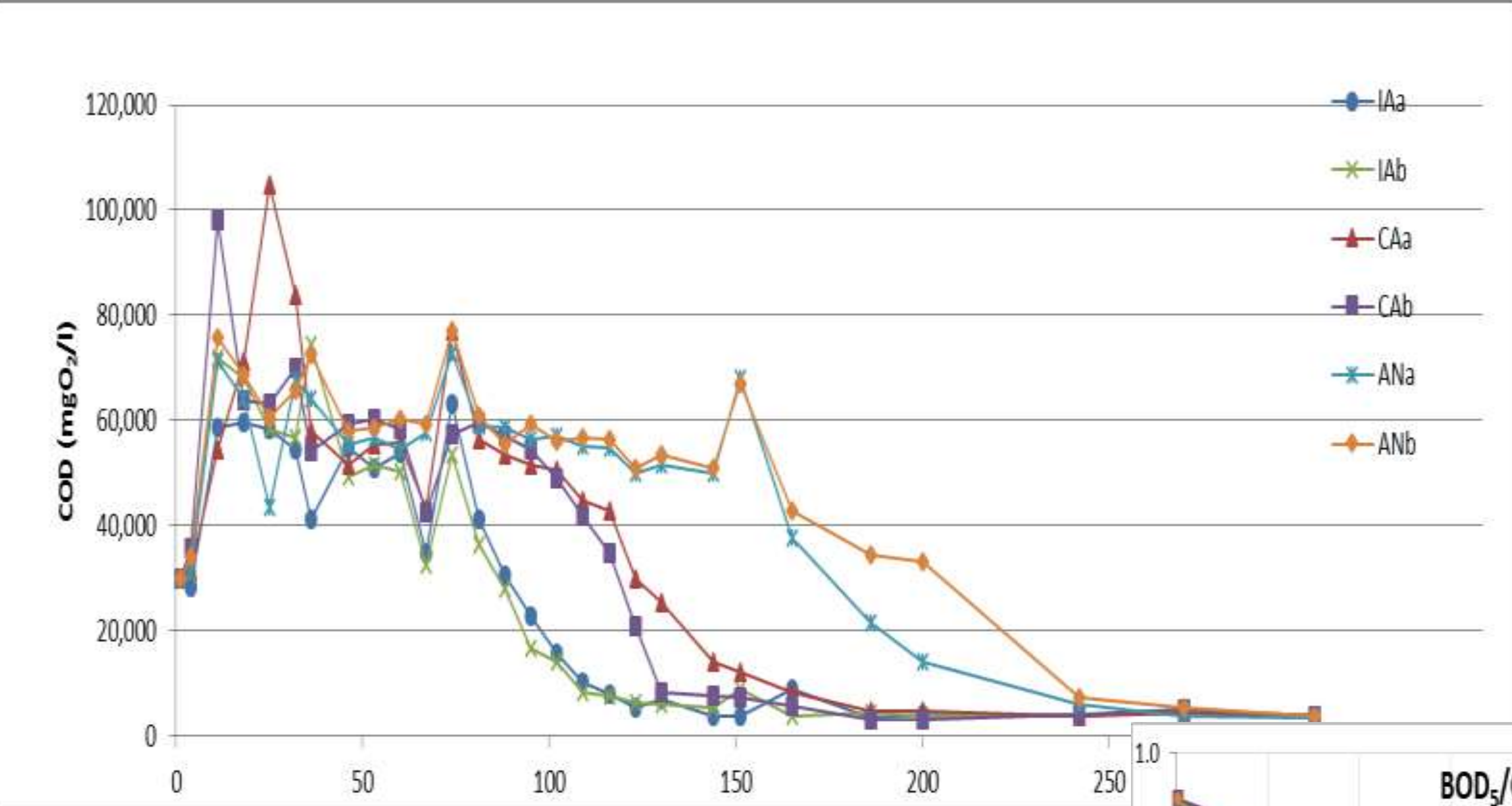

IAa
CAa
IAb
CAb
ANa
ANb
pH
8.5
8
7.5
7
6.5
6
5.5
5
0
50
100
150
200
250
300
350
Time [d]

