Solid Waste Valorization Module

Solid waste landfilling

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Municipal solid waste landfill

- Context
- Municipal solid waste landfill conception
- Anaerobic degradation in landfill: influence on leachate composition
- Landfill leachate recirculation optimisation
- Micropolutant in waste and landfill leachates
- Landfill mining

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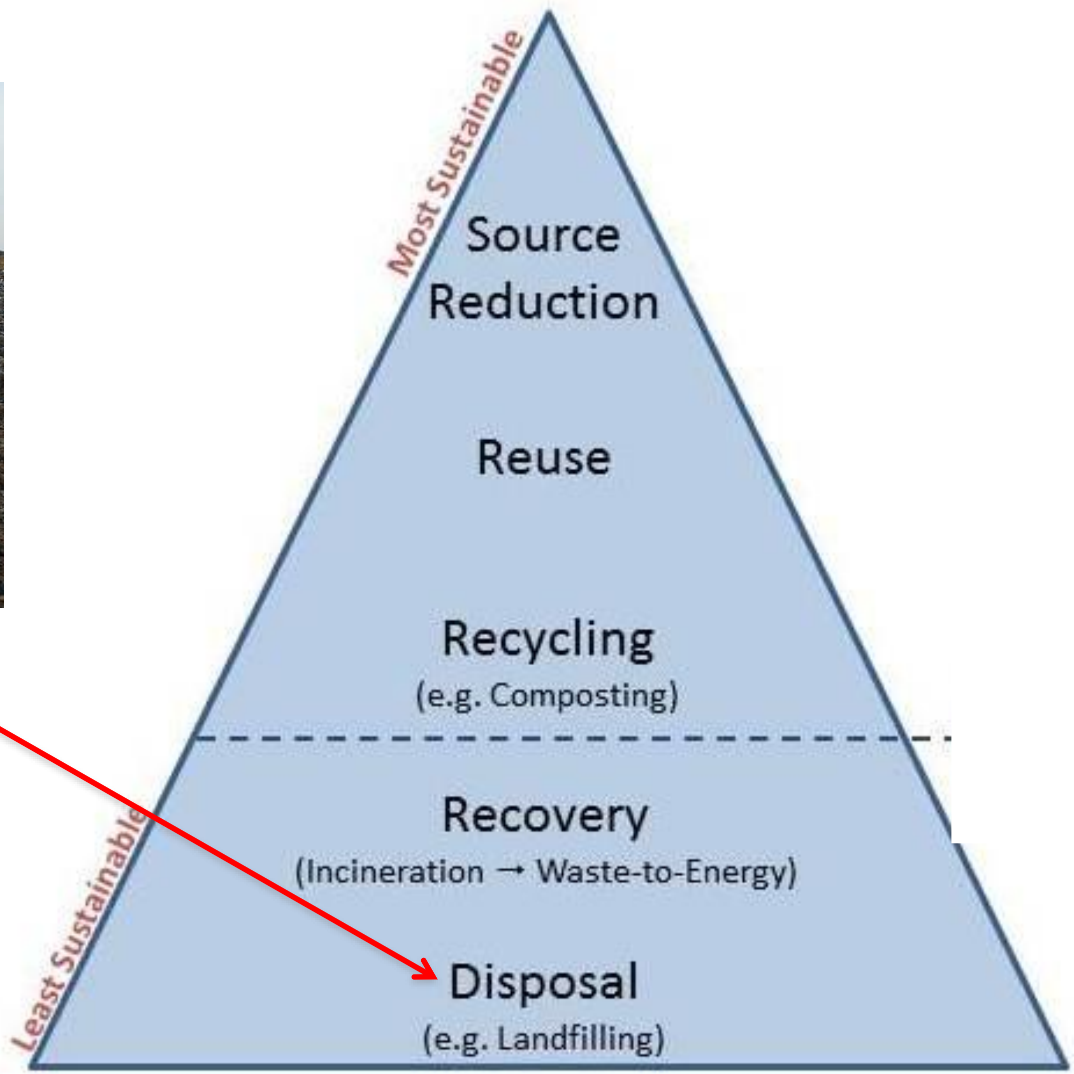
Sustainability of Landfills ?

Source: SUSANA on Flickr 2009

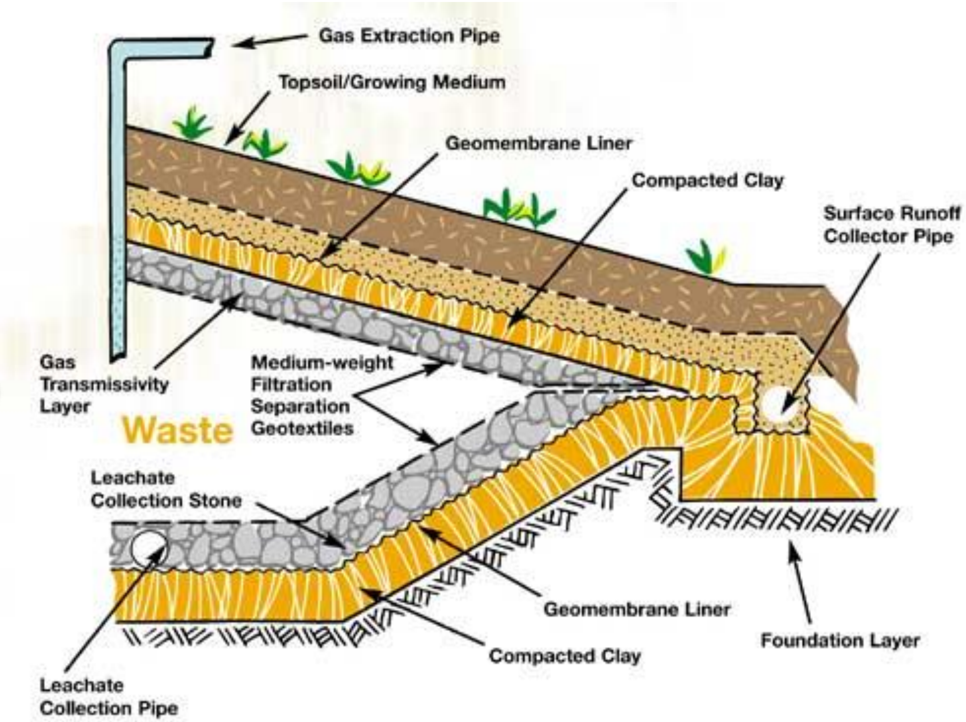
Landfilling is the least preferred method in the hierarchy of integrated solid waste management.



Is a Landfill an Open Dump?

Source: SUSANA on Flickr 2009

It is not an open dump, it is an **engineered** facility in order to protect the environment and human health!



A cross-section of a best practice landfill cell

Source: LATROBE CITY COUNCIL (2005)

Types of Landfills

- **Open Dump:**
  - ➢ Waste is discharge open without any management
- **Basic Landfill:**
  - ➢ Waste is discharged in a pit and covered every day
- **Engineered Landfill:**
  - ➢ Liner, cover, leachate treatment and gas extraction (energy production or flared)
- **Bioreactor Landfill:**
  - ➢ Acceleration of decomposition and creation of a conditions for microbiological activities -> produced gas is used for energy production.

Engineered Landfill

Engineered Landfills in Contrast to Open Dumps

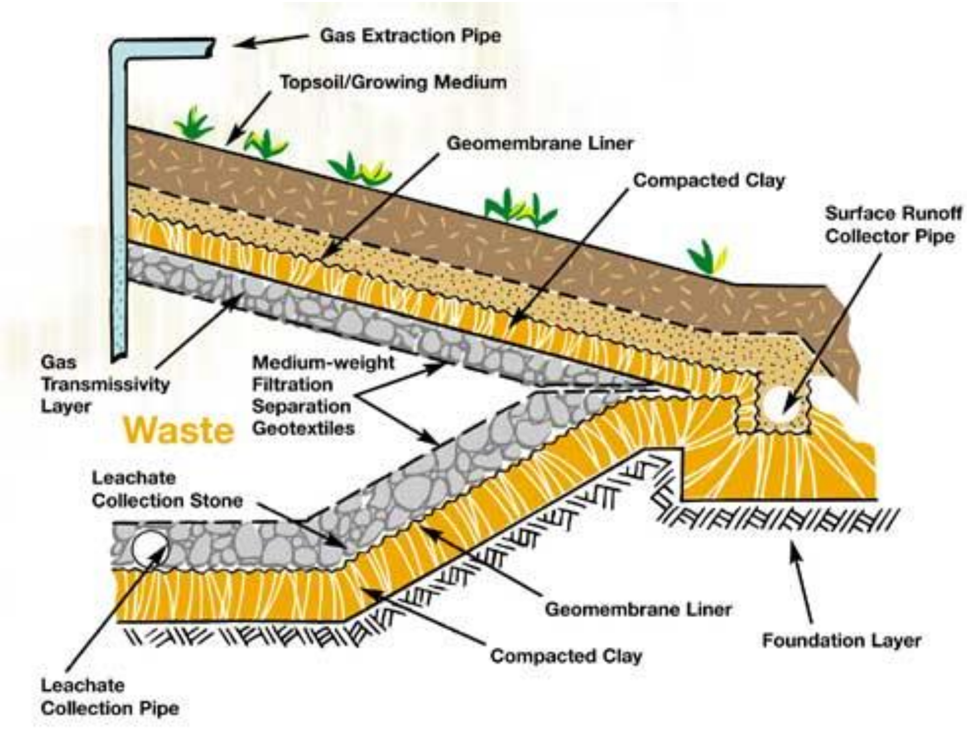
Cover layer→ avoids spreading of waste, pathogens, odour

Gas extraction well → control and reuse of biogas (mainly CO_2 and CH_4) for energy production

Liner system → avoids a contamination of ground water

Leachate system → collection and treatment of fluid effluent

Groundwater monitoring → on-going information about the groundwater quality

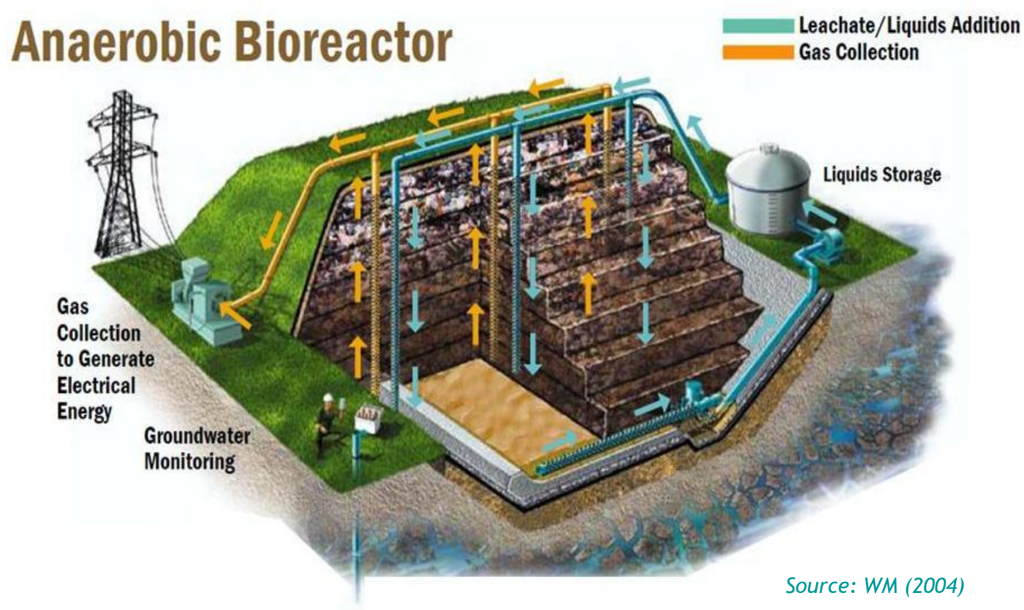


A cross-section of a best practice landfill cell

Source: LATROBE CITY COUNCIL (2005)

Bioreactor Landfill

- Acceleration of biologic decomposition (organic fraction).
- Promoting conditions necessary for the microorganisms (moisture content).
- Liquids must be added (leachate, stormwater, sewage sludge).
- Gas is collected to produce electrical energy.
- Design includes liner, cover, leachate system, groundwater monitoring.



Source: WM (2004)

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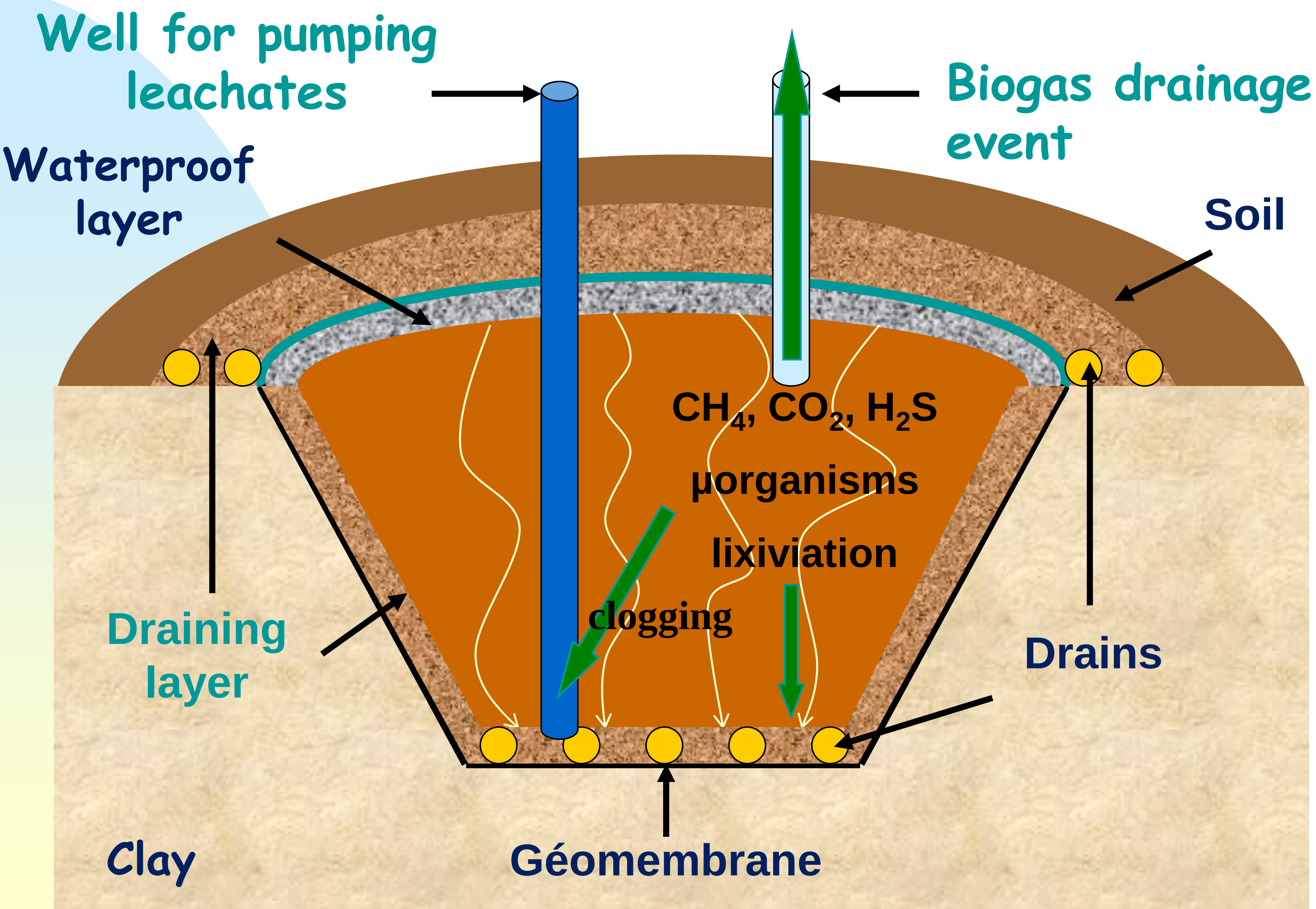
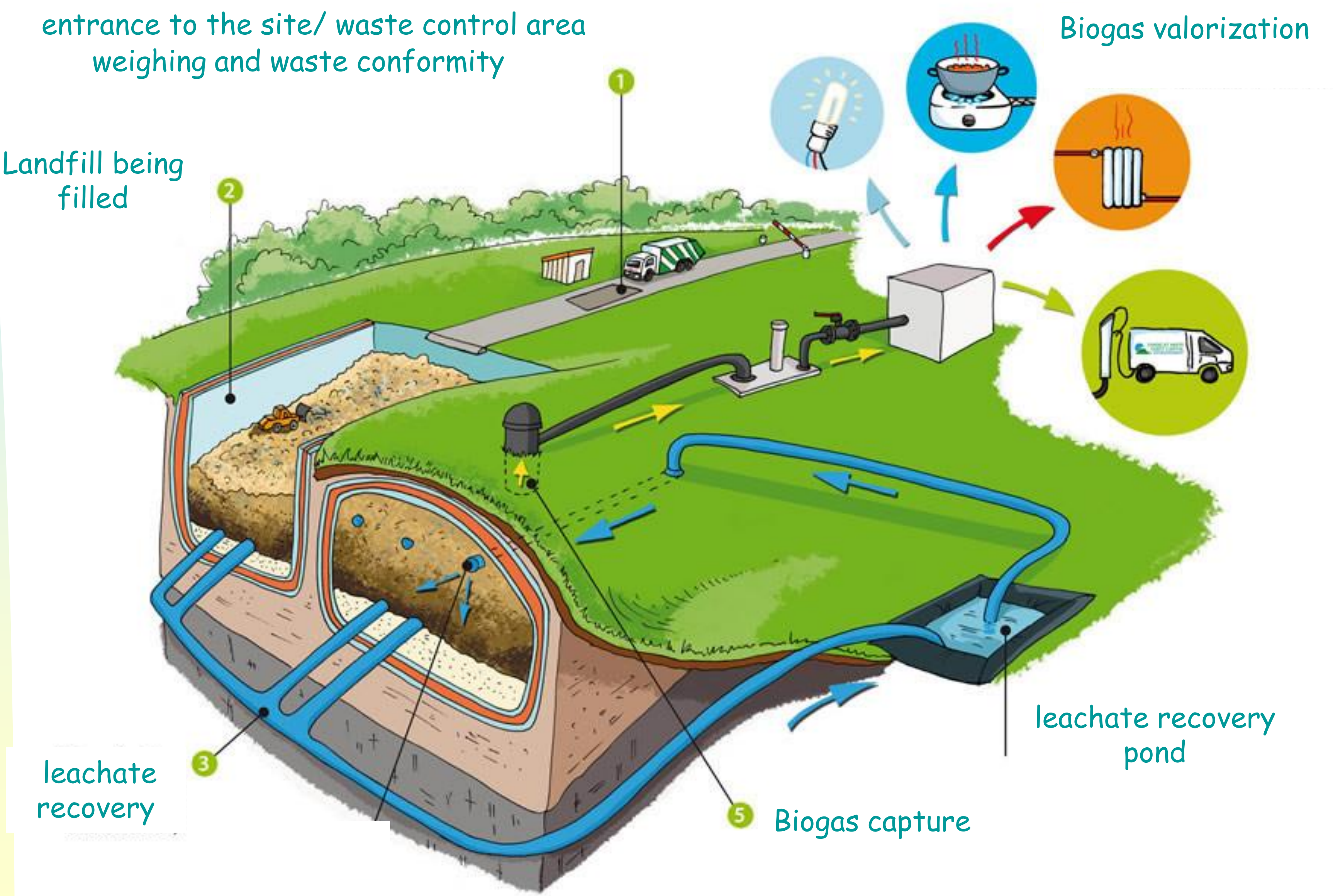
- Landfill leachate recirculation optimisation
- MSW Landfill impacts

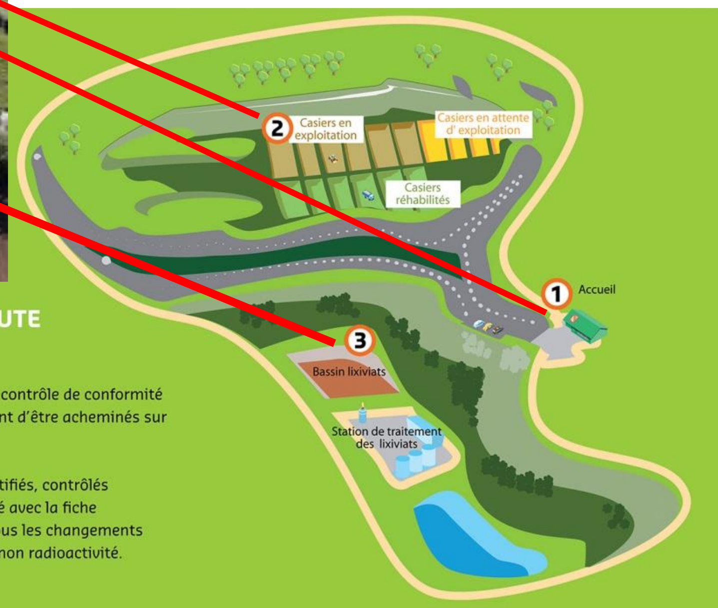
MSW Landfill conception



BIOREACTOR LANDFILL CONCEPTION



Picture of a MSW landfill



1 ENTRÉE SOUS HAUTE SURVEILLANCE

> La fiche d'acceptation

Les déchets font l'objet d'un contrôle de conformité sur le site de production avant d'être acheminés sur le site.

> Le contrôle d'accès

Les déchets sont pesés, identifiés, contrôlés visuellement et la conformité avec la fiche d'acceptation est vérifiée. Tous les changements font l'objet d'un contrôle de non radioactivité.

2 ZONES DE STOCKAGE

> Vidage du camion

Un deuxième contrôle est effectué au déchargement par le conducteur du compacteur.

> Compactage des alvéoles

La compression et le confinement des déchets en casiers de petite taille facilite la dégradation

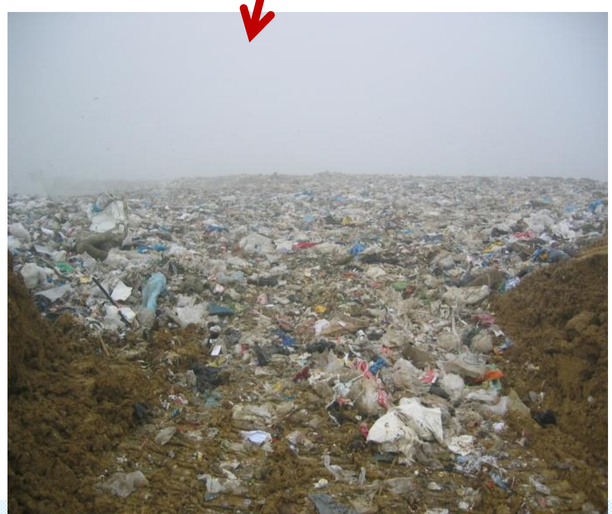
3 MAÎTRISE DES EFFLUENTS

Les effluents gazeux (biogaz) et liquides (lixiviats), produits naturellement par les déchets dans les alvéoles, sont collectés pour être traités.
Ces traitements font l'objet d'une surveillance permanente, et les rejets sont régulièrement analysés par des laboratoires indépendants.

weighing and waste conformity

1) weighing of waste
2) control of the absence of radioactivity
3) control of the nature of the waste

Deposition and compaction of waste

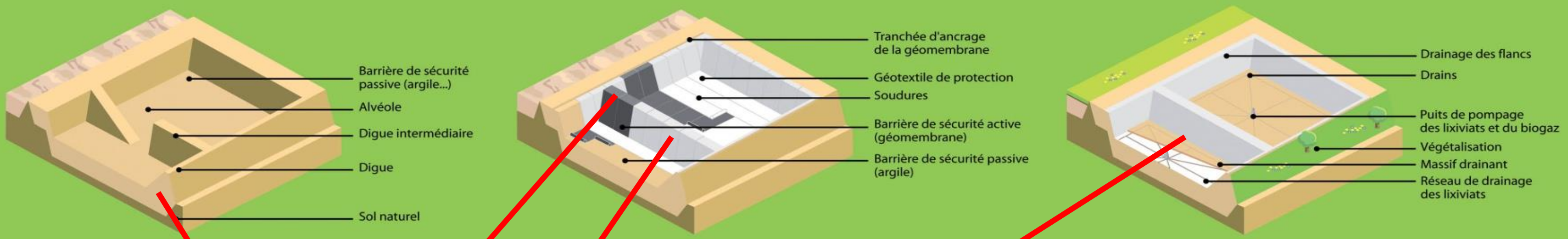


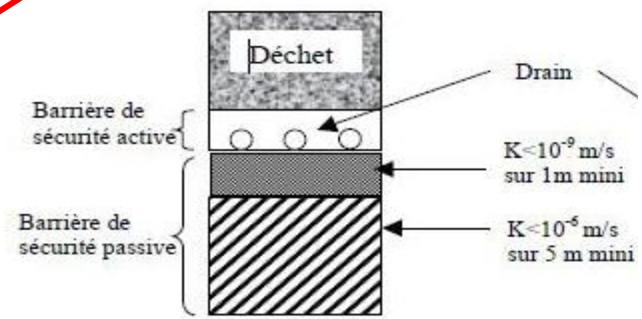
The stages of setting up a landfill

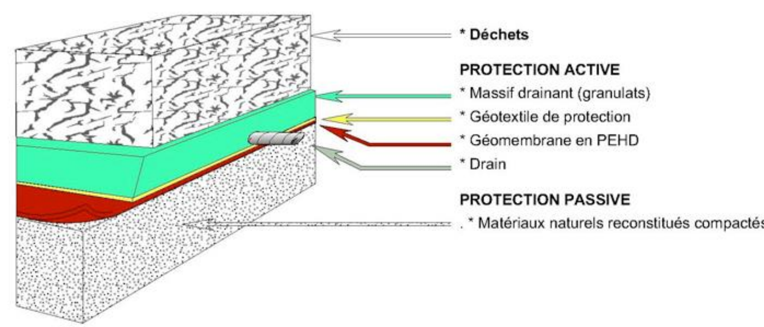
Step 1: earthwork

Step 2: sealing

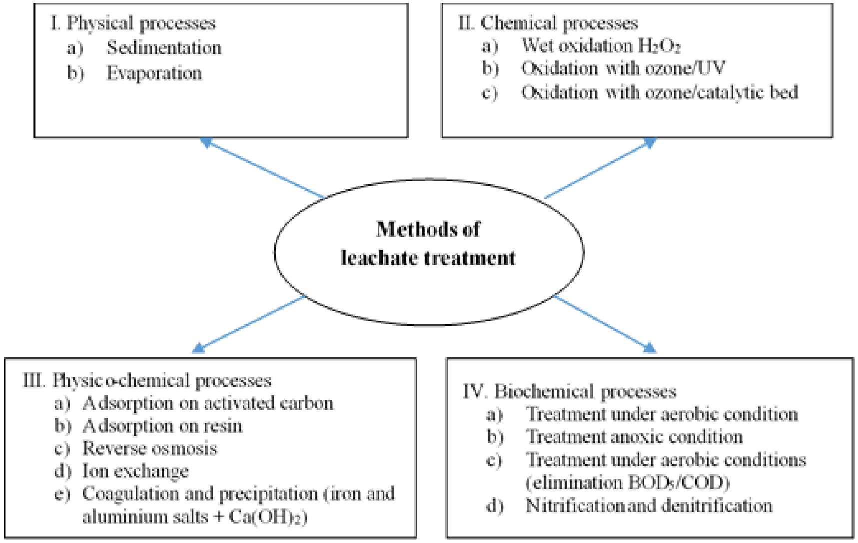
Step 3: drainage







Leachate treatment



Regulatory requirements for the release of leachates

(Annexe III de l'arrêté du 9 septembre 1997 modifié)

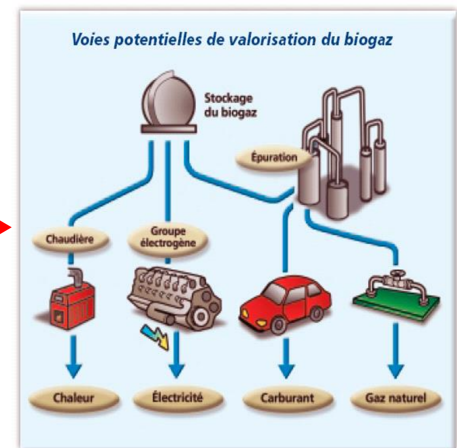
ANNEXE III

Critères minimaux applicables aux rejets d'effluents liquides dans le milieu naturel

Matières en suspension totale (M.E.S.T.)	<100 mg/l si flux journalier max < 15 kg/j < 35 mg/l au-delà
Carbone organique total (C.O.T.)	< 70 mg/l
Demande chimique en oxygène (D.C.O.)	< 300 mg/l si flux journalier max < 100 kg/j < 125 mg/l au-delà
Demande biochimique en oxygène ($D.B.O._5$)	< 100 mg/l si flux journalier max < 30 kg/j < 30 mg/l au-delà
Azote global	concentration moyenne mensuelle < 30 mg/l si flux journalier max > 50 kg/j
Phosphore total	concentration moyenne mensuelle < 10 mg/l si flux journalier max > 15 kg/j
Phénols	< 0,1 mg/l si le rejet dépasse 1 g/j
Métaux totaux,dont :	< 15 mg/l
Cr^{6+}	< 0,1 mg/l si le rejet dépasse 1 g/j
Cd	< 0,2 mg/l
Pb	< 0,5 mg/l si le rejet dépasse 5 g/j
Hg	< 0.05 mg/l
As	< 0,1 mg/l
Fluor et composés (en F)	< 15 mg/l si le rejet dépasse 150 g/j
CN libres	< 0,1 mg/l si le rejet dépasse 1 g/j
Hydrocarbures totaux	< 10 mg/l si le rejet dépasse 100 g/j
composés organiques halogénés (en AOX ou EOX)	< 1 mg/l si le rejet dépasse 30 g/j
(La référence à certaines substances toxiques a été supprimée par l'arrêté du 31/12/2001)	

N.B.: Les métaux totaux sont la somme de la concentration en masse par litre des éléments suivants : Pb, Cu, Cr, Ni, Zn, Mn, Sn, Cd, Hg, Fe, Al.

Recovery and valorization of biogas



Examples of valorization of biogas

Thermal valorization:

In Blaringhem (59), the Baudelet company has managed since 1982 a major landfill which receives household waste, industrial waste and automobile shredding residue. Rather than burning the biogas in a flare, Baudelet installed a furnace to melt the aluminum recovered on the site into lingots.

Electric valorization :

The biogas energy recovery facilities at the Claye-Souilly storage facility produce a quantity of electricity equivalent to the electricity consumption, excluding heating, of a city of 228,000 inhabitants

.

Biofuel valorization :

In September 2009, Veolia Environmental Services opened the first biomethane fuel production unit, derived from biogas captured at the non-hazardous waste storage facility at Claye-Souilly (77). The production unit demonstrates a production capacity to cover the annual energy needs of a fleet of 210 light vehicles (1 ton of household waste produces around 200 m3 of biogas or 100 m3 of methane, equivalent to 100 liters of gasoline)

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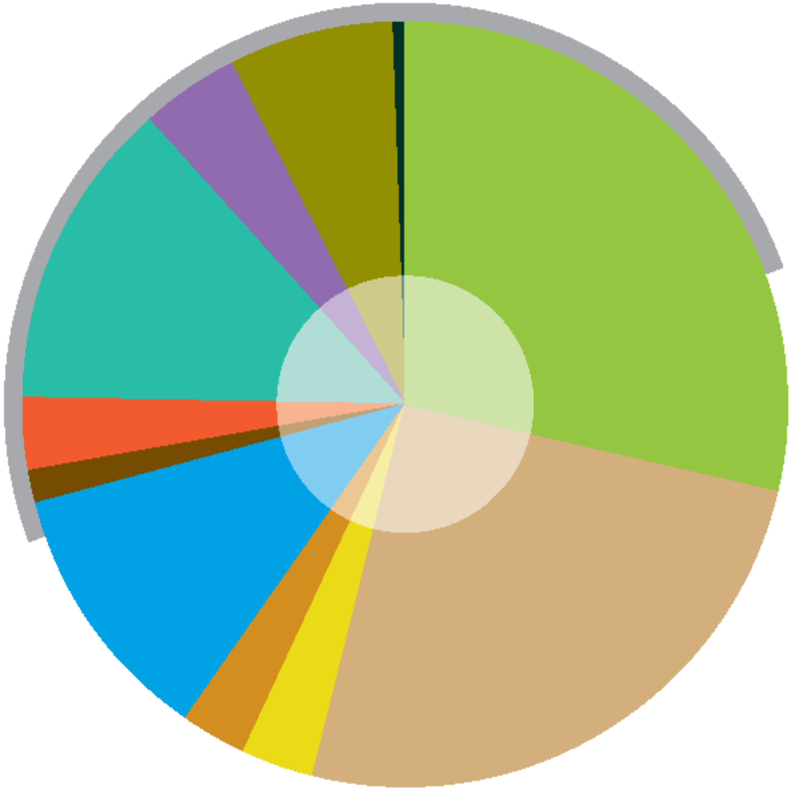
FRENCH MSW composition

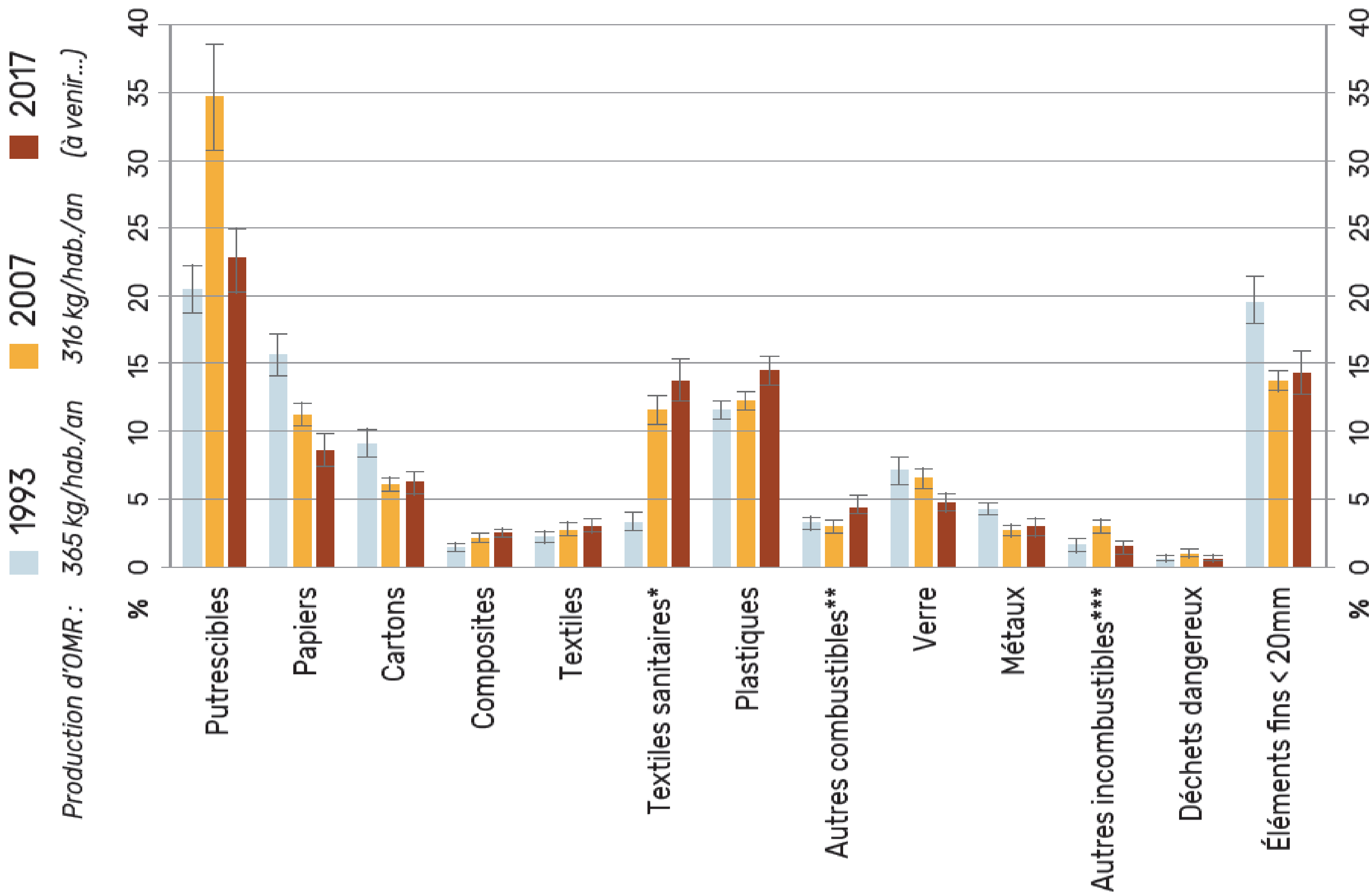


	%	kg/habitant/an
Déchets putrescibles	28,8	130
Papiers/cartons	25,3	115
Textiles sanitaires	3,1	14
Textiles	2,6	12
Plastiques	11,1	51
Complexes	1,4	6
Combustibles divers	3,2	15
Verre	13,1	60
Métaux	4,1	19
Incombustibles divers	6,8	31
Déchets spéciaux	0,5	2
Total	**100,0**	**455**

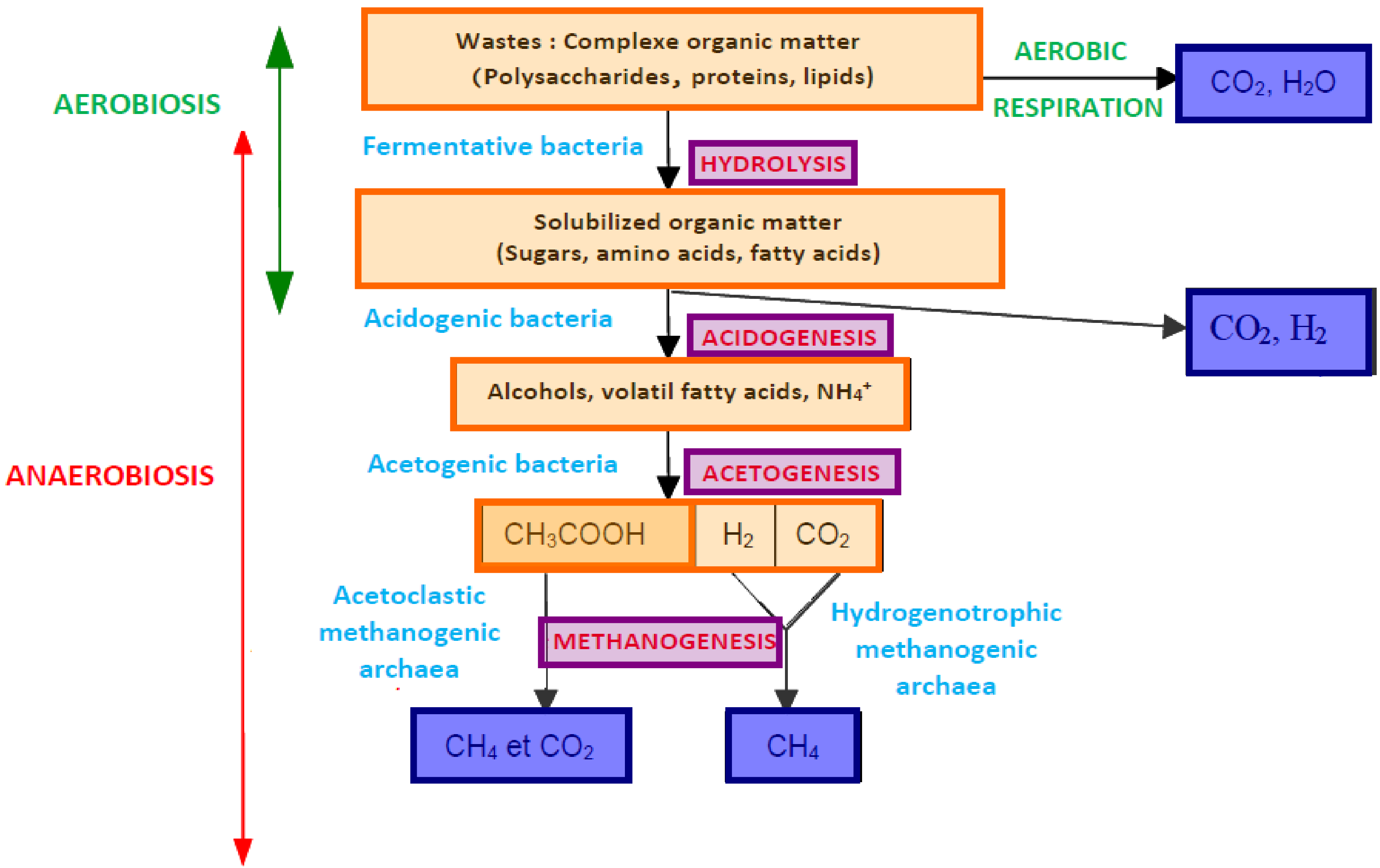
Composition des ordures ménagères - moyenne nationale
(Répartition en poids humide - évaluation pour 1998)
Sources ADEME