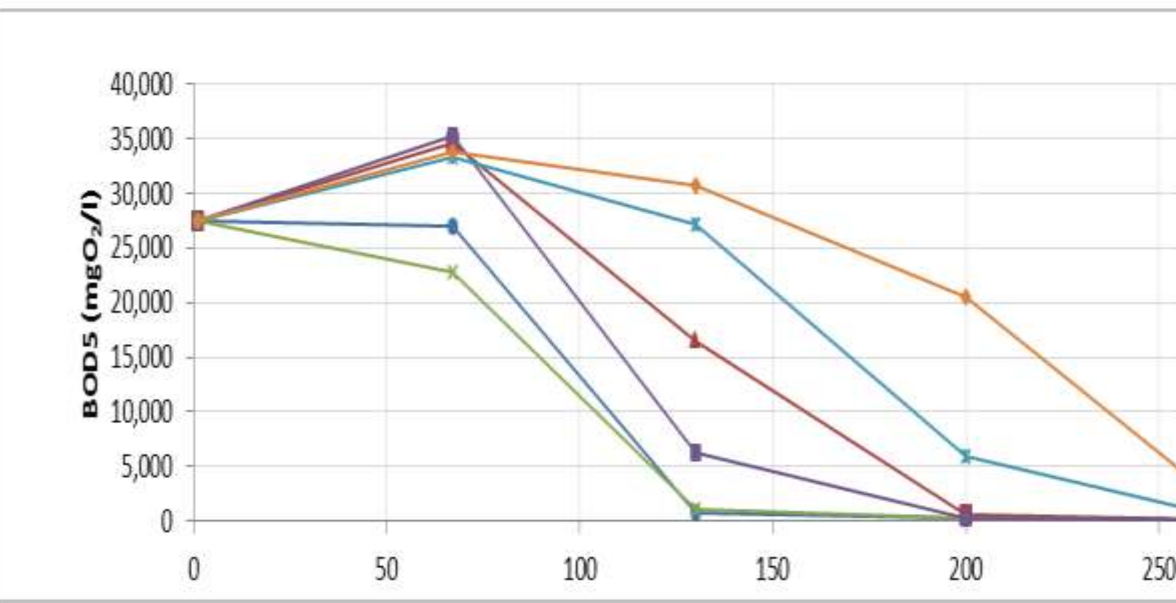


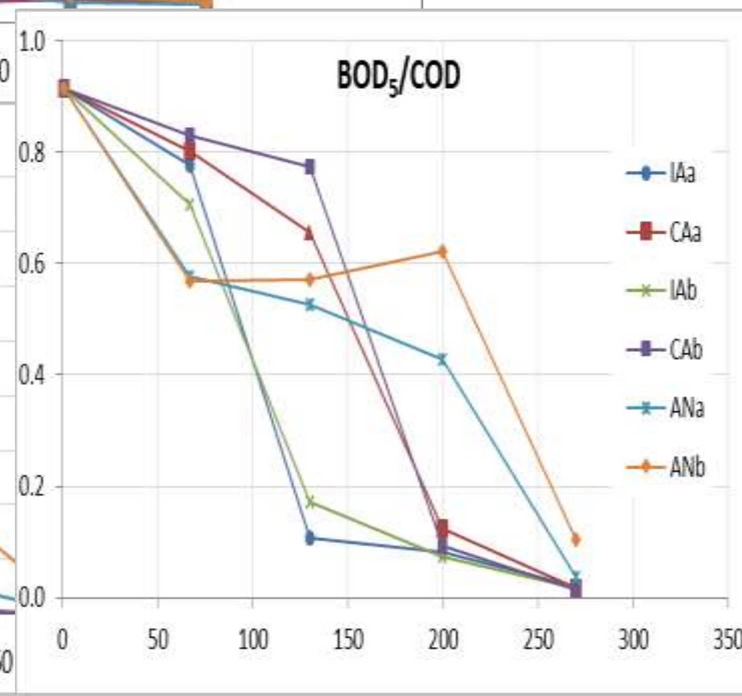
Alcalinità (mgCaCO3/l)
12,000
10,000
8,000
6,000
4,000
2,000
0
0
50
100
150
200
250
300
350
IAa
IAb
CAa
CAb
ANa
ANb

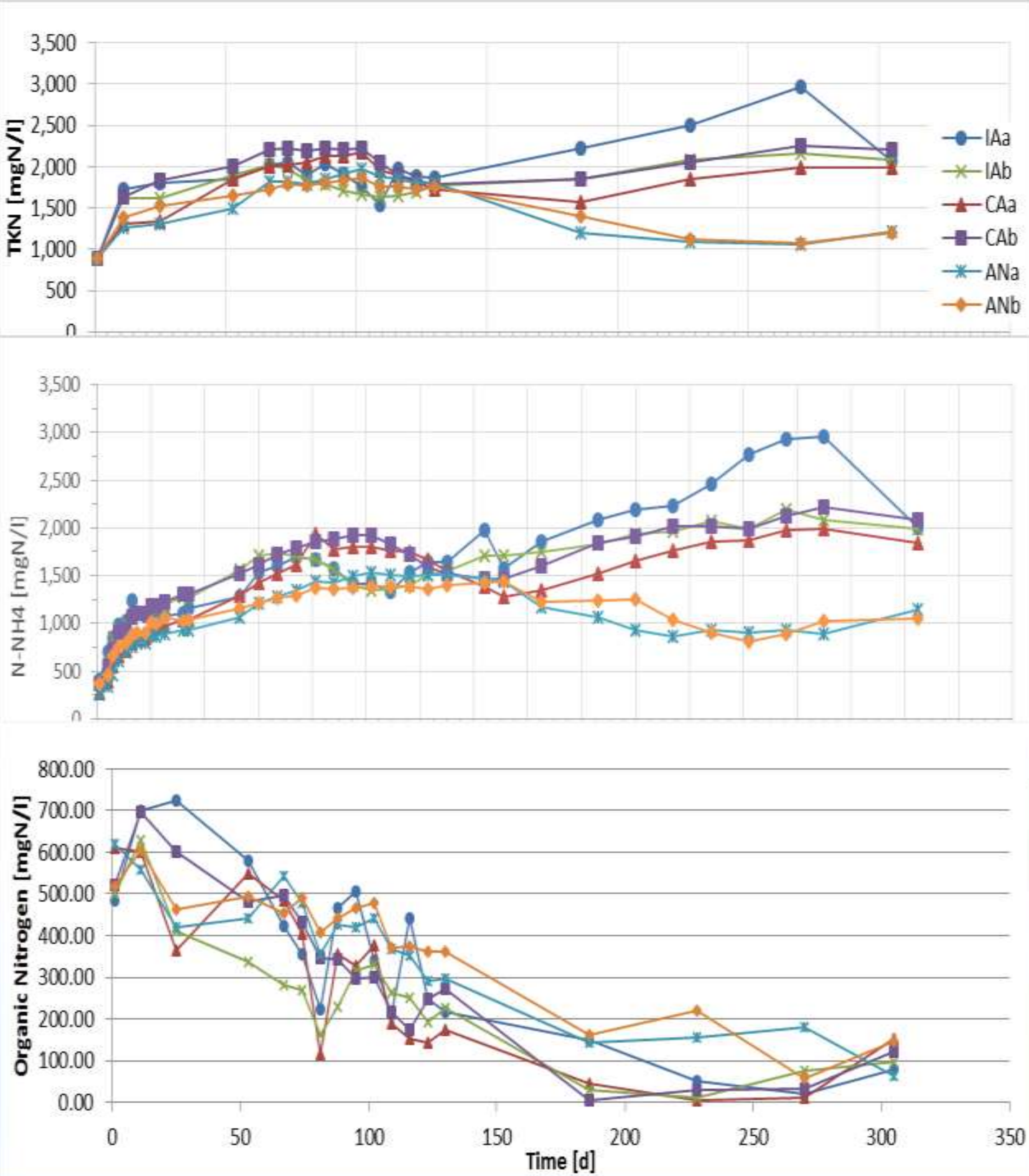


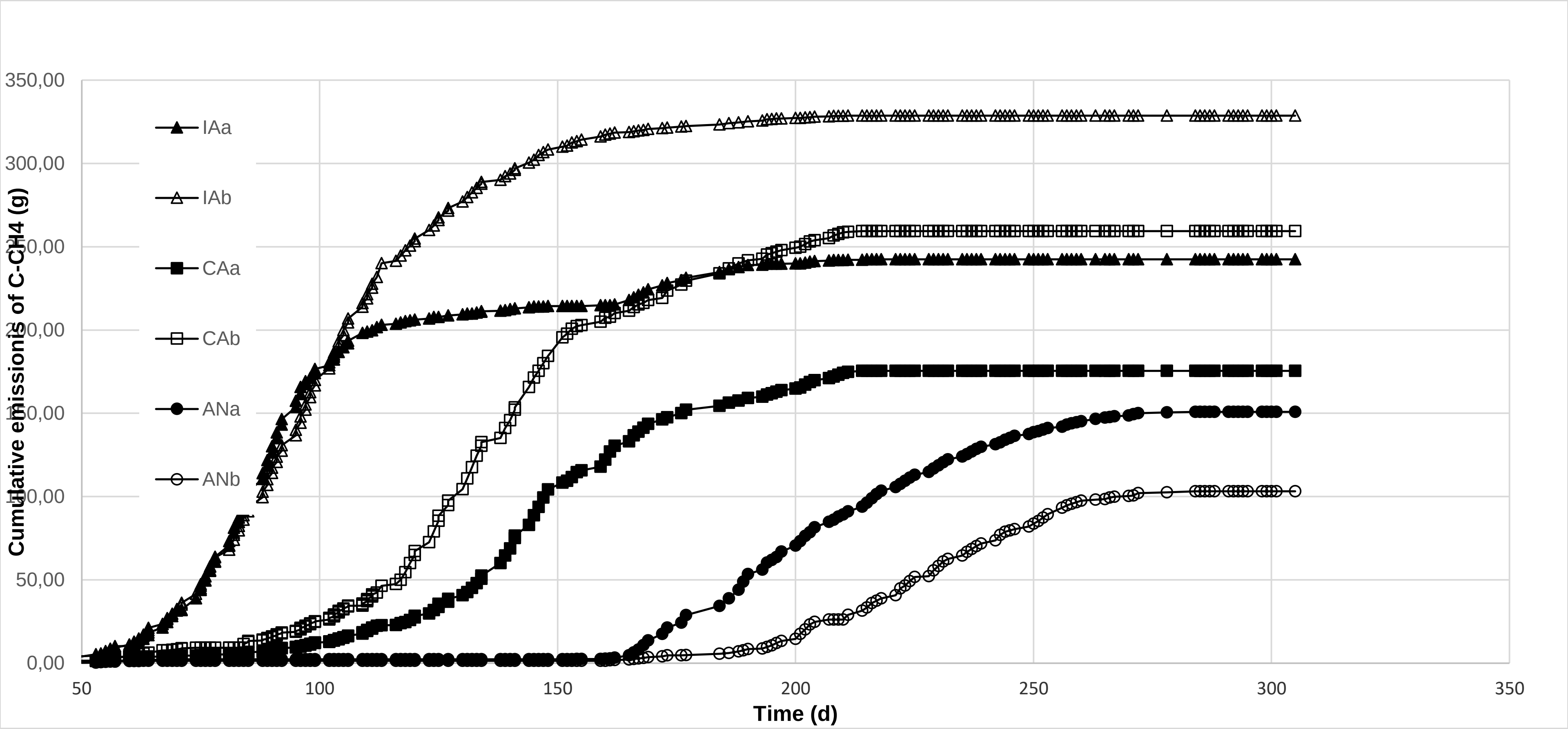
VFA (mg/l)
9,000.00
8,000.00
7,000.00
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
0.00
0
50
100
150
200
250
300
350