1/3 putrescible waste + paper/cardboard = 50 % de biodegradable

French MSW composition evolution

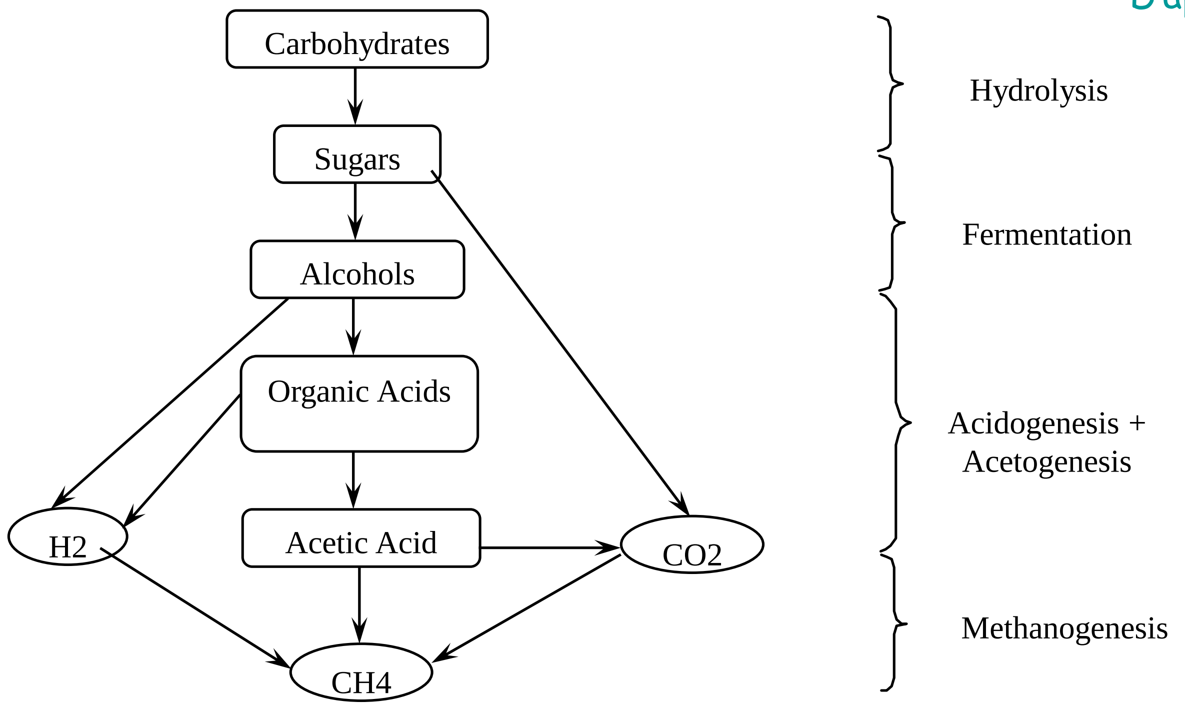


The stages of anaerobic degradation of waste



Anaerobic degradation of carbohydrates

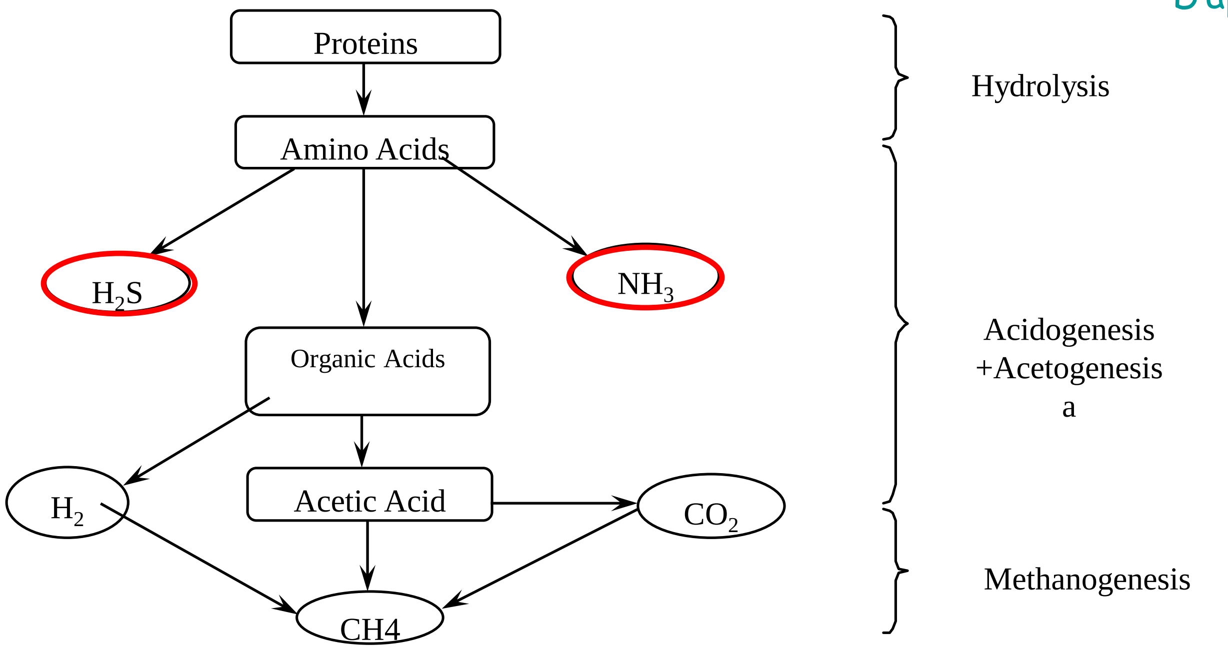
D'après Butler *et al.*, 99



Pour n=2 : $C_6H_{12}O_6 + 2\ H_2O \rightarrow 2\ CH_3\text{-}CH_2\text{-}OH + 2\ CO_2 + 2\ H_2O$ Glucose Ethanol Pour n=3 : $C_9H_{18}O_9 + 2\ H_2O \rightarrow 2\ CH_3\text{-}(CH_2)_2\text{-}OH + 3\ CO_2 + 3\ H_2O$ Pour n=4 : $C_{12}H_{24}O_{12} + 2\ H_2O \rightarrow 2\ CH_3\text{-}(CH_2)_3\text{-}OH + 4\ CO_2 + 4\ H_2O$	Hydrolyse des sucres et fermentation en alcools.
Pour n=2 : $CH_3\text{-}CH_2\text{-}OH + H2O \rightarrow CH_3\text{-}COOH + 2\ H_2$ Pour n=3 : $CH_3\text{-}(CH_2)_2\text{-}OH + H_2O \rightarrow H(CH_3)_2\text{-}COOH – 2\ H_2$ Pour n=4 : $CH_3\text{-}(CH_2)_3\text{-}OH + H_2O \rightarrow H(CH_3)_3\text{-}COOH + 2H_2$	Acidogenèse des alcools (conversion en acides gras volatils)
Pour n=3 : $H(CH_3)_2\text{-}COOH + 3\ H_2O \rightarrow CH_3\text{-}COOH + H_2CO_3 + 3\ H_2$ Pour n=4 : $H(CH_3)_3\text{-}COOH + 2\ H_2O \rightarrow 2\ CH_3\text{-}COOH + 2\ H_2$	Oxydation des acides carboxyliques en acétate
Division Acetate : $CH_3\text{-}COOH \rightarrow CH_4 + CO_2$ Oxydation hydrogène : $CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$	Méthanogenèse

Anaerobic degradation of proteins

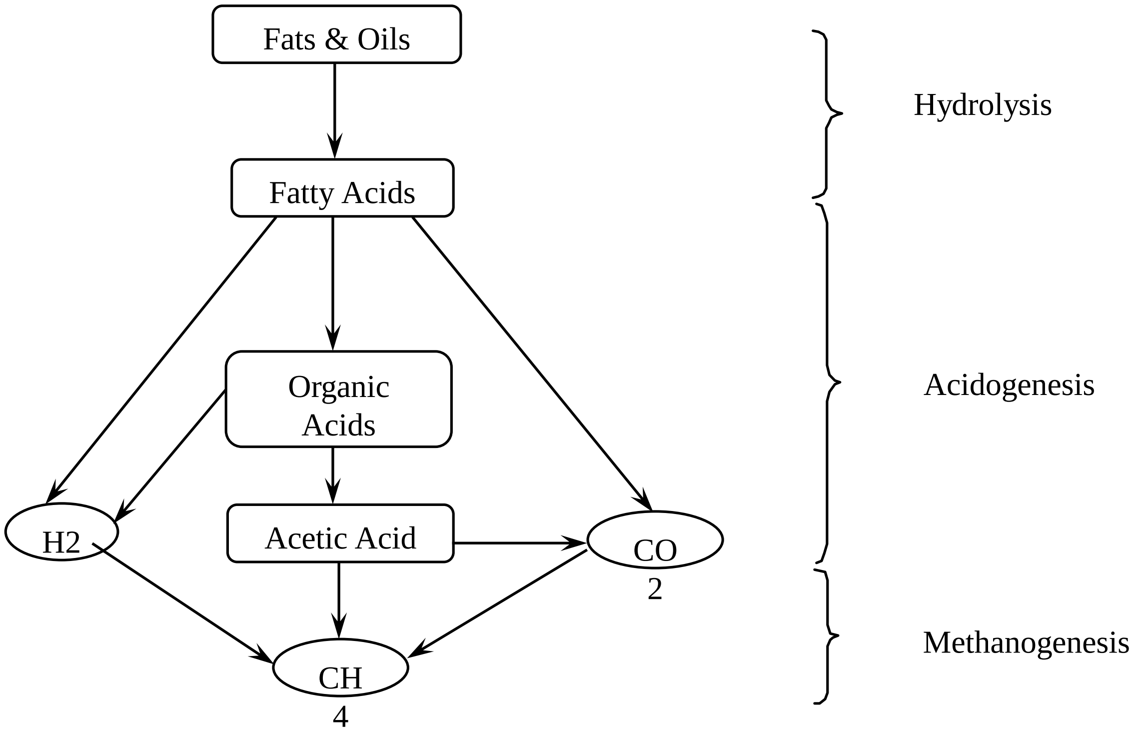
D'après Butler *et al.*, 99



$C_{53}H_{117}O_{22}N_{11}S \rightarrow 10\ C_5H_{11}O_2N_1 + C_3H_7O_2NS$ + Protéine modèle (mélange de 10 molécules d'acide é-aminopentanoïque et d'une molécule de cystéine)	Hydrolyse des protéines en amino-acides correspondants
$C_5H_{11}O_2N_1 \rightarrow CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}COOH + NH_3$ $C_3H_7O_2NS$ -> $CH_3\text{-}CH_2\text{-}COOH + NH_3 + H_2S$	Acidogenèse : conversion des amino-acides en acides carboxyliques
$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}COOH + 5\ H_2O$ $\rightarrow 2CH_3\text{-}COOH + H_2CO_3 + 5\ H_2$ $CH_3\text{-}CH_2\text{-}COOH5\ H_2O \rightarrow CH_3\text{-}COOH + H_2CO_3 + 3\ H_2$	Acetogenèse : oxydation des acides carboxyliques en acétate
Division acétate : $CH_3\text{-}COOH \rightarrow CH_4 + CO_2$ Oxydation hydrogène : $CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$	Méthanogenèse

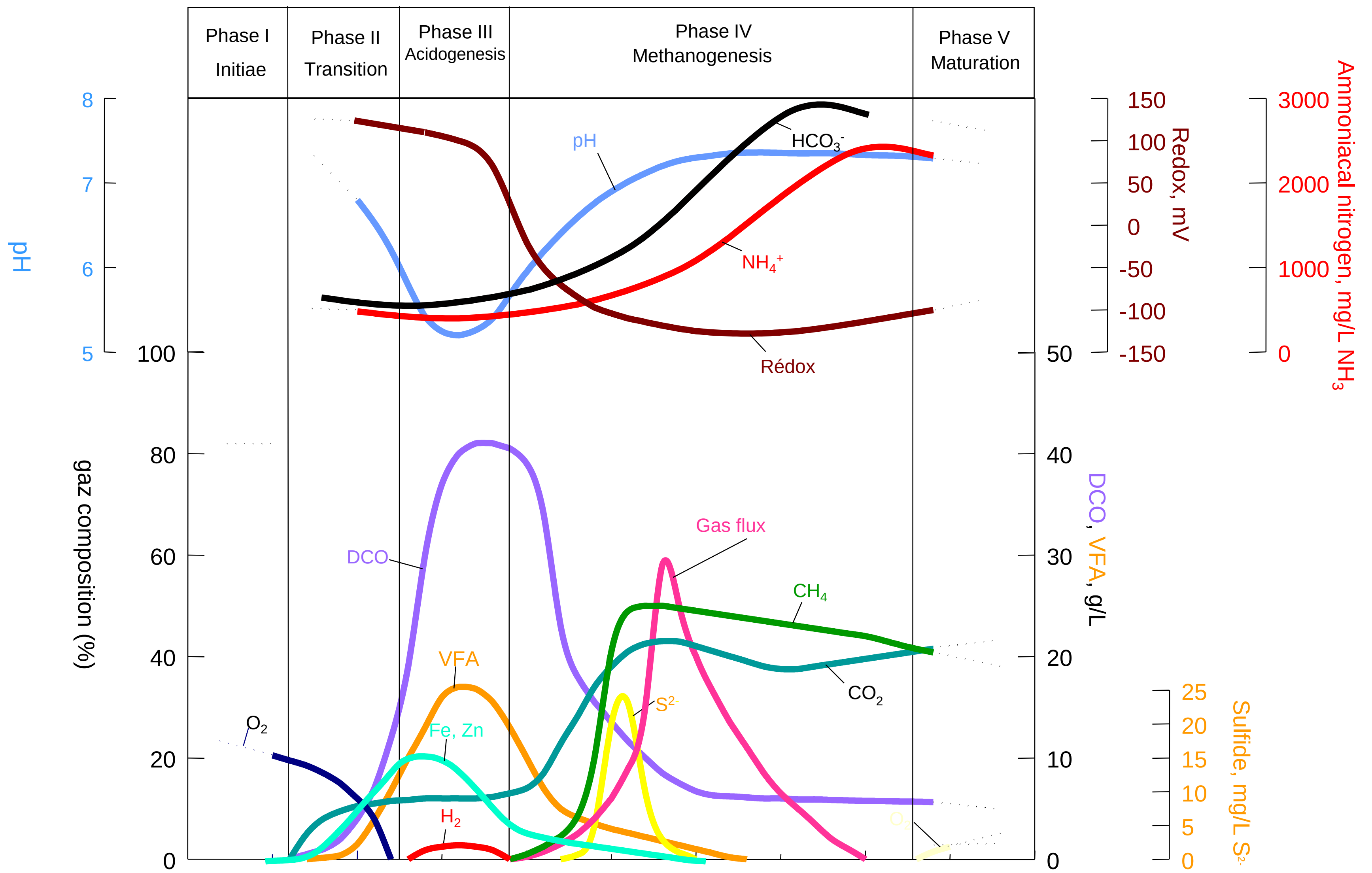
Anaerobic degradation of lipids

D'après Butler *et al.*, 99



$C_{55}H_{104}O_6 + 3\ H_2O \rightarrow$ $C_{15}H_{31}COOH + C_{17}H_{35}COOH + C_{18}H_{33}COOH + C_3H_5(OH)_3$ [acides gras] [Glycerol]	Hydrolyse en acides gras de structure plus simple
$C_{15}H_{31}COOH + 28\ H_2O \rightarrow CH_3COOH + 42\ H_2 + 14\ CO_2$ $C_{17}H_{35}COOH + 32\ H_2O \rightarrow CH_3COOH + 48\ H_2 + 16\ CO_2$ $C_{18}H_{33}COOH + 32\ H_2O \rightarrow CH_3COOH + 47\ H_2 + 16\ CO_2$	Oxydation des acides carboxyliques en acétate
$2\ C_3H_5(OH)_3 \rightarrow 3\ CH_3COOH + 2\ H_2$	Oxydatin du glycerol en acide acétique
Division acétate : $CH_3\text{-}COOH \rightarrow CH_4 + CO_2$ Oxydation hydrogène : $CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$	Méthanogenèse

Evolution of the composition of the effluents generated during the degradation of of waste in landfill



(from Pohland, 2002)

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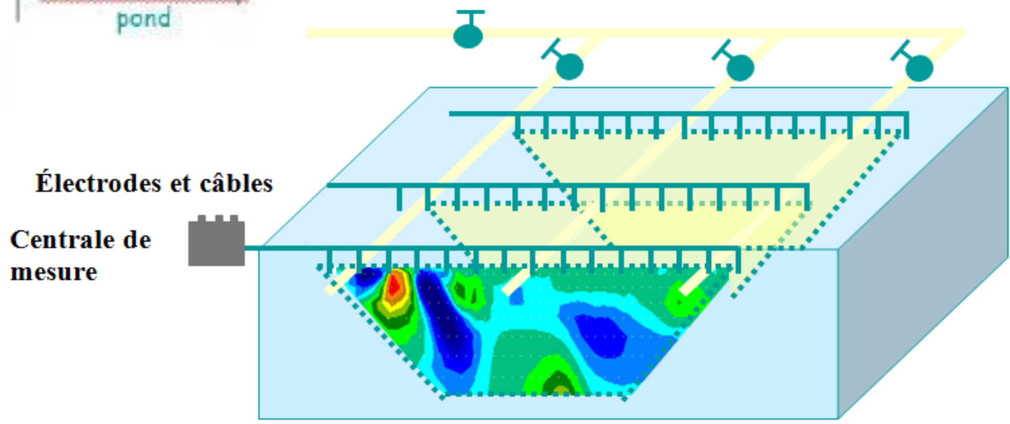
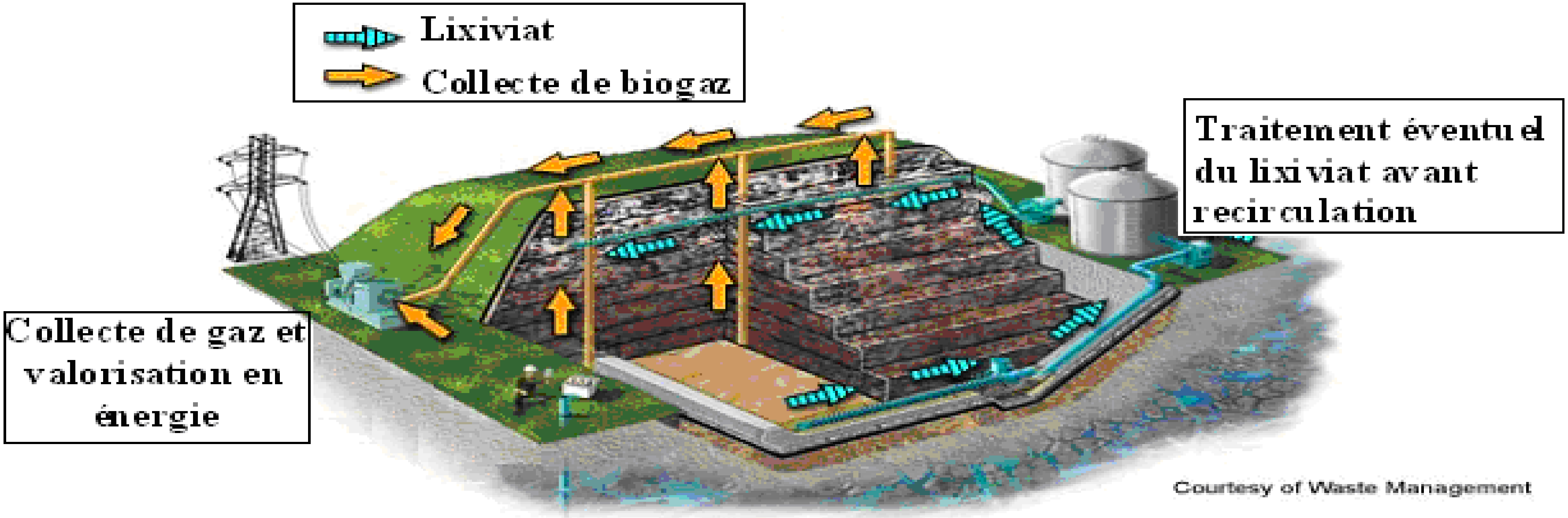
Bioreactor landfill optimisation



Objectives:

- Optimize humidity
- Accelerate waste degradation
- Increase biogas production

Bioreactor landfill optimisation



Leachate recirculation

- Optimize humidity
- Accelerate waste degradation
- Increase biogas production

The amount of leachate produced is often not important enough to get optimal moisture levels within waste mass