COD (mgO2/l)
120,000
100,000
80,000
60,000
40,000
20,000
0
0
50
100
150
200
250
IAa
IAb
CAa
CAb
ANa
ANb


BOD5 (mgO2/l)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
50
100
150
200
250


BOD5/COD
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
350
IAa
CAa
IAb
CAb
ANa
ANb


TKN [mgN/l]
3,500
3,000
2,500
2,000
1,500
1,000
500
0
IAa
IAb
CAa
CAb
ANa
ANb
N-NH4 [mgN/l]
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Organic Nitrogen [mgN/l]
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0
50
100
150
200
250
300
350
Time [d]

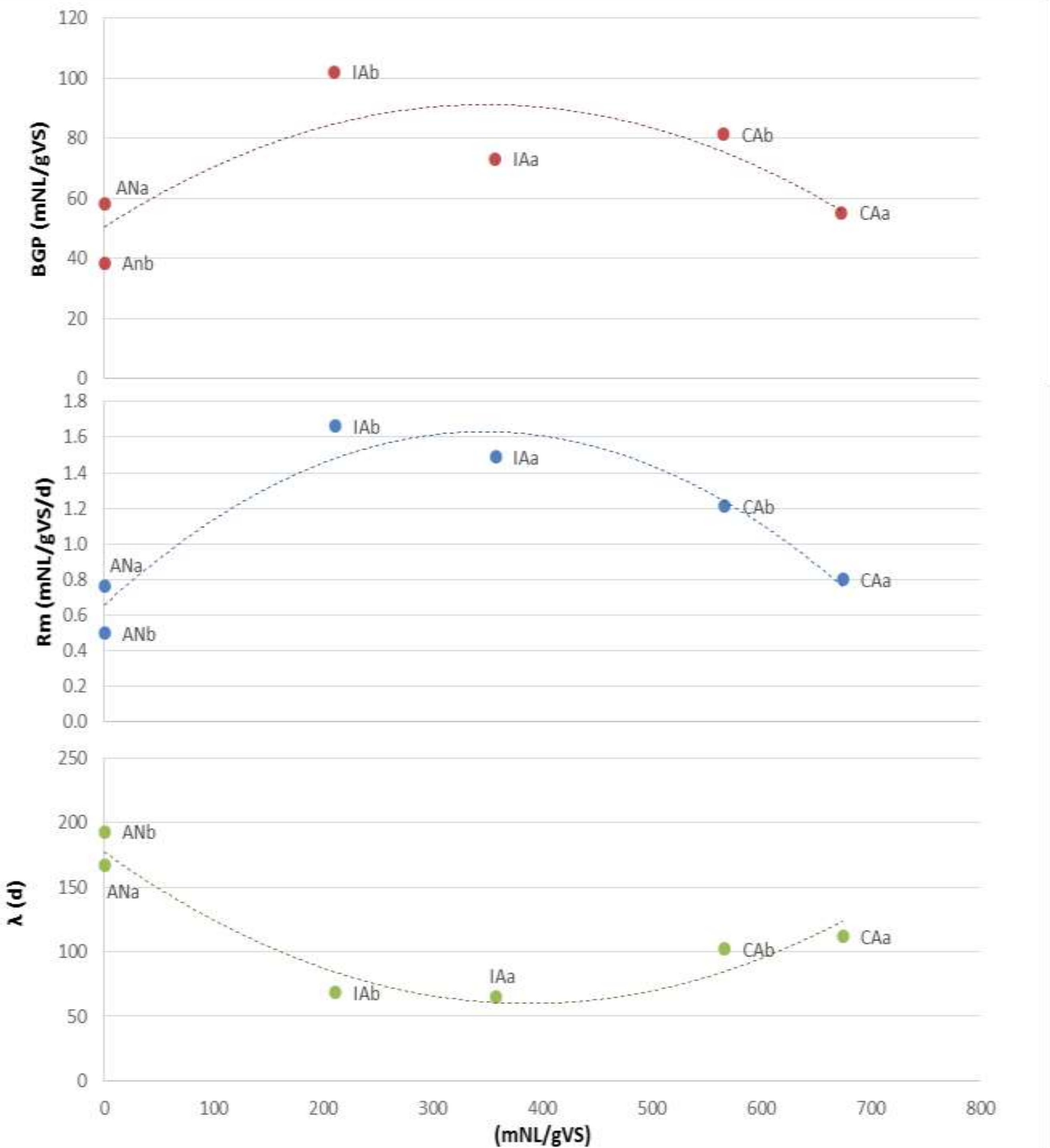

IAa
IAb
CAa
CAb
ANa
ANb
Cumulative emissions of C-CH4 (g)
350,00
300,00
250,00
200,00
150,00
100,00
50,00
0,00
50
100
150
200
250
300
350
Time (d)

For the comparison of results, a Gompertz model is used, calibrated for each reactor.

- Methane production potential (BGP) is 1.5 - 2 times higher in pre-aerated reactors respect to non pre-aerated ones

	Experimental Data				Gompertz Model parameters			
	Total volume of injected air (NL/kgVS)	Pre-aeration time (d)	Maximum daily methane Production (NL/d/kgVS)	Cumulative methane production (NL/kgVS)	BGP (NL/kgVS)	R_m (NL/d/kgVS)	λ (d)	Standard Deviation
IAa	357.4	54	2.9	75.1	73.4	1.5	64.4	2.5
IAb	210.4	35	2.8	101.7	102.0	1.7	68.3	0.0
CAa	674.5	95	2.3	53.7	54.6	0.8	112.3	0.0
CAb	566.2	81	2.5	80.2	81.0	1.2	102.6	1.6
ANa	0.0	0	1.6	55.2	57.1	0.8	167.2	0.6
ANb	0.0	0	1.2	32.0	34.4	0.5	192.8	0.5

- Reaction kinetics (Rm) are higher in hybrid reactors
- Lag phase (λ) is lower in pre-aerated reactors
- The optimum quantity of air injected is in range 200-400 NL/kgVS.
- Intermittent air injection has a positive effect on methano-genic phase.



Mass Balance

- Carbon emissions via leachate are 2-3 % respect to initial content
- Carbon emissions via biogas are 15-20 % in pre-aerated columns and 4-5 % in non pre-aerated ones
- Nitrogen emissions via leachate are 12-14 % respect to initial content.
- Nitrogen emissions via biogas are null and no nitrates were found in leachate.

	TOC (%)					
	IAa	IAb	CAa	CAb	ANa	Anb
Initial Content	100	100	100	100	100	100
Final Content	48.9	56.6	62.8	82.4	76.7	74.5
Out leachate	2.0	1.9	2.4	2.5	2.9	2.8
Out biogas	23.9	17.4	11.8	15.5	4.3	4.4
Missing	25.2	24.1	23.0	-0.4	16.1	18.3

	TKN (%)					
	IAa	IAb	CAa	CAb	ANa	Anb
Initial Content	100	100	100	100	100	100
Final Content	78.3	75.4	82.6	87.6	79.2	78.2
Out leachate TKN	14.6	13.5	12.8	14.7	12.1	12.1
Out leachate NOx	0.0	0.0	0.0	0.0	0.0	0.0
Out Biogas	0.0	0.0	0.0	0.0	0.0	0.0
Missing	7.1	11.1	4.6	-2.3	8.7	9.7

Conclusions

- ✓ Semi-aerobic pre-aeration has a positive effect on methane generation potential, on reaction kinetics and on speeding up methanogenic phase. Intermittent aeration seems to have better effects respect to continuous one.
- ✓ The optimum quantity of air injected is 200-400 NL/kgVS, in semi-aerobic conditions (5 NL/kgTS/d). Pre aeration increase the organic carbon degradation and the emissions in biogas
- ✓ Bilancio di massa di carbonio e azoto grazie alle emissioni, al campione di solidi iniziale, ad un campione di solido fra seconda e terza fase e ad un campione di solido a terza fase conclusa.