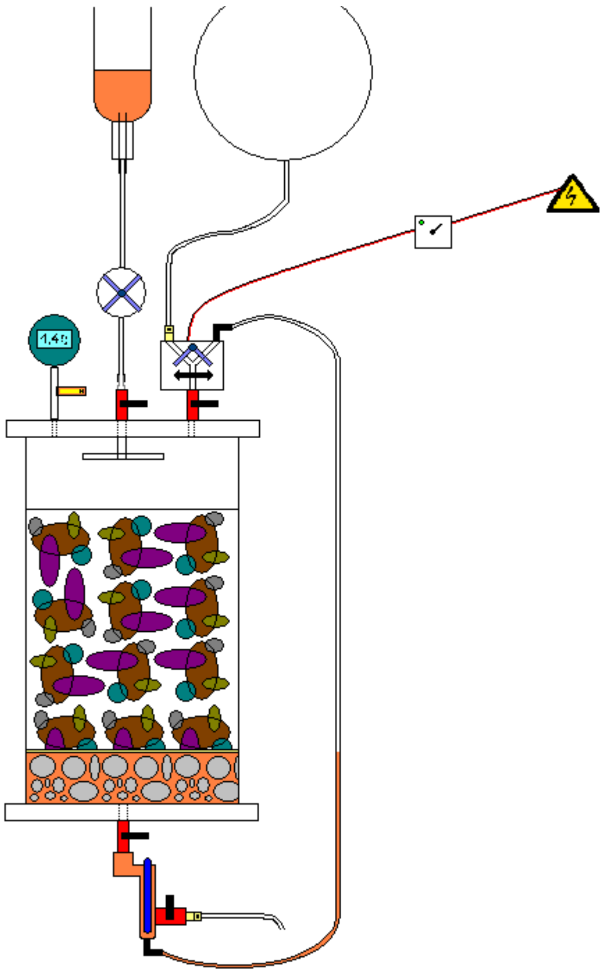
RECIRCULATED EFFLUENTS

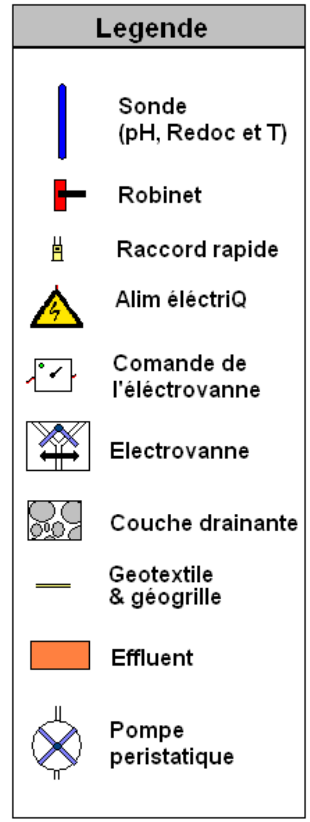
- MSW LANDFILL LEACHATES

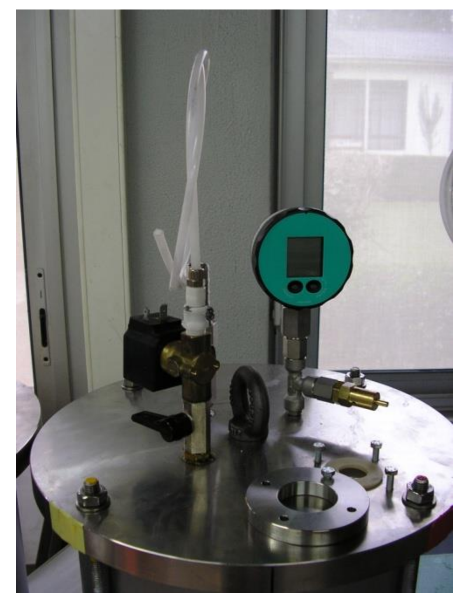
- GREEN WASTE COMPOSTING PLATFORM LEACHATE

- SEWAGE SLUDGE

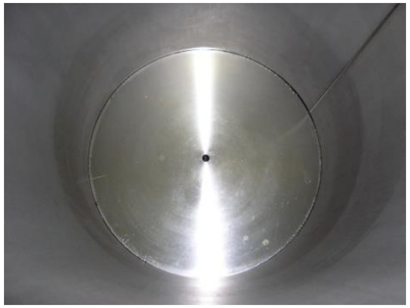
EXPERIMENTAL PILOTS





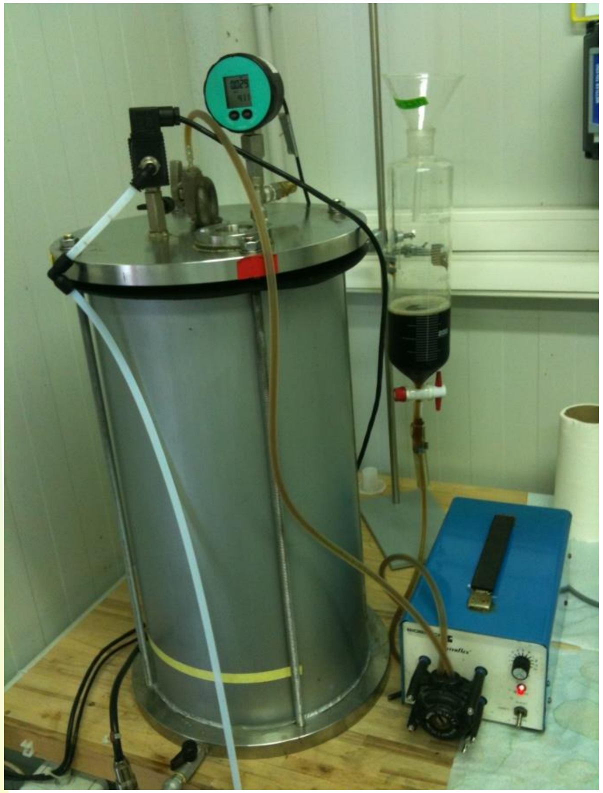


Pilote filling with 5 Kg of reconstituted wastes

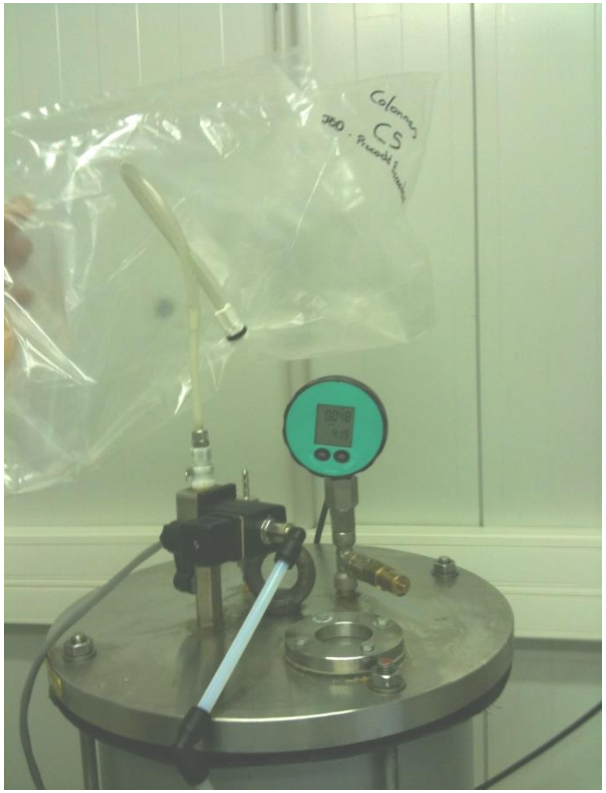


Pilots monitoring

Effluents injection

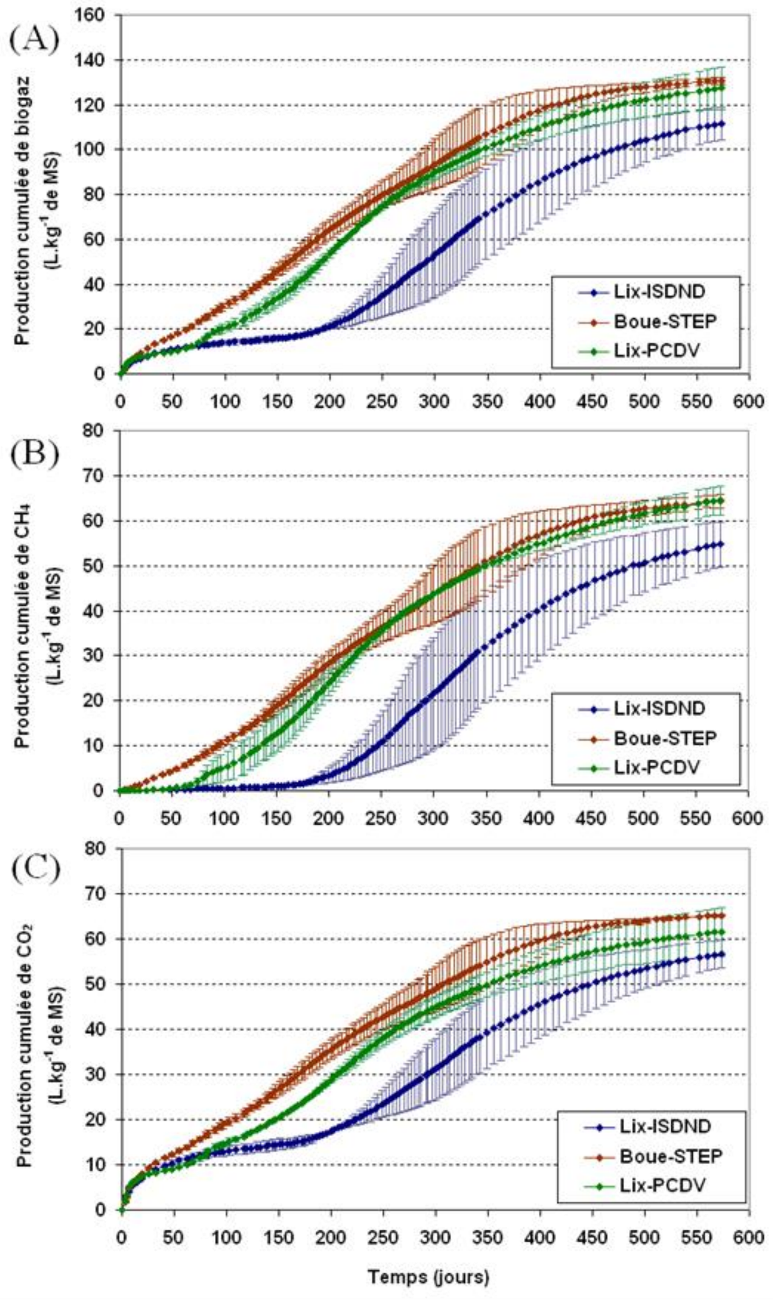


Biogas sampling

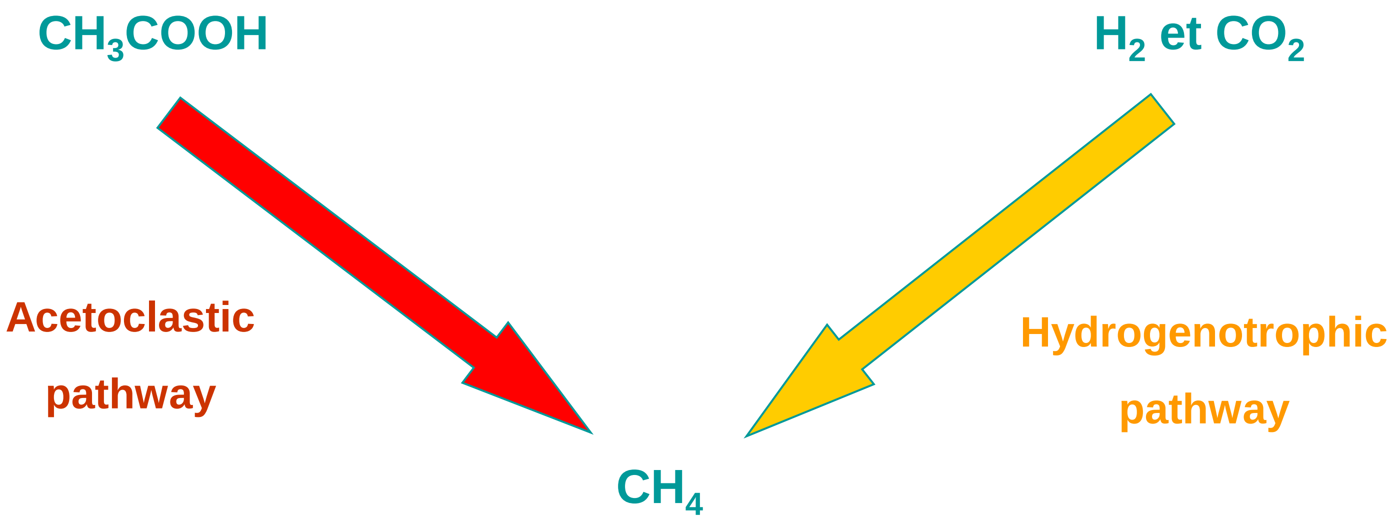


Leachate sampling

Cumulated biogas production



Methanogenesis pathways



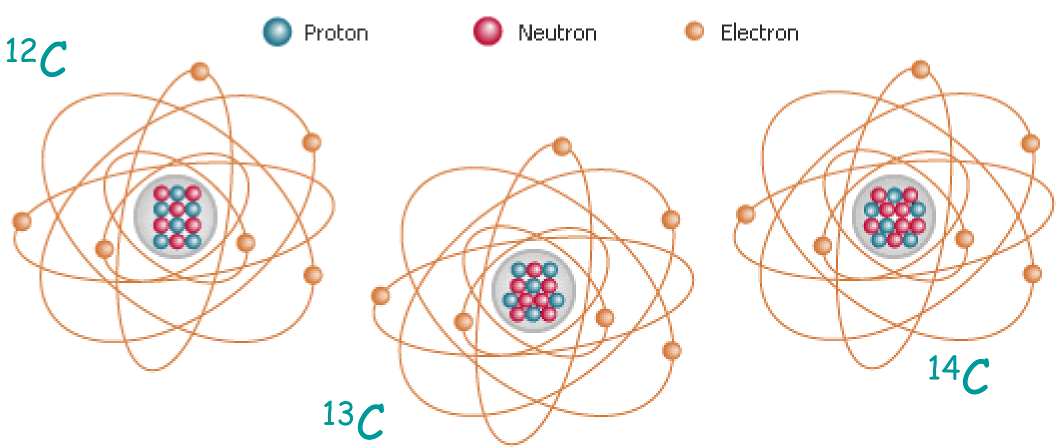
Reactions :

$CH_3COOH + H_2O \rightarrow CH_4 + CO_2$

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

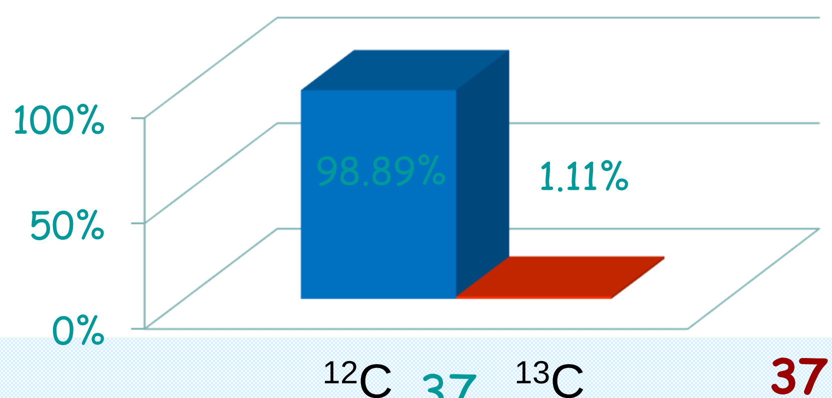
Carbon isotope

- Isotopes are atoms whose nuclei contain the same number of protons but a different number of neutrons



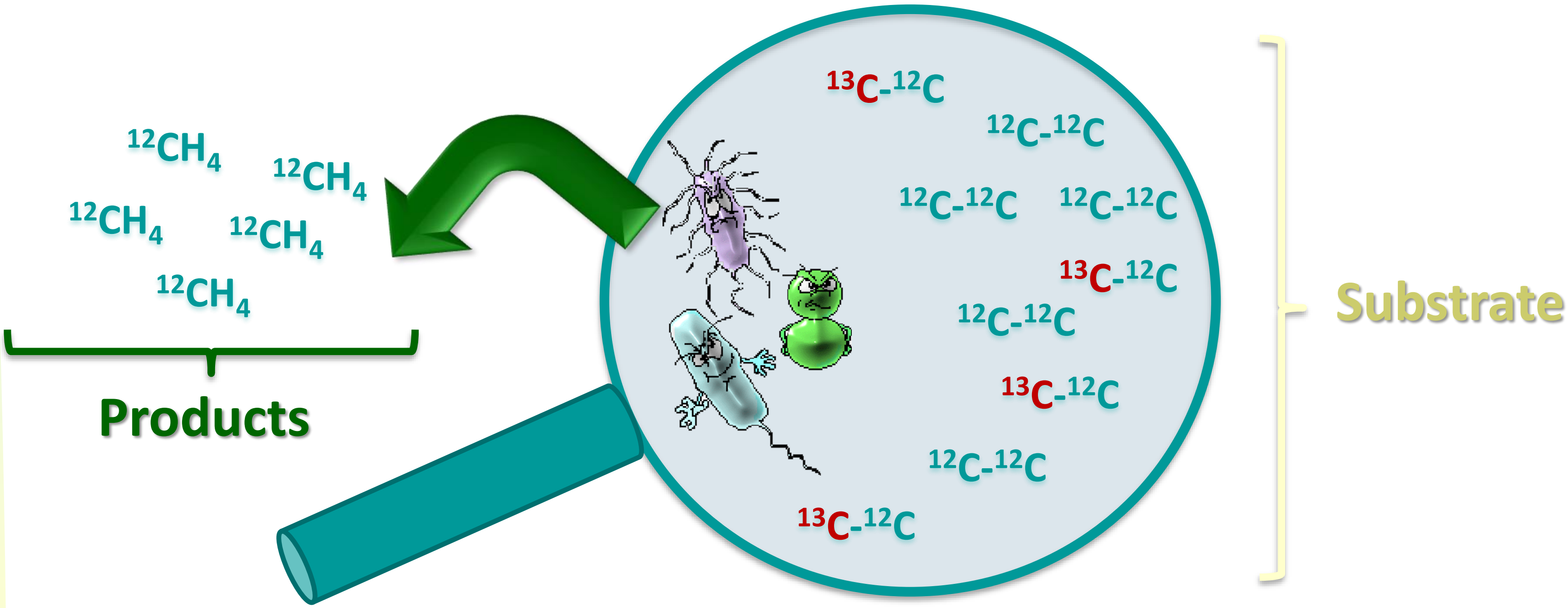
Carbon 12: stable
6 protons / 6 neutrons
Carbon 13: stable
6 protons / 7 neutrons
Carbon 14: unstable
6 protons / 8 neutrons

- The natural average abundance of ^{13}C isotope is 1.11 %



Isotopic fractionation

- Molecules containing heavy isotopes undergo the same chemical or biological reactions than light molecules, but simply because chemical bonds involving heavy isotopes are stronger, they have slower reaction rates



- Due to these tiny differences in reaction rates the products of reactions have different isotope ratios than the source materials

Isotopic composition

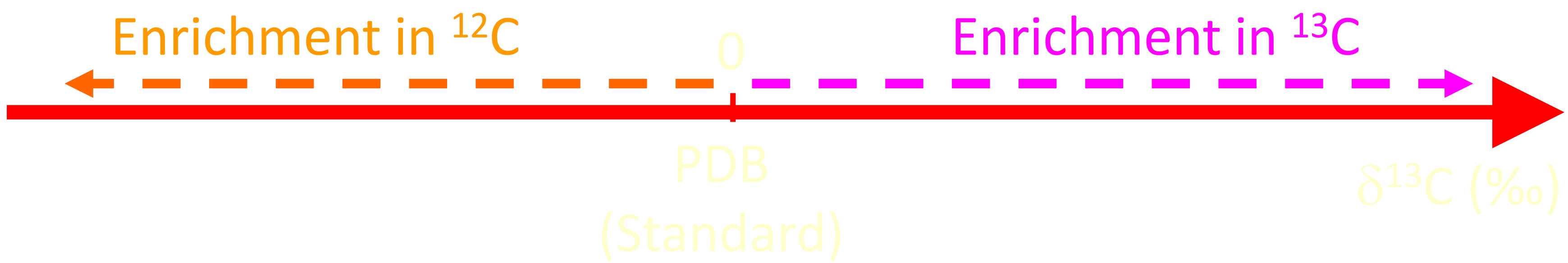
Delta notation is a way to express isotopic composition of a sample relative to an international standard (marine carbonate, PDB)

$$\delta^{13}C = \frac{R_{sample} - R_{standard}}{R_{standard}} \times 1000 \quad [\,^0\!/_{00}]$$

$R = {}^{13}C/{}^{12}C$

➔ When $\delta^{13}C$ is positive, the sample is enriched in ^{13}C / Standard

➔ When $\delta^{13}C$ is negative, the sample is enriched in ^{12}C / Standard



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Stable isotopic approach

Isotopic composition is generall[y] different between C[O2] and Ac[etate]

M

Mic

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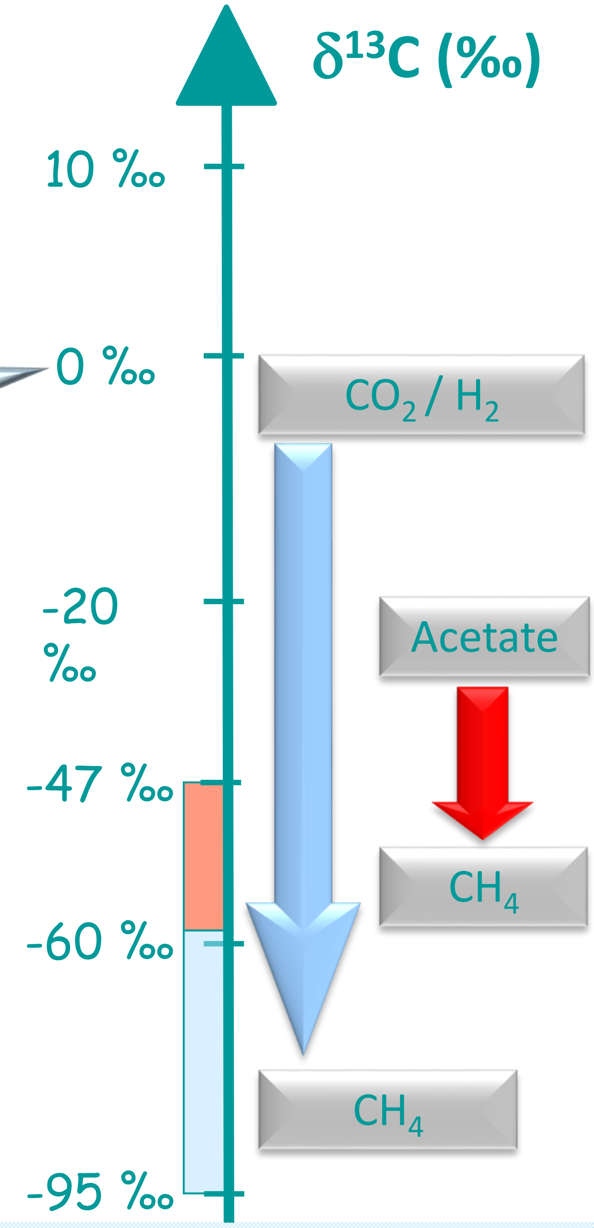
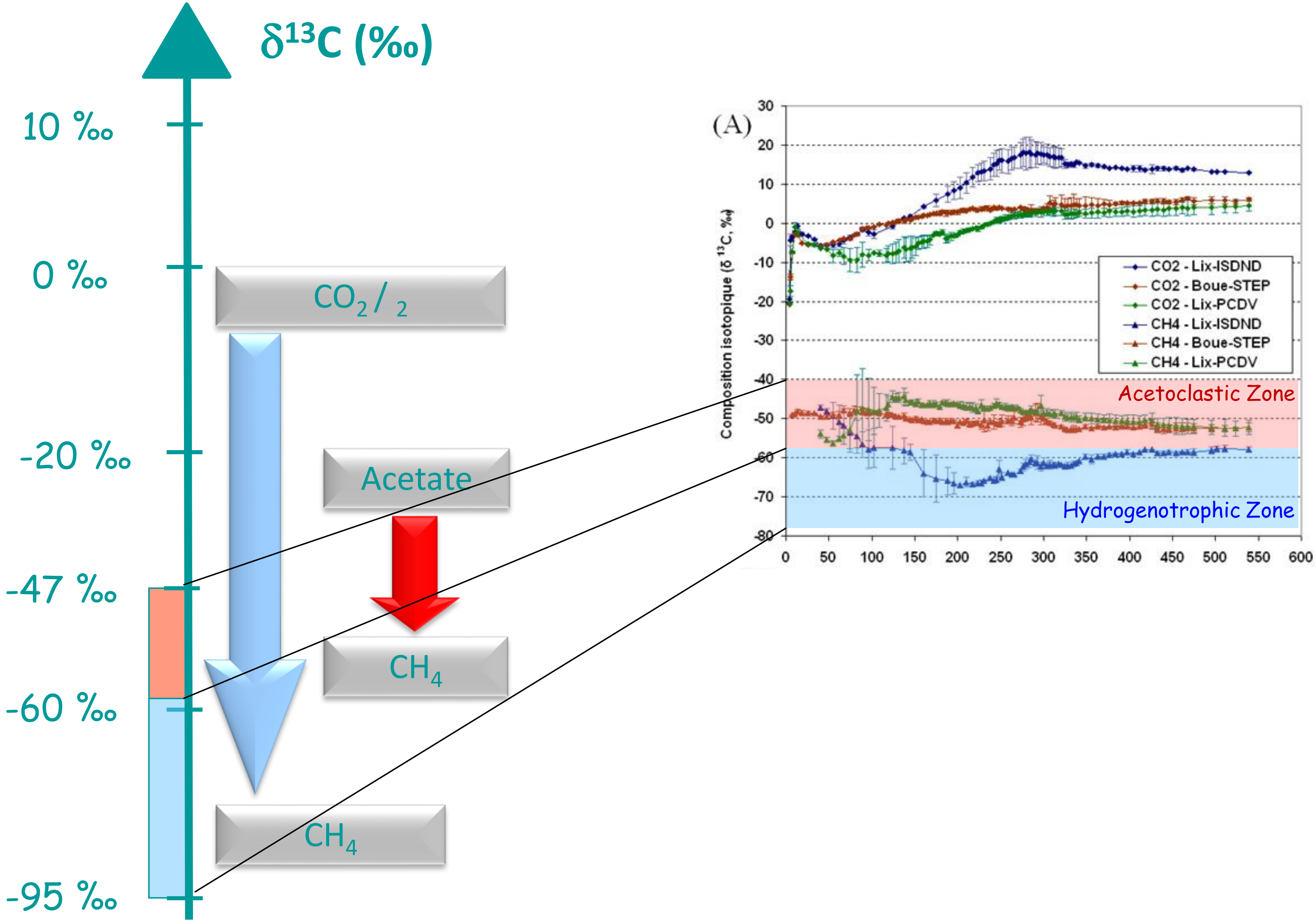
is ... e important for the hy... genot...phic methanogenesis