Plano III Fase

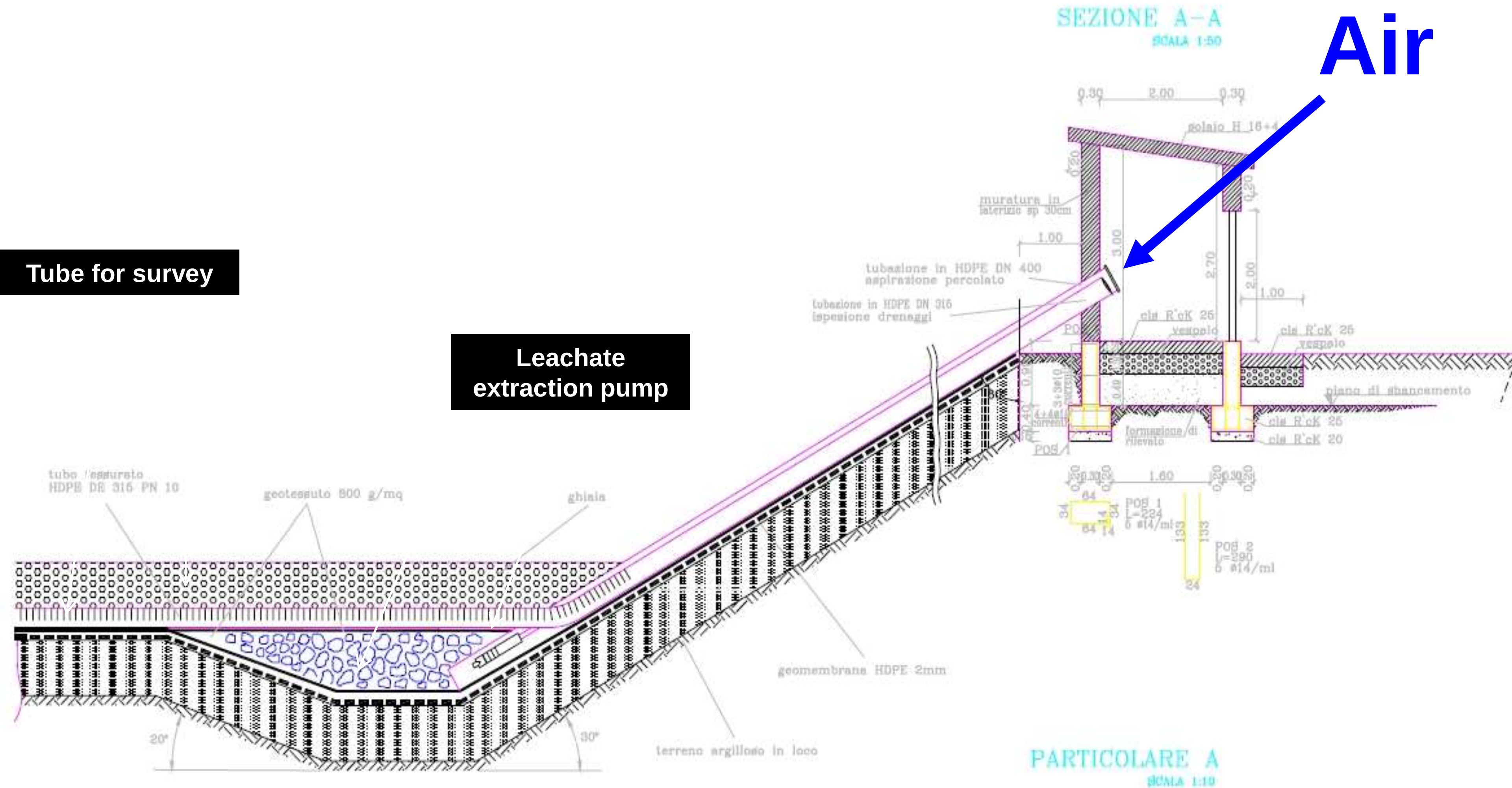
- Abbattere i composti di carbonio persistenti mediante areazione, con analisi periodiche su TOC ed emissioni di lignina e acidi umici e fulvici. Monitoraggio delle emissioni di gas.
- Nitrificare l'ammoniaca, mediante areazione, e monitorare la simultanea denitrificazione e le emissioni di composti di azoto in generale.
- Analisi sul percolato NH4, NOX.
- Monitoraggio delle emissioni di ammoniaca strippata mediante uno scrubber acido.

- Quantificare le emissioni a lungo termine di cloruri, solfati e metalli e verificare la fattibilità di un bilancio di massa anche per essi.
- Calcolo dei coefficienti cinetici di reazione e lisciviazione dei composti, dei contaminanti ancora presenti, delle massime emissione ottenute, e del tempo richiesto di areazione per fare un confronto matematico con le areazioni applicate.
- Se possibile Verificare l'emissione a lungo termine di composti in tracce come AOX e altri da trovare.
- Confronto di tutte le emissioni finali con le massime emissioni calcolate mediante il test di cessione sul rifiuto iniziale.