The stable isotopic approach is already used for the study of natural methanogenic environnement

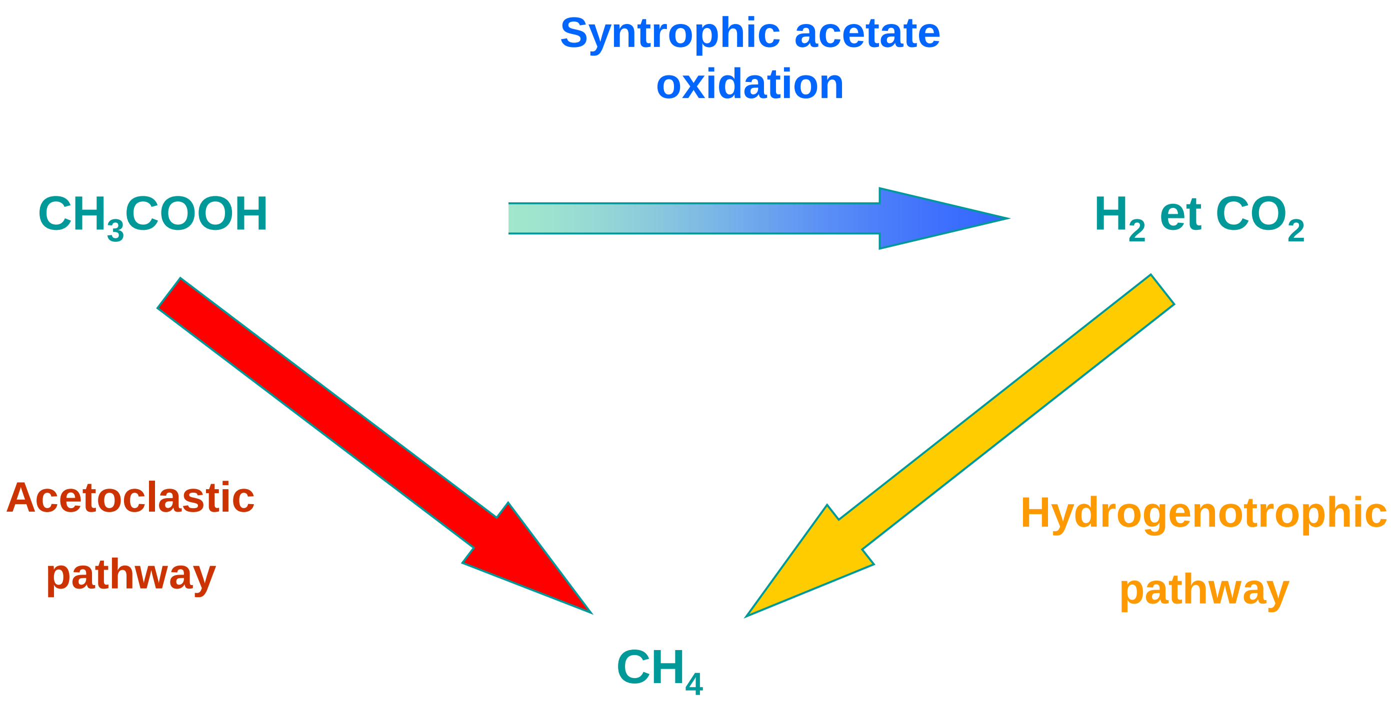


Using bibliographic data, it's possible to determine the methanogenic pathway by using methane stable isotopic composition

Biogas isotopic composition



Methanogenesis pathways



Reactions :

$CH_3COOH + H_2O \rightarrow CH_4 + CO_2$

$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

$CH_3COOH + 2H_2O \rightarrow 4H_2 + 2CO_2$

Synthrophic acetate oxidation

Tow step reaction:

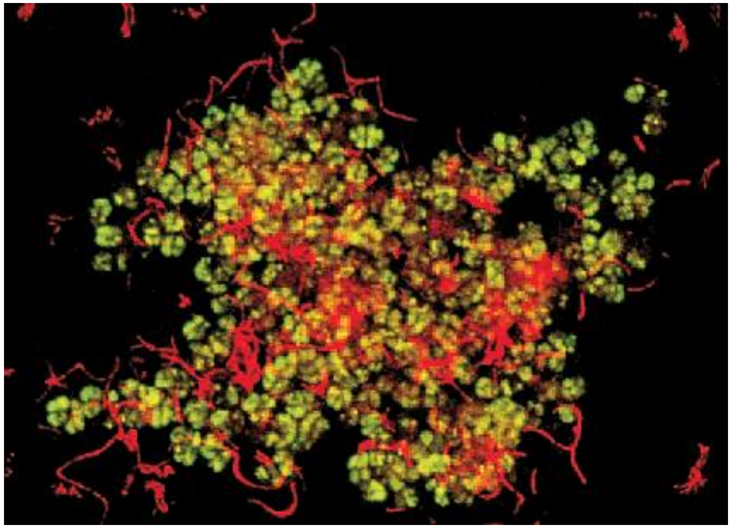
1) $CH_3COOH + 2H_2O \rightarrow 4H_2 + 2CO_2$ Bacteria

!

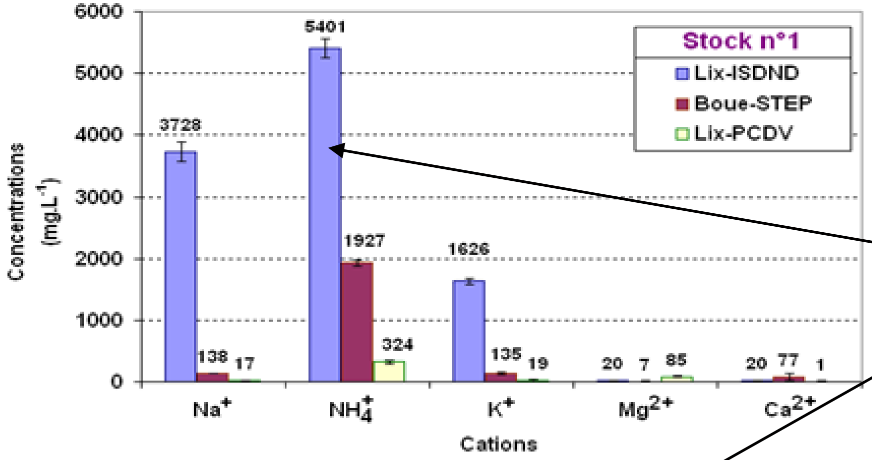
2) $4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$ Archeae

syntrophic relationship between

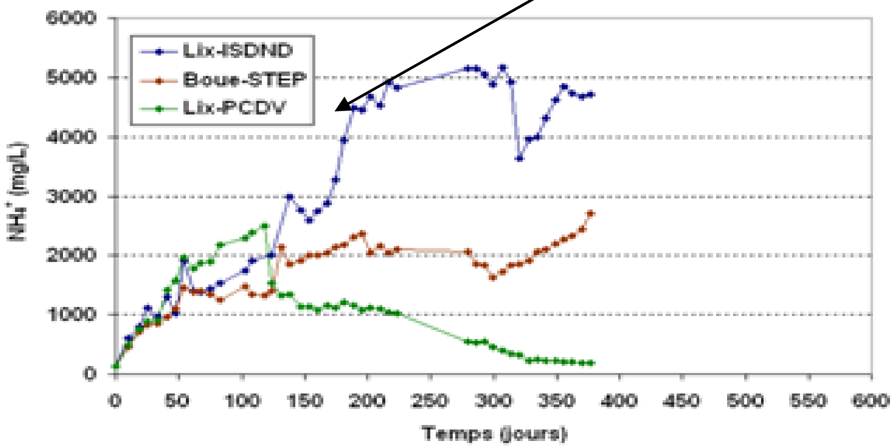
bactaria and archaea



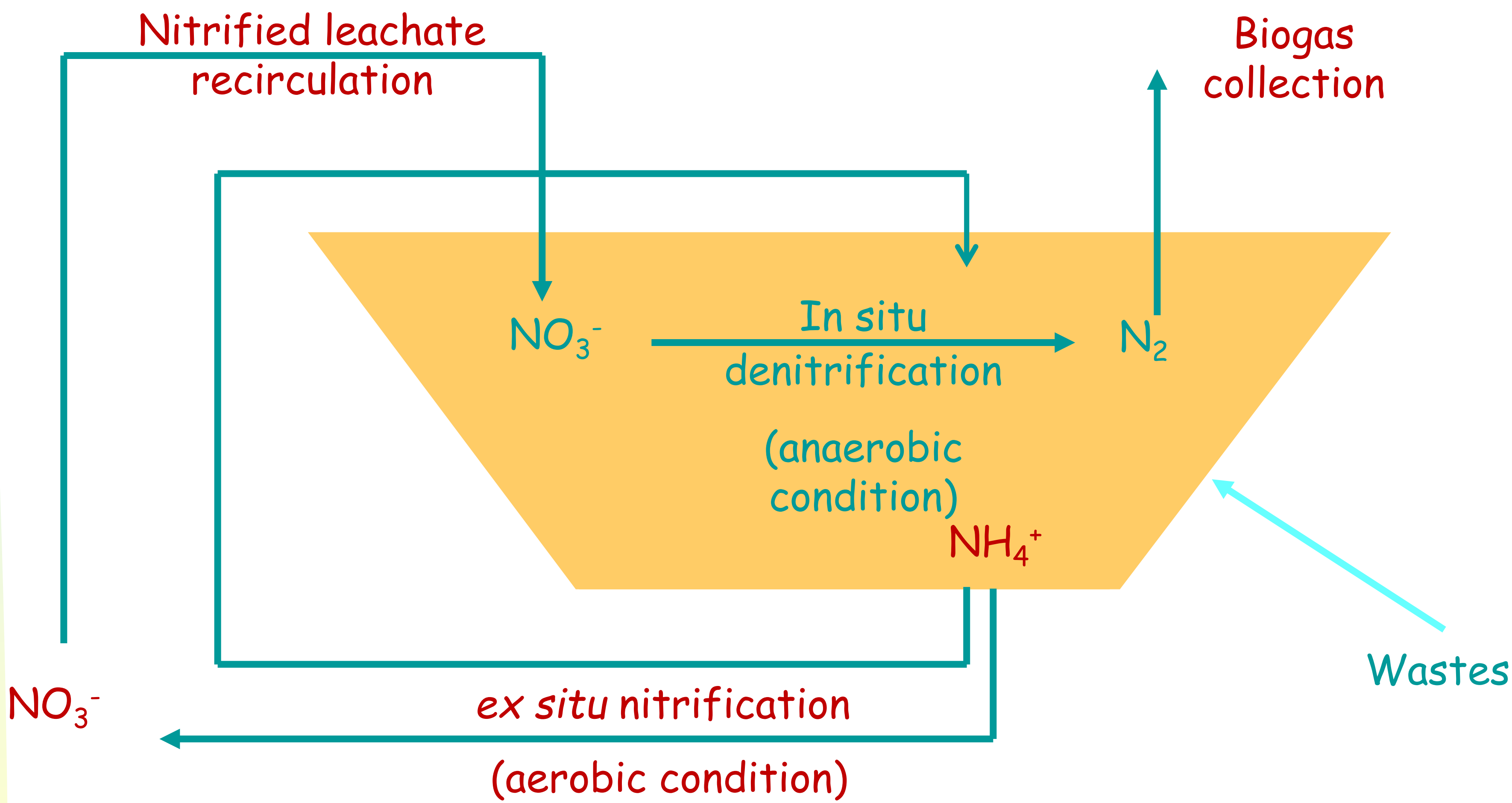
Why biogas production is slower with landfill leachates?i



Amonia methanogenesis inhibition



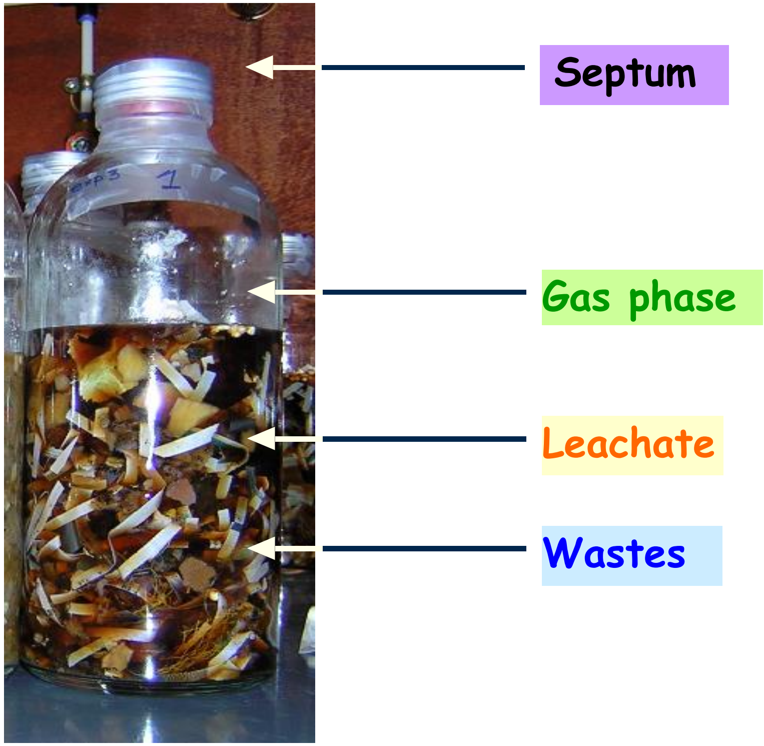
Bioreactor Municipal solid waste landfill



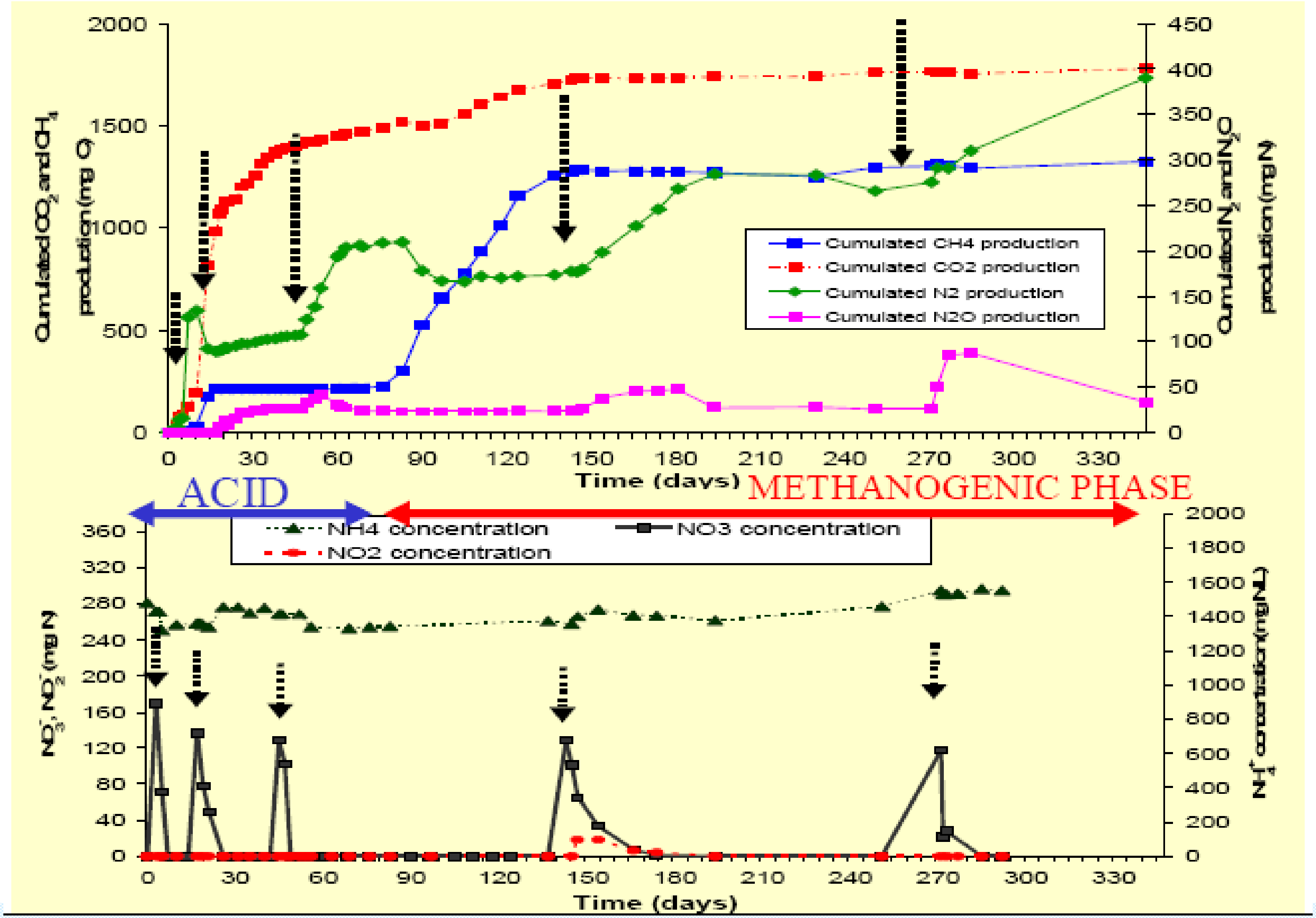
Strategy: leachate pretreatment before recirculation

Experimental set up

Anaerobic batch experiment



Experimental design



Case 1 Results interpretation

N_2 production = denitrification

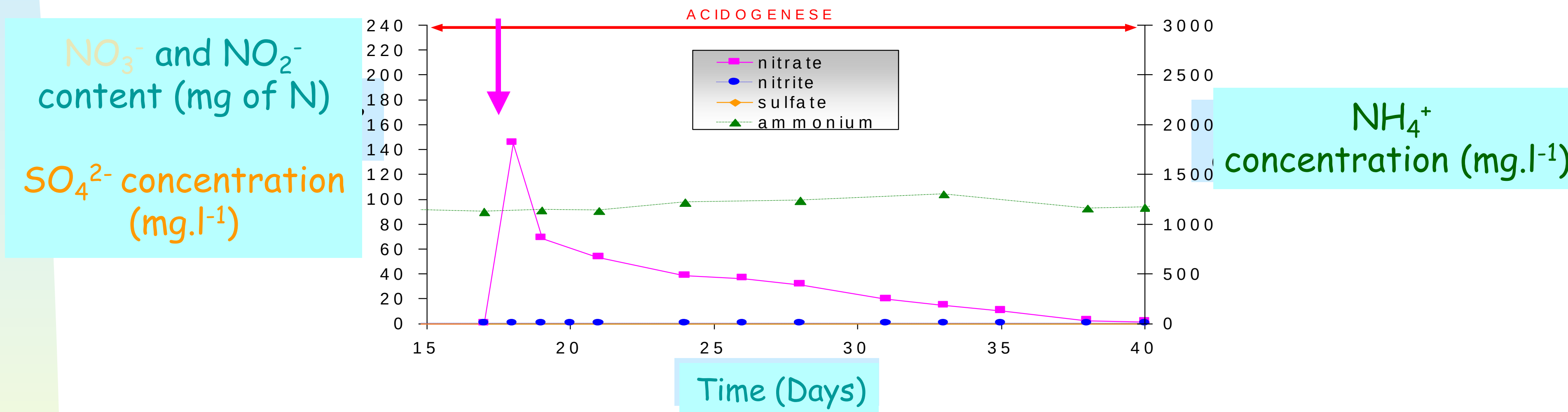
Presence of organic matter

→ Heterotrophic denitrification

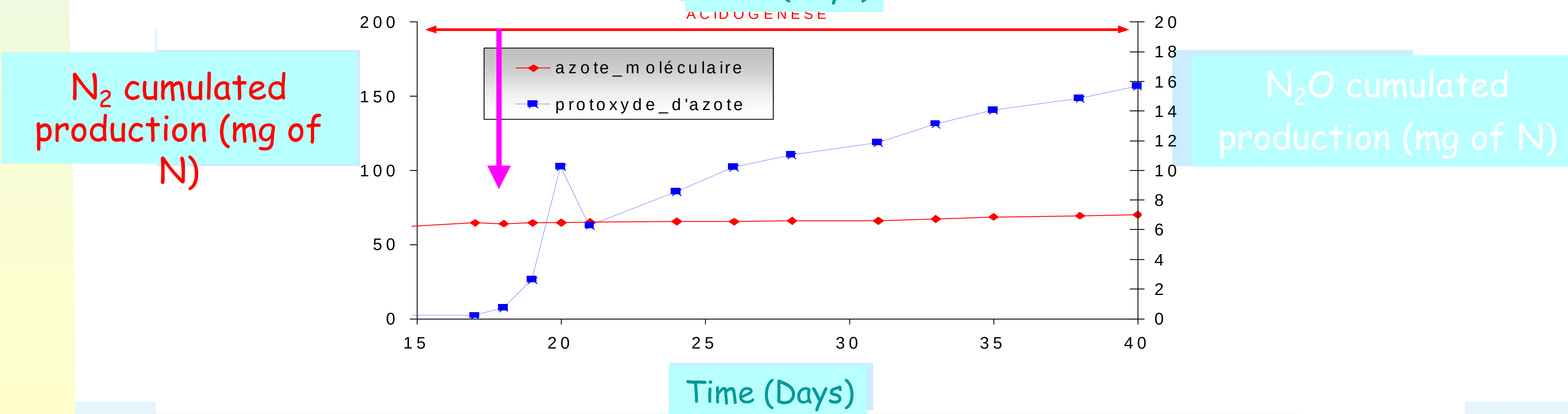
$$0{,}625\ CH_3COOH + NO_3^- \rightarrow HCO_3^- + 0{,}25\ CO_2 + 0{,}75\ H_2O + 0{,}5\ N_2$$

Observed in 13 cases upon 20

Second Case



NO3- and NO2- content (mg of N)
SO42- concentration (mg.l-1)
NH4+ concentration (mg.l-1)
ACIDOGENESE
nitrate
nitrite
sulfate
ammonium
240
220
200
180
160
140
120
100
80
60
40
20
0
3000
2500
2000
1500
1000
500
0
15
20
25
30
35
40
Time (Days)



N2 cumulated production (mg of N)
N2O cumulated production (mg of N)
ACIDOGENESE
azote_moléculaire
protoxyde_d'azote
200
150
100
50
0
20
18
16
14
12
10
8
6
4
2
0
15
20
25
30
35
40
Time (Days)

Case 2 Results interpretation

No N_2 production = Nitramonification?