Aerated landfill

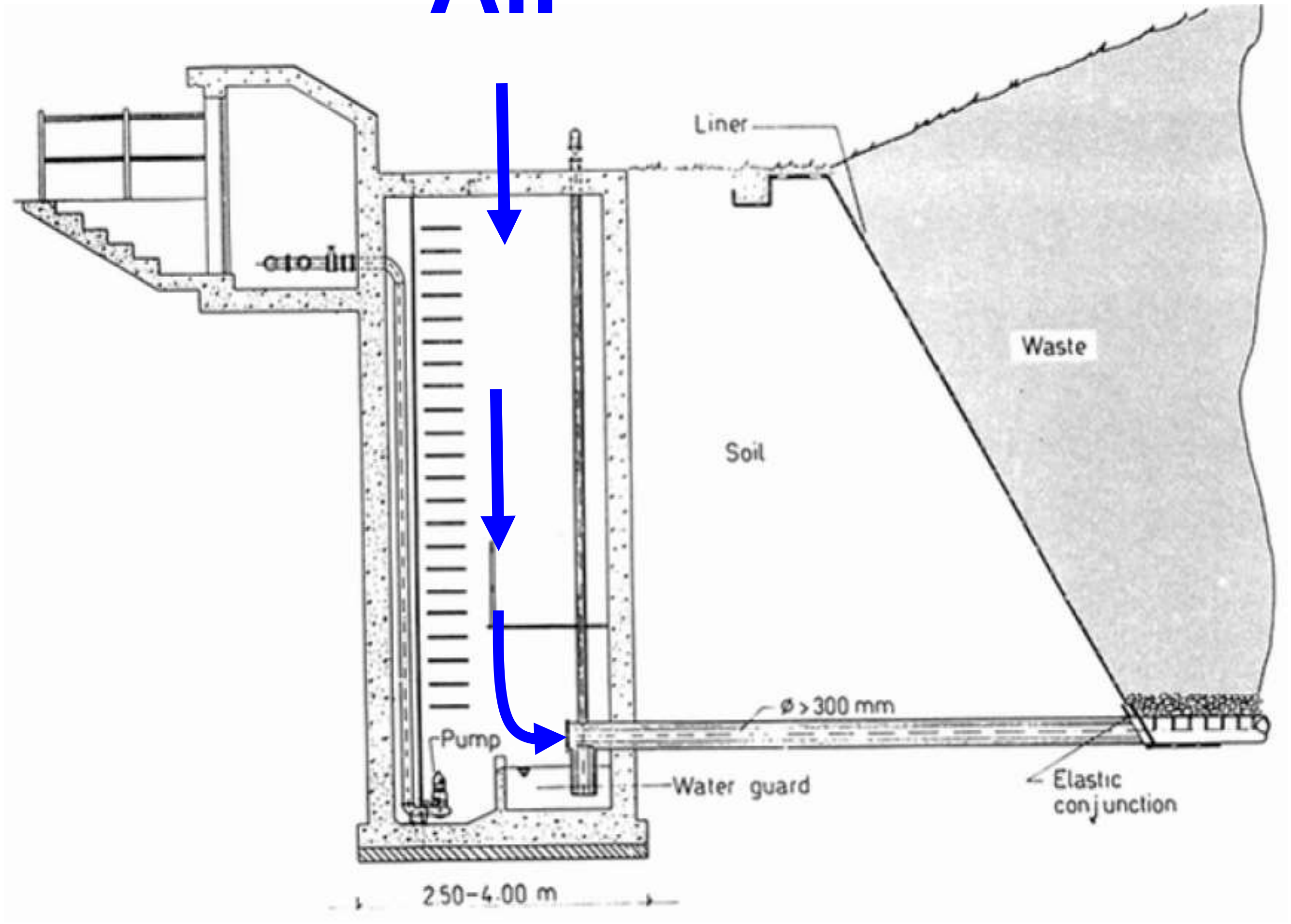
Vertical shaft

Leachate collection – lateral slope

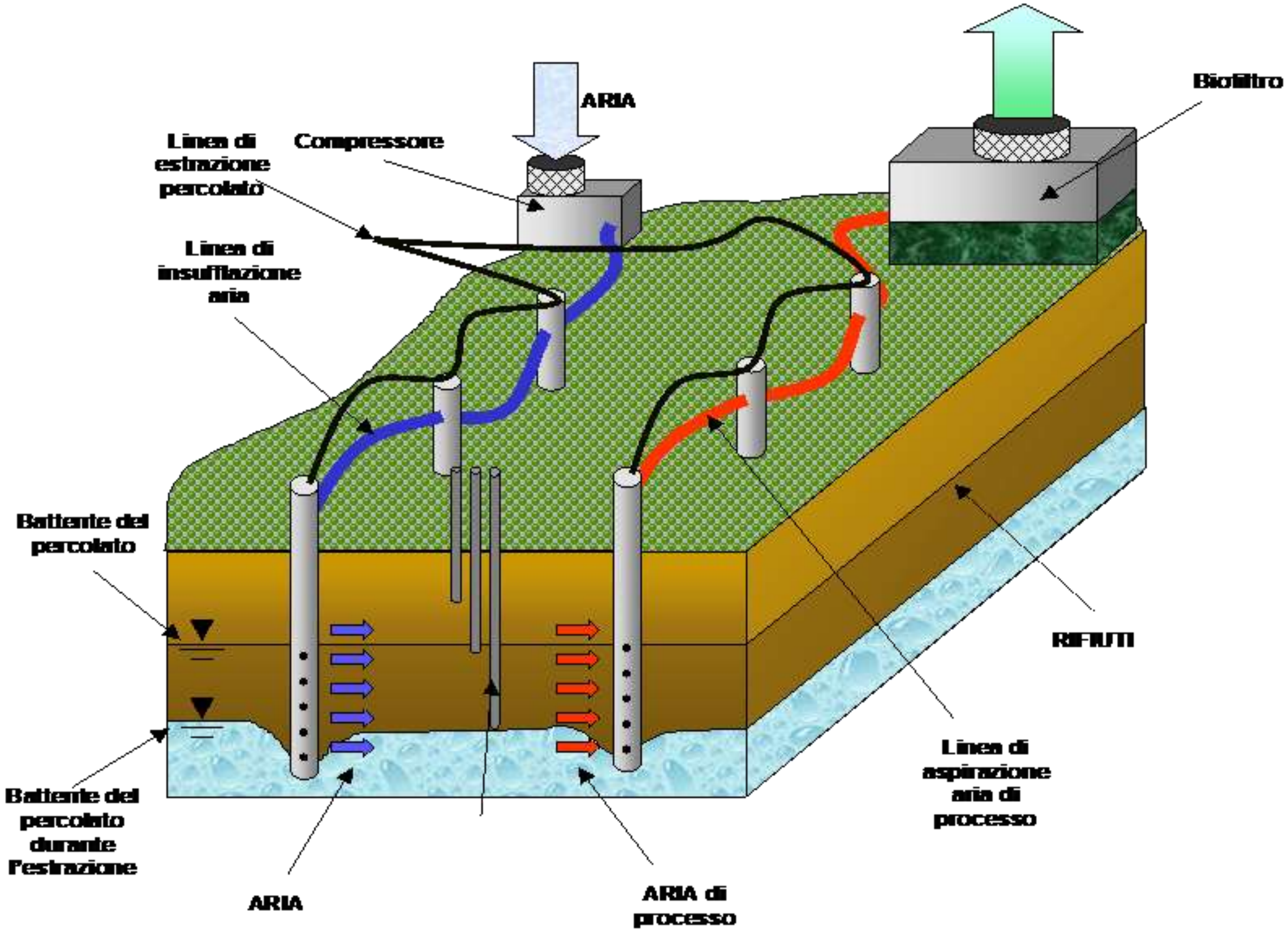


Leachate collection – out-site shaft

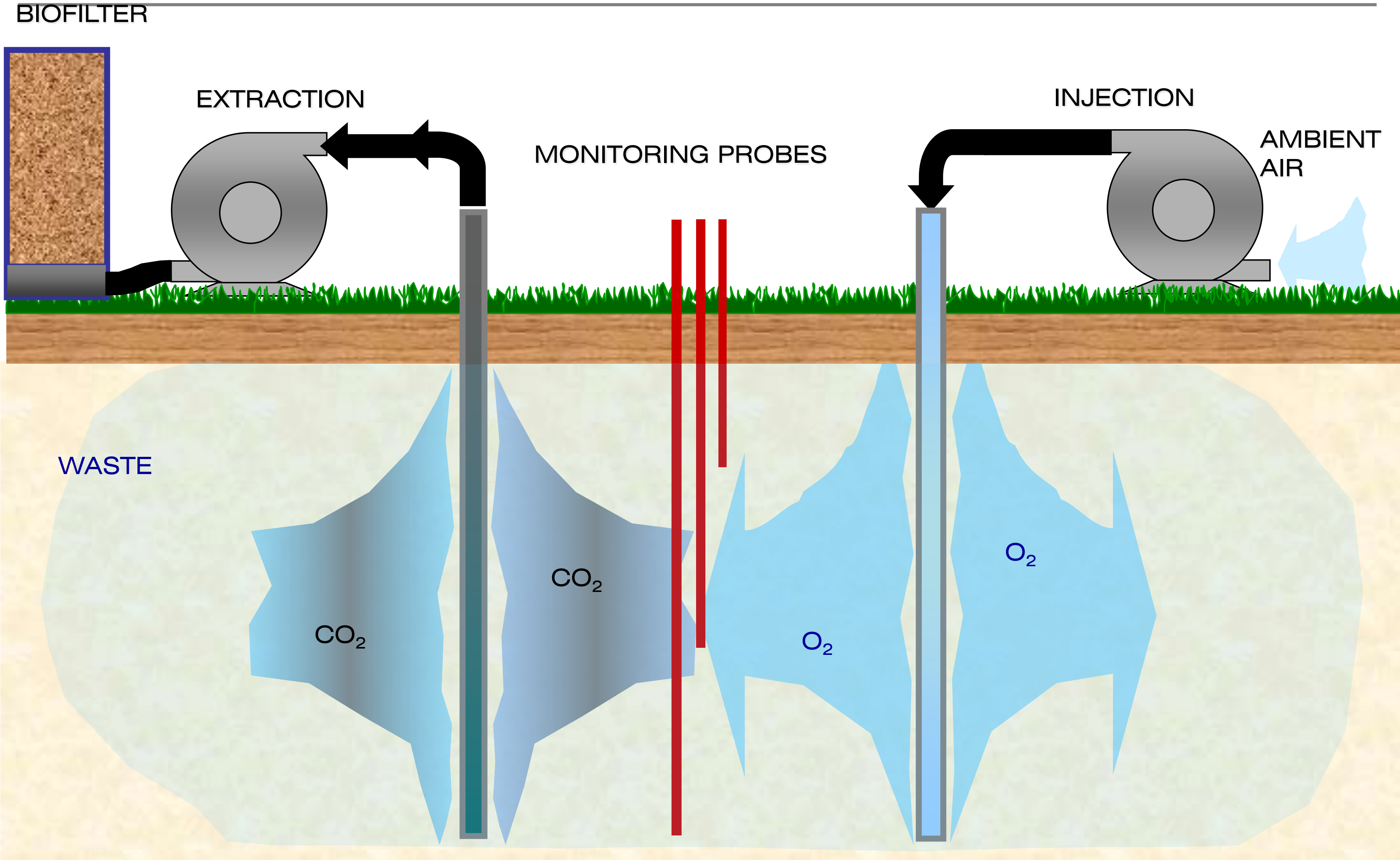
Air



In situ experiences



In situ aeration: “Airflow” technology



Modena landfill

Modena : air injection and control system

Legnago landfill

Legnago landfill


Noooo! Rafael Cossu ablerà Viernes, tambièn! Yo divento loco!