$$NO_3^- + 4\ H_2 + 2\ H^+ \rightarrow NH_4^+ + 3\ H_2O$$

Observed in 4 cases upon 20

Identification of the shifting parameter

Statistical analysis :

$$N_2 \text{ production} = 0{,}5245 + 0{,}1059\ [\text{acetate}] - 6{,}2153\ [H_2S]$$

R^2=0,801

Positive effect on N_2 production

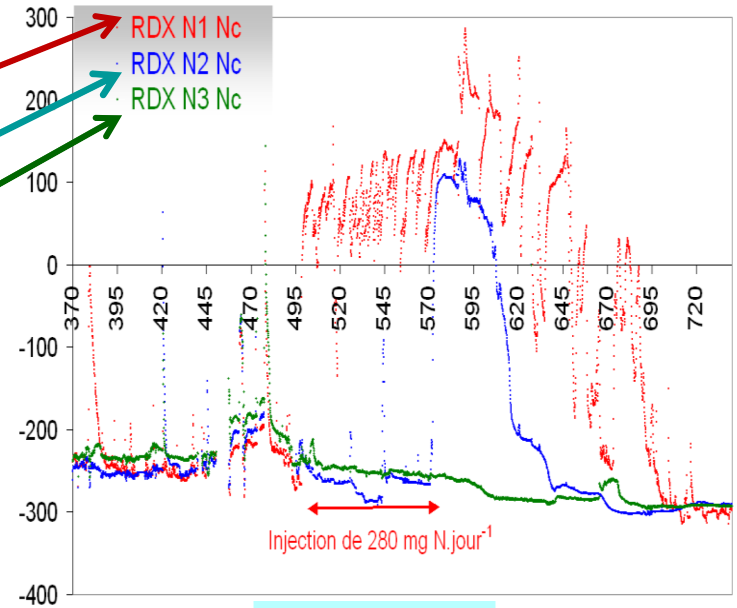
(Positive coefficient)

Negative effect on N_2 production

(Negative coefficient)

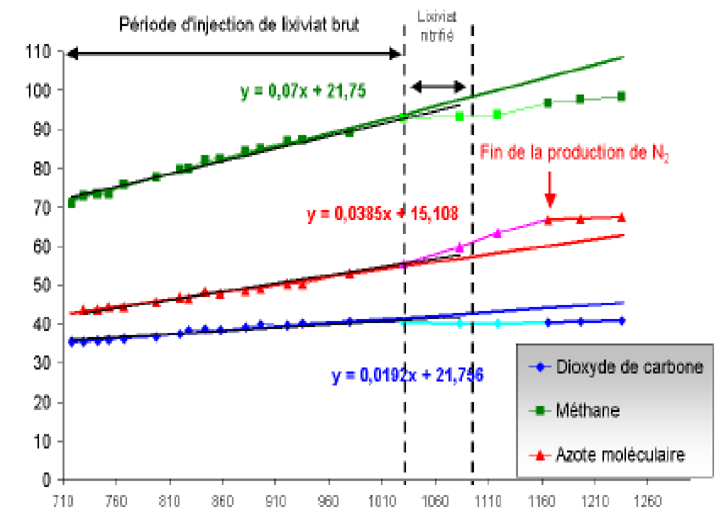
Mesocosm experiment

Oxido-reduction potential against Eh



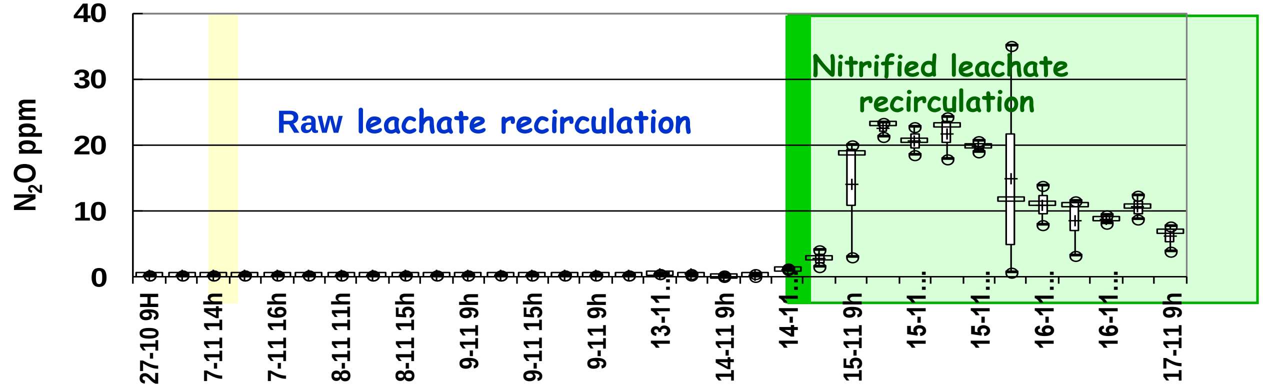
Time (Days)

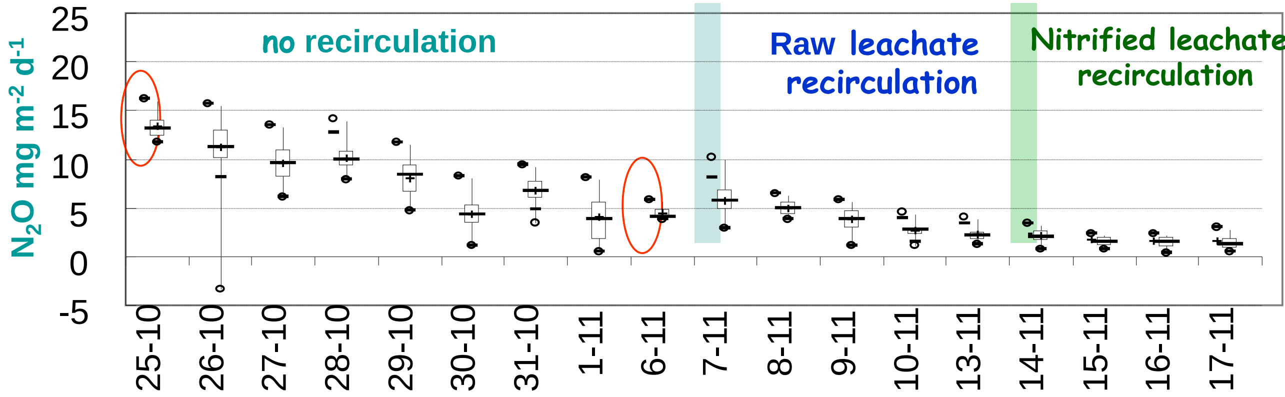
Cumulated production of CO_2, CH_4 and N_2



Time (Days)

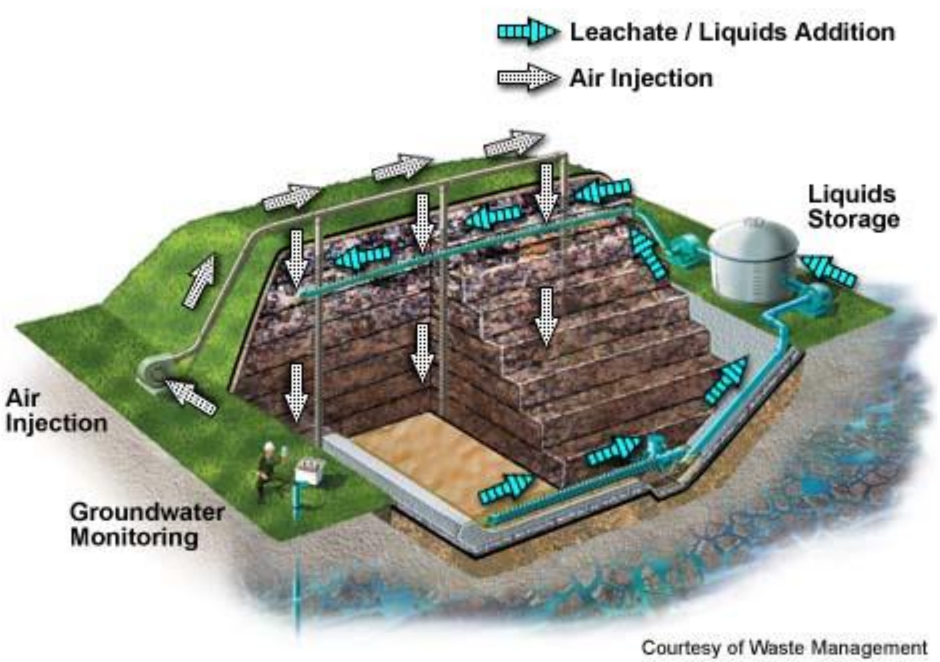
Field experiment





Aerobic bioreactor landfill

In an aerobic bioreactor landfill, leachate is removed from the bottom layer, piped to liquids storage tanks, and re-circulated into the landfill in a controlled manner. Air is injected into the waste mass using vertical or horizontal wells to promote aerobic activity and accelerate waste stabilization.



Municipal solid waste landfill

- Context
- Municipal solid waste landfill conception
- Anaerobic degradation in landfill: influence on leachate composition
- Landfill leachate recirculation optimisation
- MSW Landfill impacts
- Landfill mining

MSW Landfill impacts

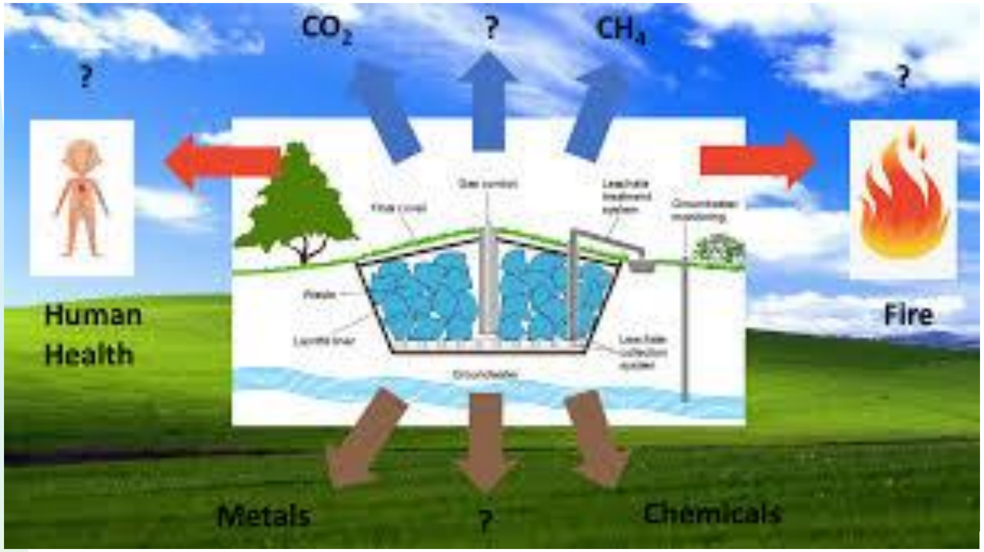
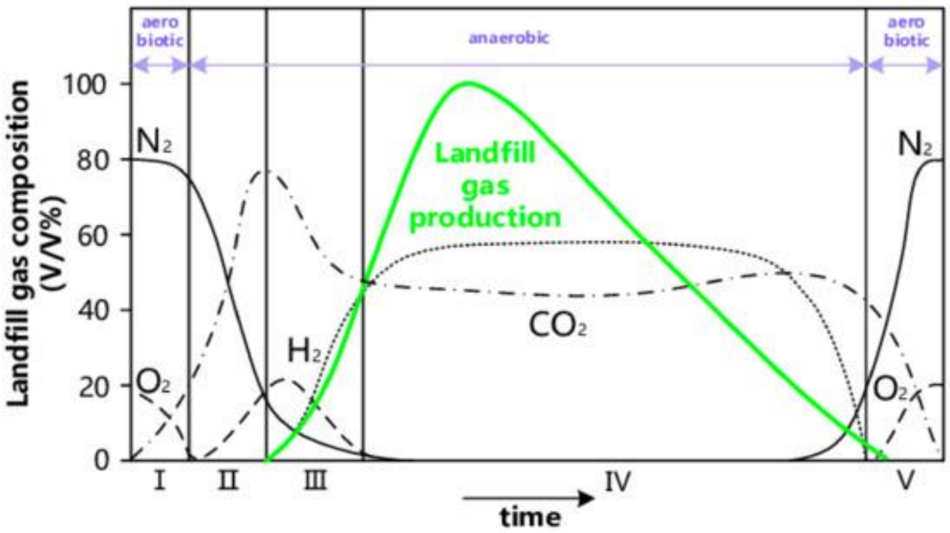
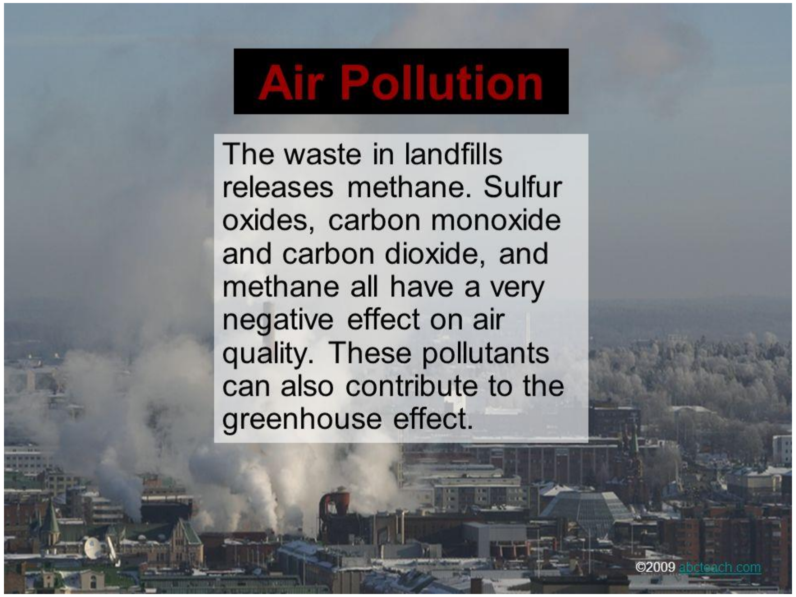


Figure 1. Potential impact of landfills on the environment.

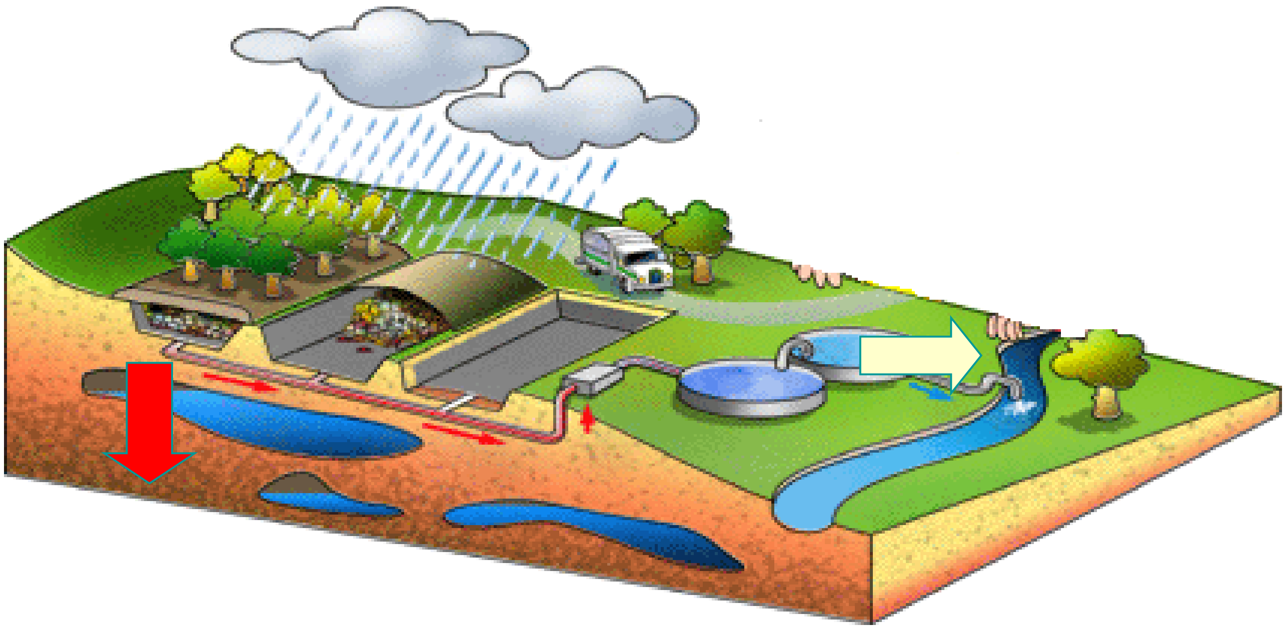
Air pollution

Composants	Ordures ménagères
CH_4 % vol	50-60
CO_2 % vol	38-34
N_2 % vol	5-0
O_2 % vol	1-0
H_2O % vol	6 (à 40 ° C)
Total % vol	100
H_2S mg/m3	100 - 900
NH_3 mg/m3	-
Aromatiques mg/m3	0 - 200
Organochlorés ou organofluorés mg/m3	100-800





MSW Landfill leachates impacts



❶

Transfers of micropollutants through the sealing barriers

Contamination of subsoils and groundwater

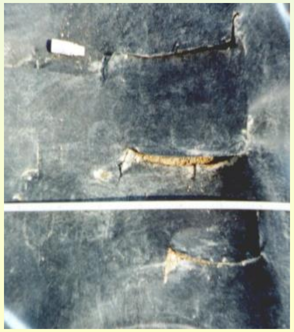
❷

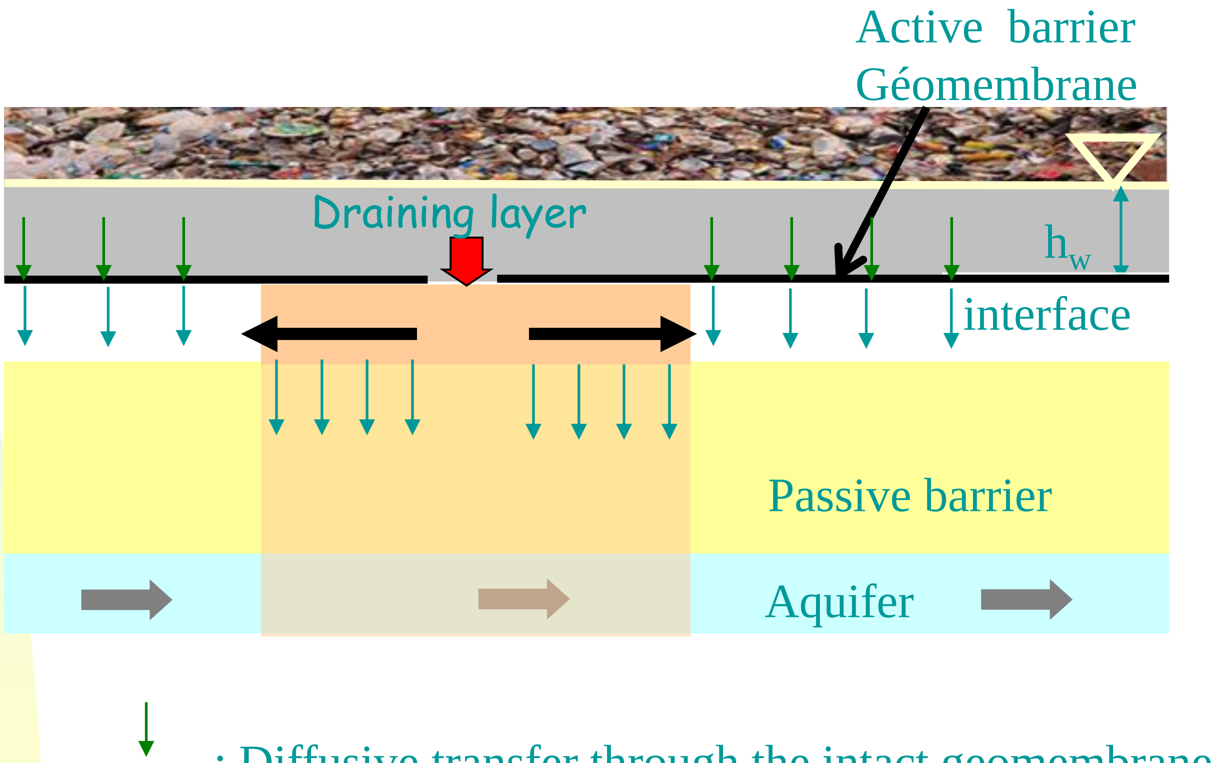
Recalcitrant micropollutants to leachate treatments

Contamination of surface water

Two basic modes of transfer in the sealing barriers :

- **advective transfers (defects in the geomembrane)**
- **diffusive transfers**





Micro-pollutants found in leachates

Database under access grouping:

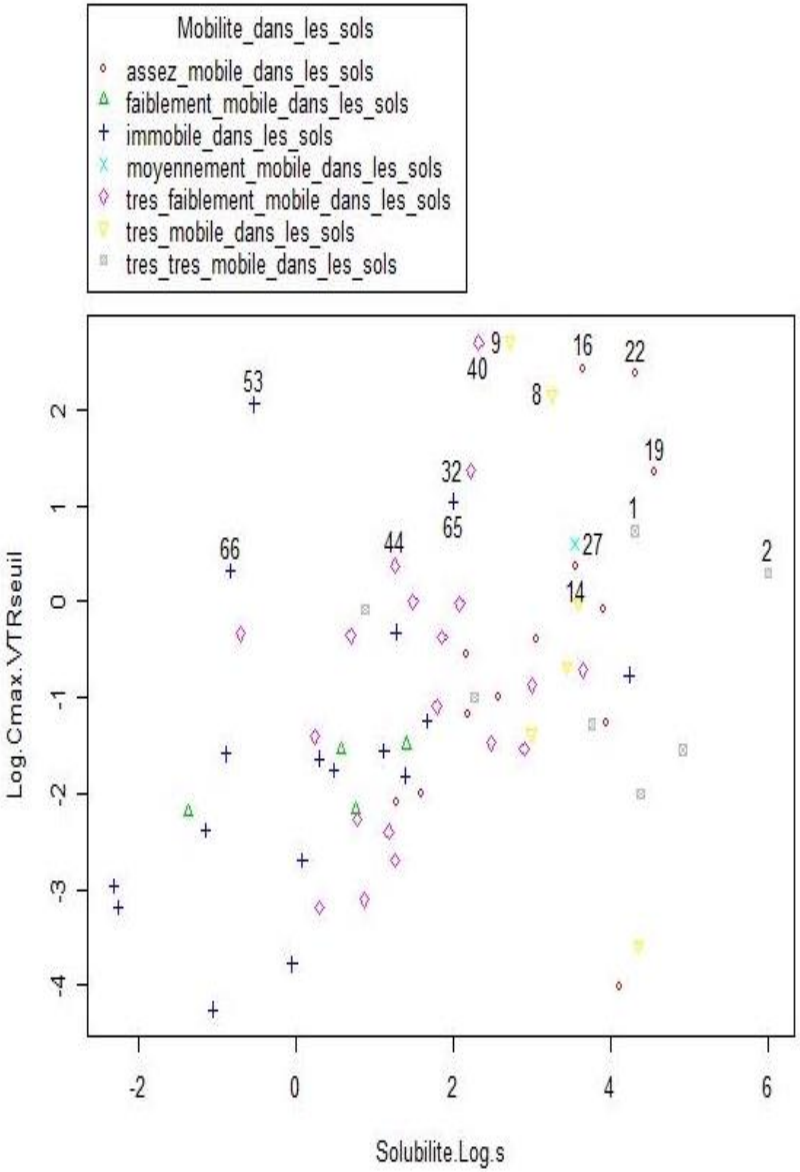
- 33 publications and study reports
- 100 different ISD
- 311 leachate samples
- 402 organic compounds

-The physical-chemical properties (solubility, Koc ...)

-The toxicological properties of pollutants (TRV, CMR classification ...)

→ **no public data in France**

Selection of compounds for impact analysis



1: Dichloromethane
2: 1,4_Dioxane
8: Benzene
9: Toluene
14: Z- 1,2_Dichloroethylene
16: E-1,2_Dichloroethylene
19: Aniline
22: p_Cresol
27: 1,1,2_Trichloroethane
32: Ethylbenzene
40: Bisphenol_A
44: 1,2,4_Trichlorobenzene
53: Bis2_ethylhexylphthalate
65: Aldrin
66: dieldrin

Composition of leachates in France: analysis campaign

The choice of leachate collection sites: 8 sites

Compounds analyzed:

- Volatile Organic Compounds (VOCs)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- PolyChlorinated Biphenyls (PCBs)
- PolyBrominated Diphenyl Ethers (PBDEs)
- Phenols and bisphenol A
- Phtalates
- Pesticides
- Pharmaceutical products
- Organometallic compounds

The organic compounds were analyzed both in the dissolved and particulate phases

Analysis campaign : main results

- Presence in large quantity of bisphenol A (antioxidant) and phthalates (plasticizer) which are plastic additives with reprotoxic properties

- Presence also of some VOC (mono-aromatic, chlorinated solvent ...) with carcinogenic properties

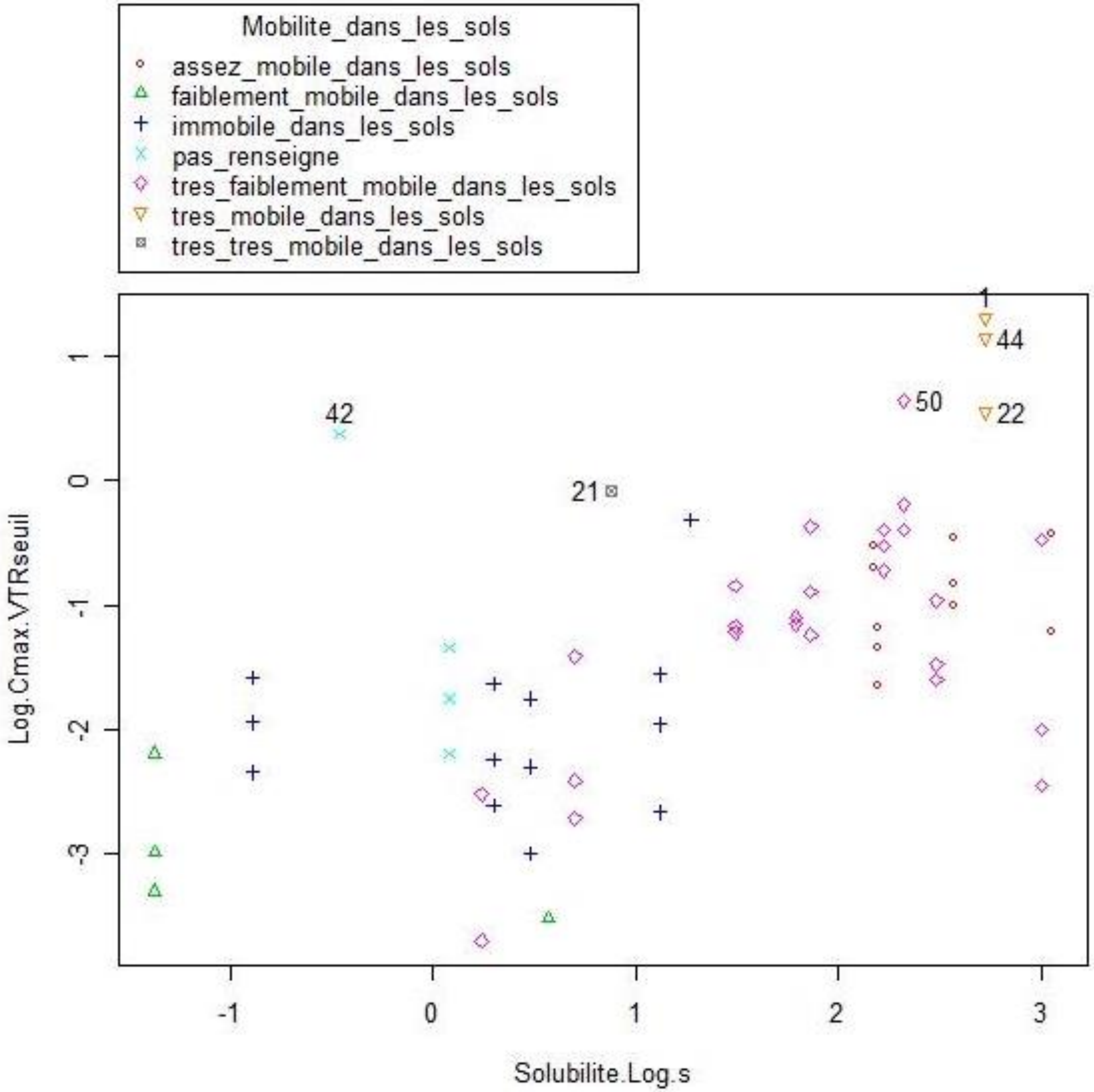
- Presence of PAHs, PCBs and PBDEs mainly on the particulate phase because these compounds are not very soluble

- Pharmaceuticals and hormones have not been found

CMR compounds found in leachates

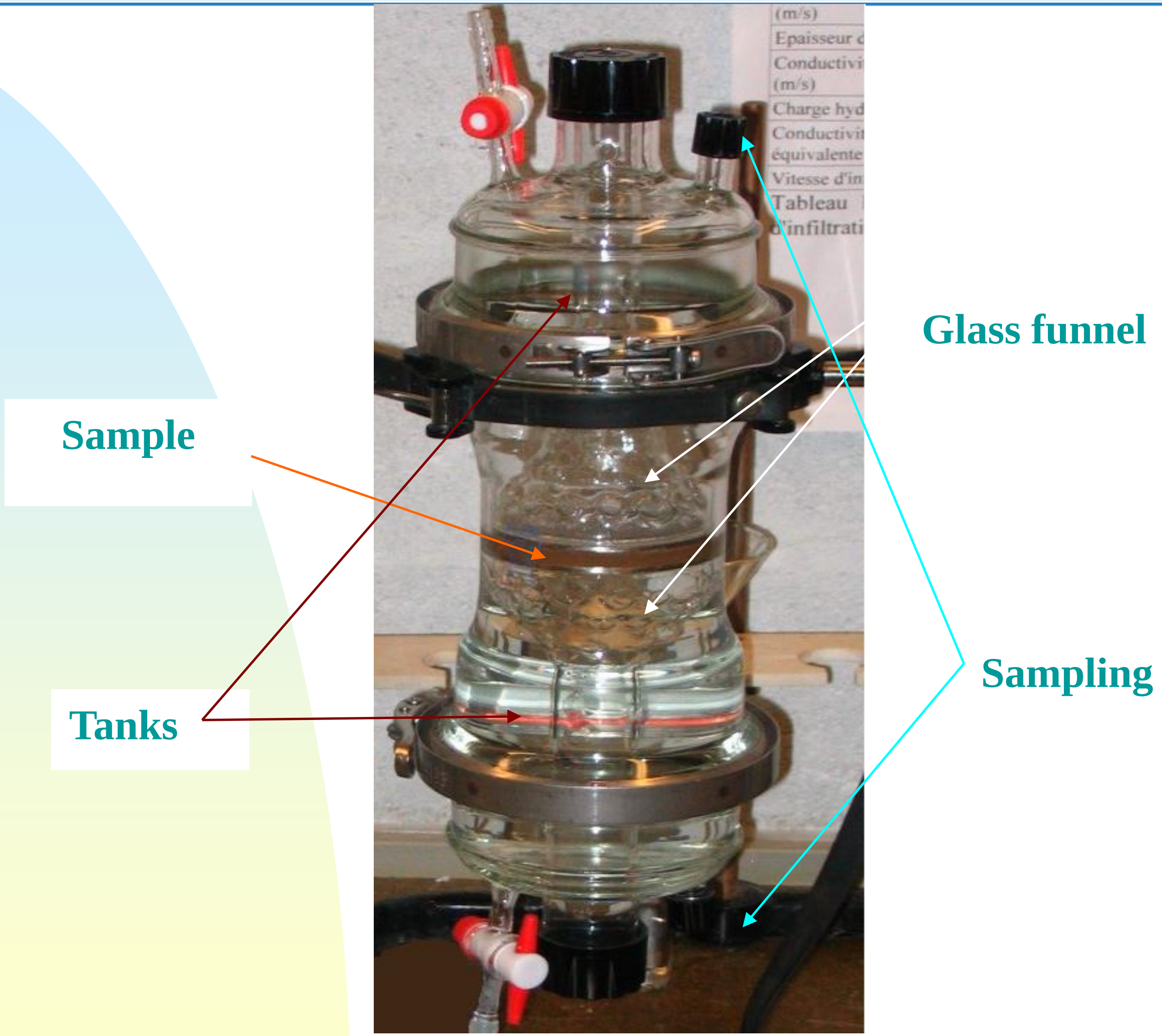
Compounds	CMR Classification	Tracking frequency (%)
Dibutyl phthalate	REPRO 2 / REPRO 3	100
Bisphenol A	REPRO 3	100
Toluène	REPRO 3	100
Benzène	CARC1/MUTA2	100
Dichlorométhane	CARC 3	100
p-dichlorobenzène	CARC3	75
Benz[a]anthracène	CARC 2	62,5
Butyl benzyl phtalate	REPRO 2 / REPRO 3	37,5
Trichloroethylène	CARC 2/ MUTA 3	37,5
Tetrachloroéthylène	CARC 3	37,5
Benzo[e]pyrène	CARC 2	25
Benzo[a]pyrène	CARC 2/ MUTA 2/ REPRO 2	25
Heptachlor epoxide	CARC3	12,5
Heptachlor	CARC 3	12,5

Selection of compounds for impact analysis



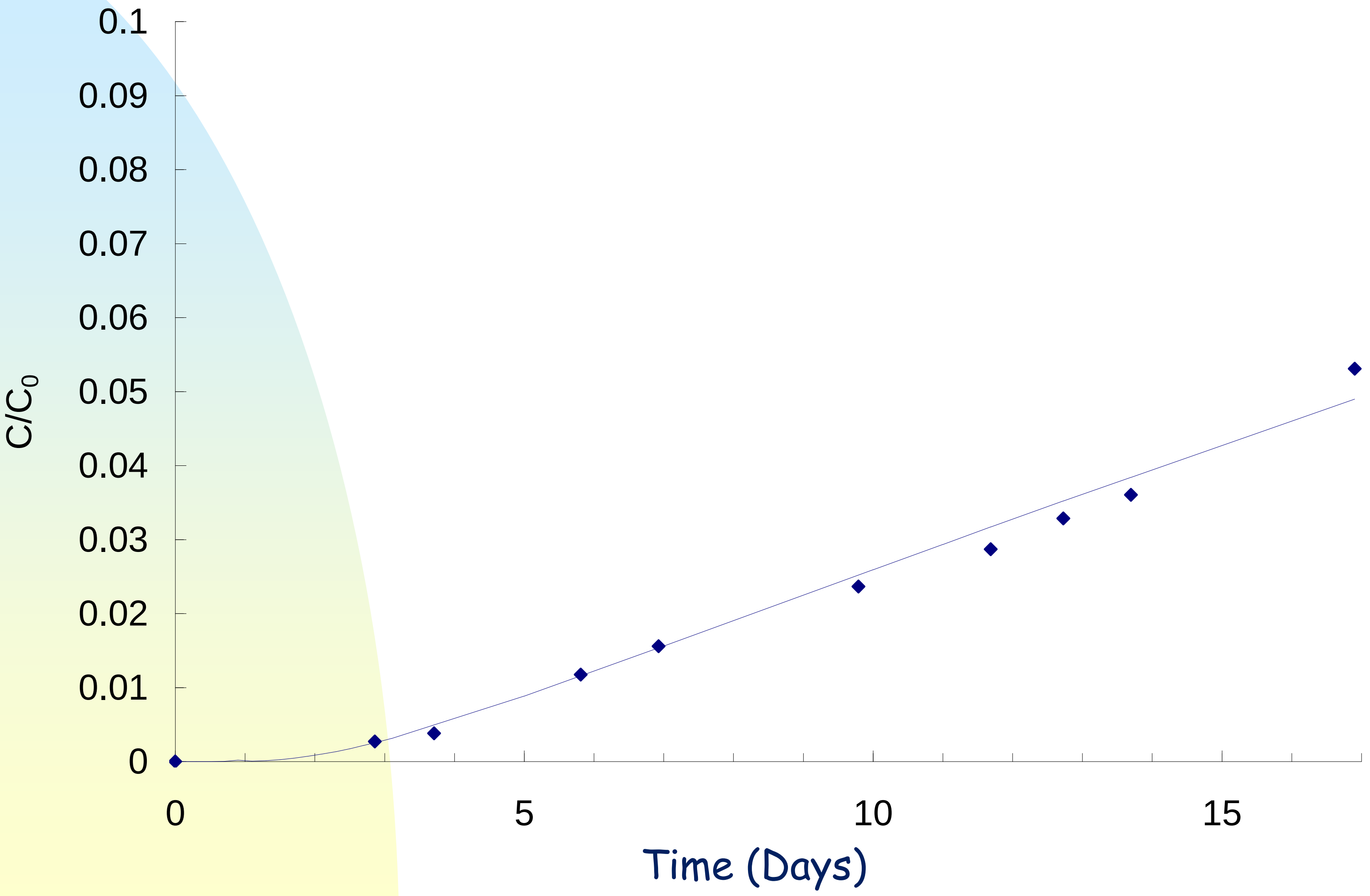
1: Toluène (DIB)
44: Toluène (OM + DIB)
22: Toluène (OM)
50: Bisphenol_A (OM + DIB)
42: Heptachlor_epoxide (OM)

Determination of diffusion coefficients

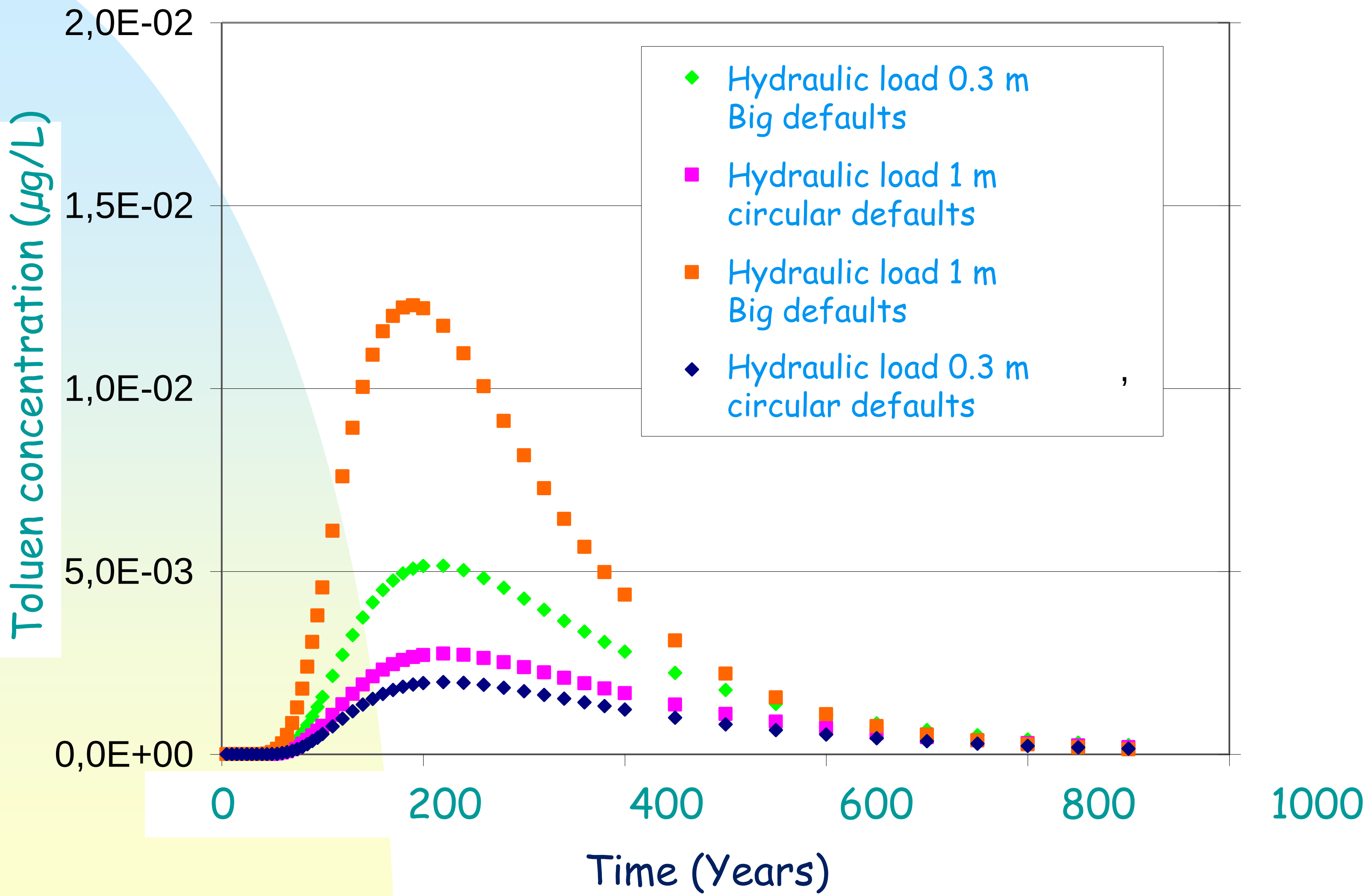


Determination of diffusion coefficients

Toluen



Calculation of the concentration in the aquifer



Assessment of the toxicity of non-hazardous waste storage facility leachates and identification of the chemical agents responsible

université de BORDEAUX

LPTC

UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR

LCABIE

INERIS maîtriser le risque pour un développement durable

Nature of analyzed leachates

Raw leachate

Aerated leachate

Treated leachate

Samples	Site	Characteristics
Site1-LB	Site 1	Lixiviat brut provenant de plusieurs casiers d'âges différents.
Site1-LA	Site 1	Lixiviat prélevé dans le bassin d'aération recevant le lixiviat site1-LB.
Site1-LT	Site 1	Perméat prélevé en sortie de traitement (évapo-concentration suivie d'une osmose inverse) du site1.
Site2-LB	Site 2	Lixiviat brut prélevé au niveau de la station de relevage du site 2.
Site2-LA	Site 2	Lixiviat prélevé dans le bassin d'aération recevant le lixiviat site2-LB.
Site2-LT	Site 2	Effluent de sortie de traitement (réacteur membranaire suivi d'une filtration sur charbon actif) du site 2.

Evaluation of the toxicity of the organic fraction

Toxicity test

Targeted mechanisms	Methods	Detected molecules	References
Génotoxicity	SOS Chromotest	Genotoxics et pro genotoxics: HAP, nitrosamin , pesticides…	Quillardet et Hofnung, 1985
Dioxin receptor (AhR)	EROD activity	Dioxins et dioxin-likes, HAPs, PCBs	Laville et al., 2004
Estrogen receptor (ER)	Luciferase activity	Steroïds naturals et synthetics, Alkylphenols, Bisphenol A…	Pillon et al., 2005

Toxicity tests results

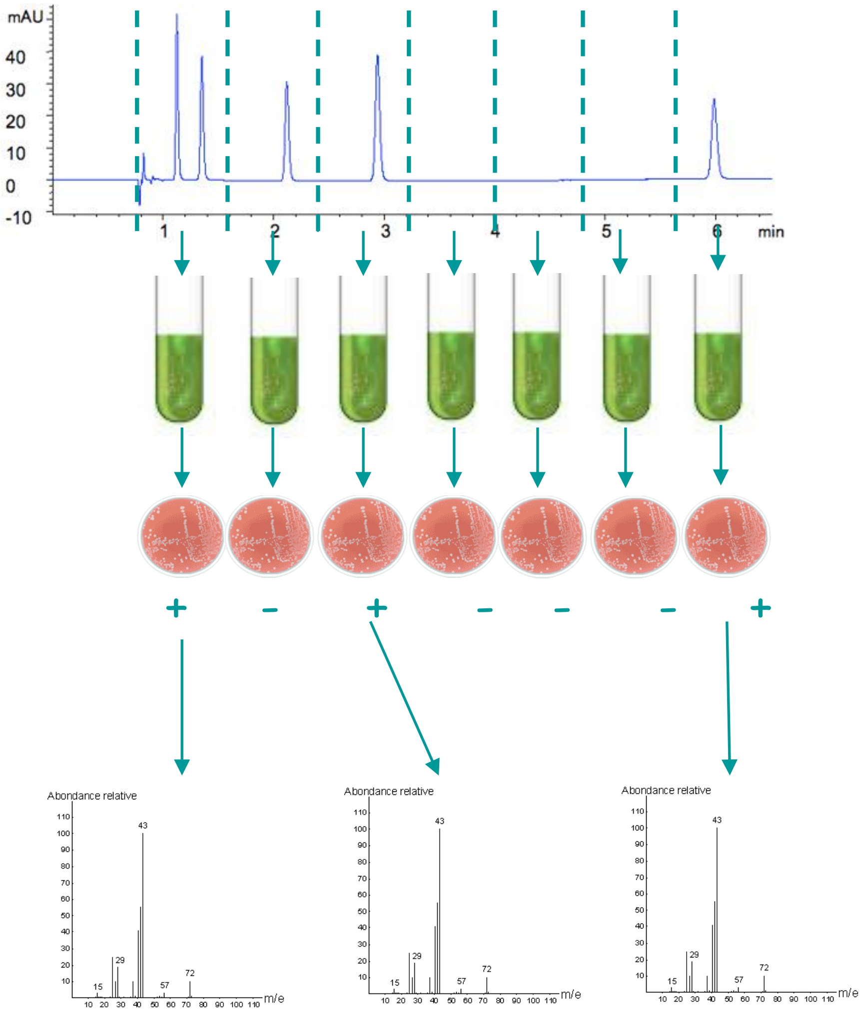
	Activity		
	Genotoxicity	Dioxin-like	Estrogenicity
Site 1 - Raw	+	++	+++
Site 1 - Aerated	-	+	+
Site 1 - Treated	-	-	-
Site 2 - Raw	-	++	++
Site 2 - Aerated	-	+	++
Site 2 - Treated	-	-	-

Principle of the effect directed analysis approach

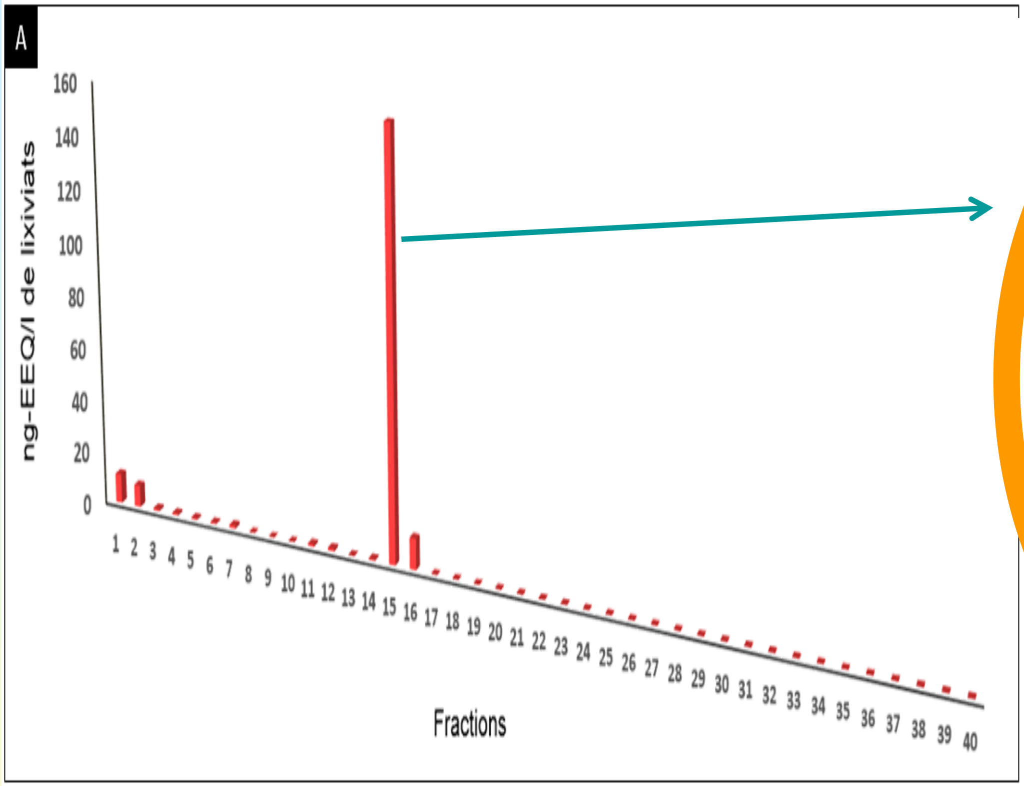
Fractionation of the leachate organic fraction by HPLC

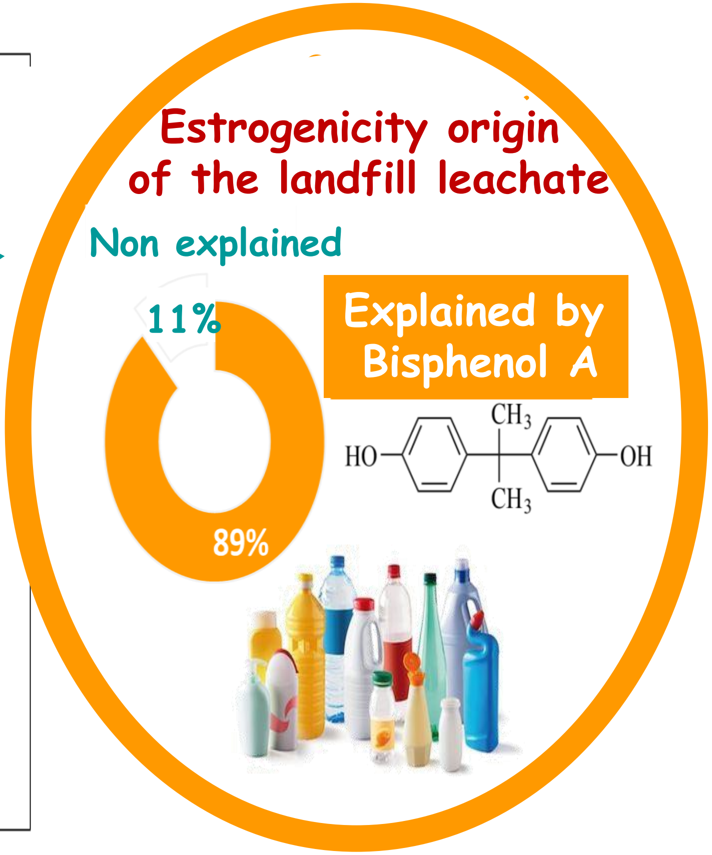
Identification of toxics fractions by toxicity tests (*Genotoxicity, Estrogenicity*)

Identification of molecules present in the fractions presenting toxicity by chemical analysis

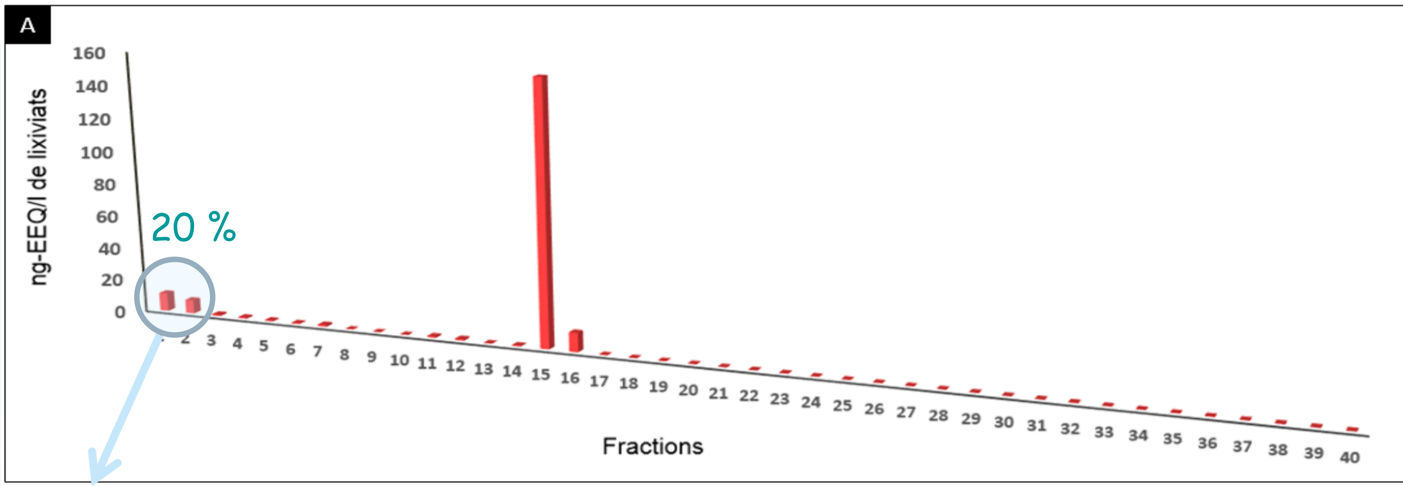


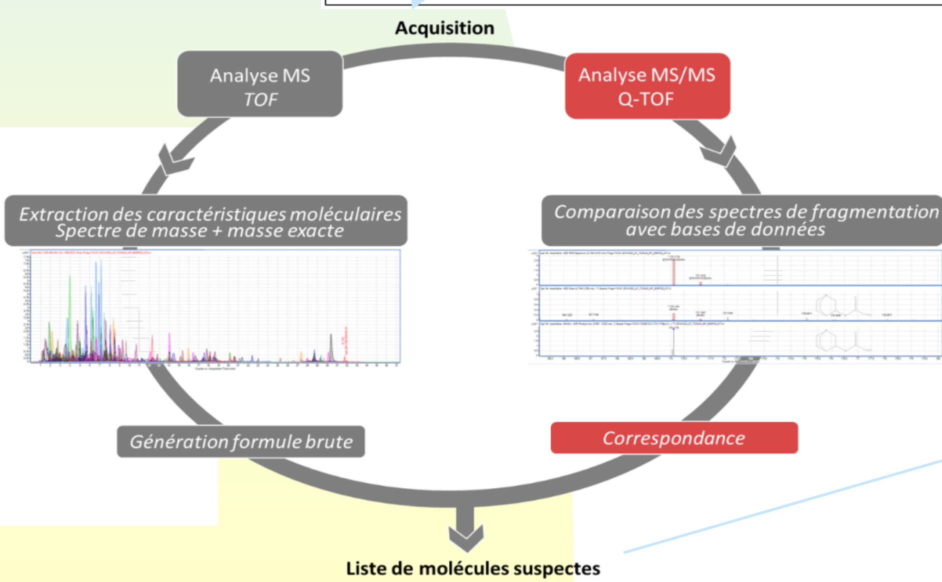
EDA approach to ISDND leachates

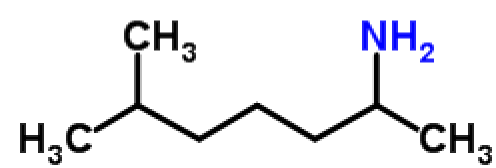




Identification of the responsible compounds







Octodrine

Concentrations of metals in leachates

Concentrations in mg/l

	Danemark	Germany	England	Drinking water
Cd	0.006	0.005	< 0.04	0.005
Zn	0.67	0.6	< 0.47	5.0
Cu	0.07	0.065	< 0.17	1.3
Cr	0.08	0.28	< 0.05	0.1

Levels of metals in leachates are low.

Metal trapping in waste as a precipitate (sulphide, carbonate…) or complexes with organic matter

However, in the long term, there may be significant release of metals when returning to aerobic conditions.

Sulfooxidation: a long-term risk?

sulfo-oxydation

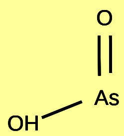
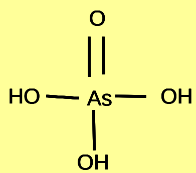
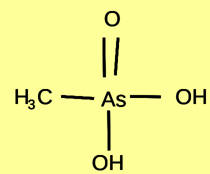
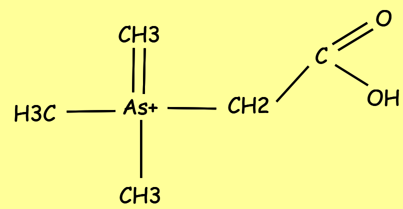
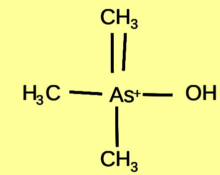
Consumption of sulphides in the presence of oxygen or nitrates (DMA) :

$$MS + O_2 + 2\ OH^- \rightarrow M^{2+} + H_2SO_4$$

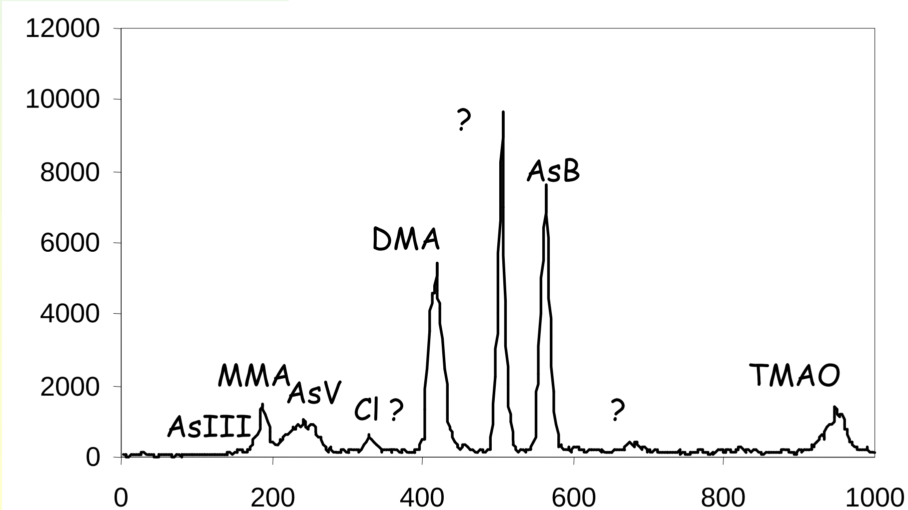
Consequences :

- Significant drop in pH
- Resolubilization of sulphides, hydroxides and carbonates

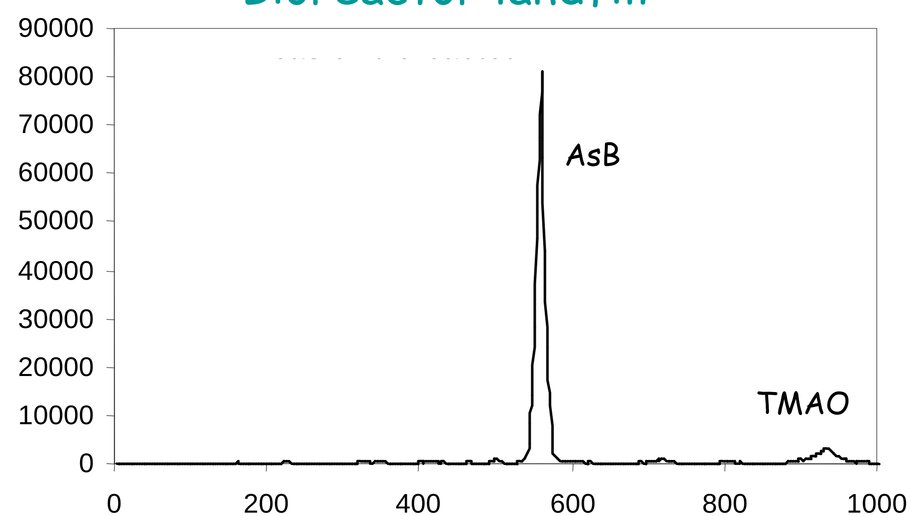
Arsenic speciation

	AsIII	AsV	MMA	AsB	TMAO
					
LD 50	8	22	916	4260	5500
TOXICITY					

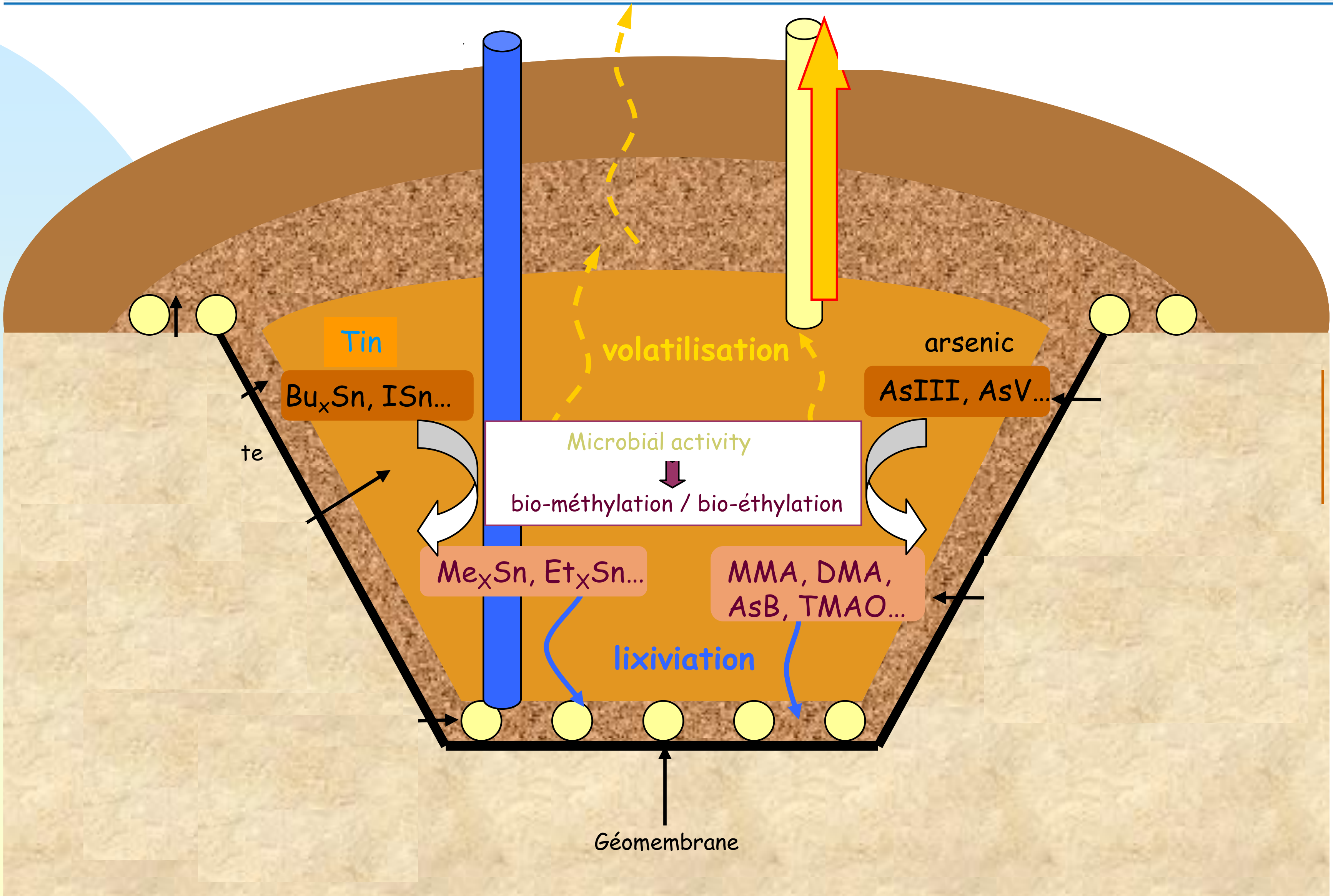
Normal landfill



Bioreactor landfill



Metals biogeochemical cycles in MSW landfill

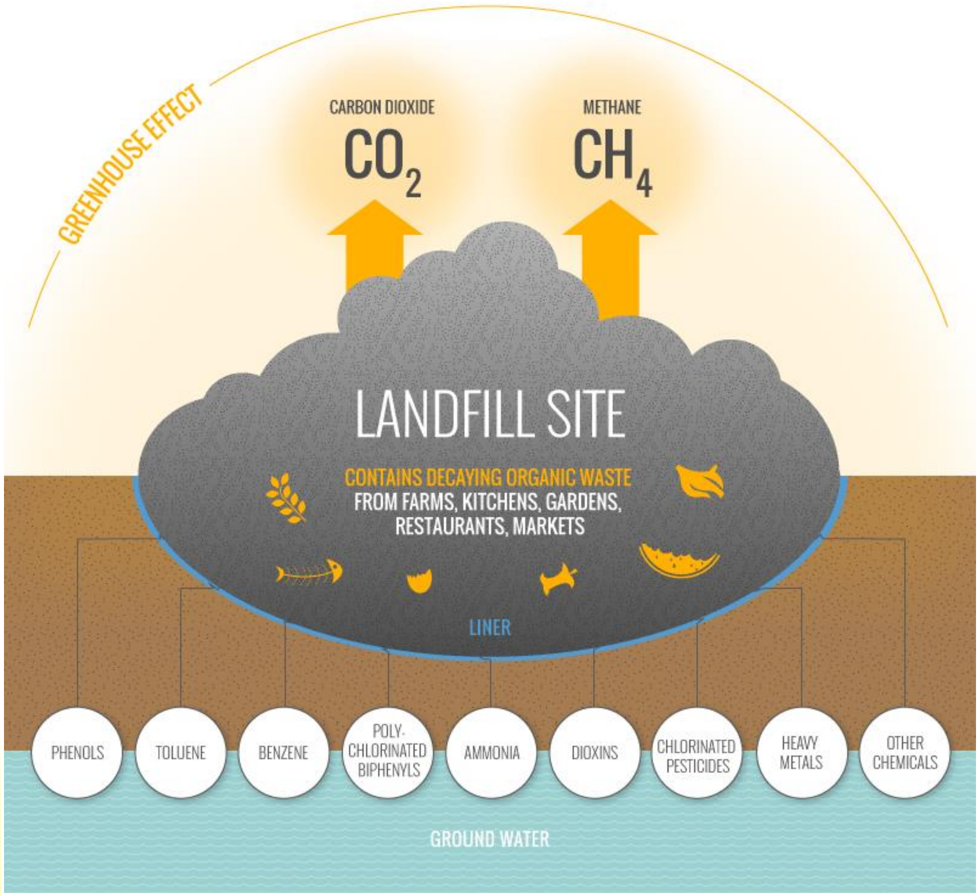


Municipal solid waste landfill

- Context
- Municipal solid waste landfill conception
- Anaerobic degradation in landfill: influence on leachate composition
- Landfill leachate recirculation optimisation
- Micropolutant in waste and landfill leachates
- Landfill mining

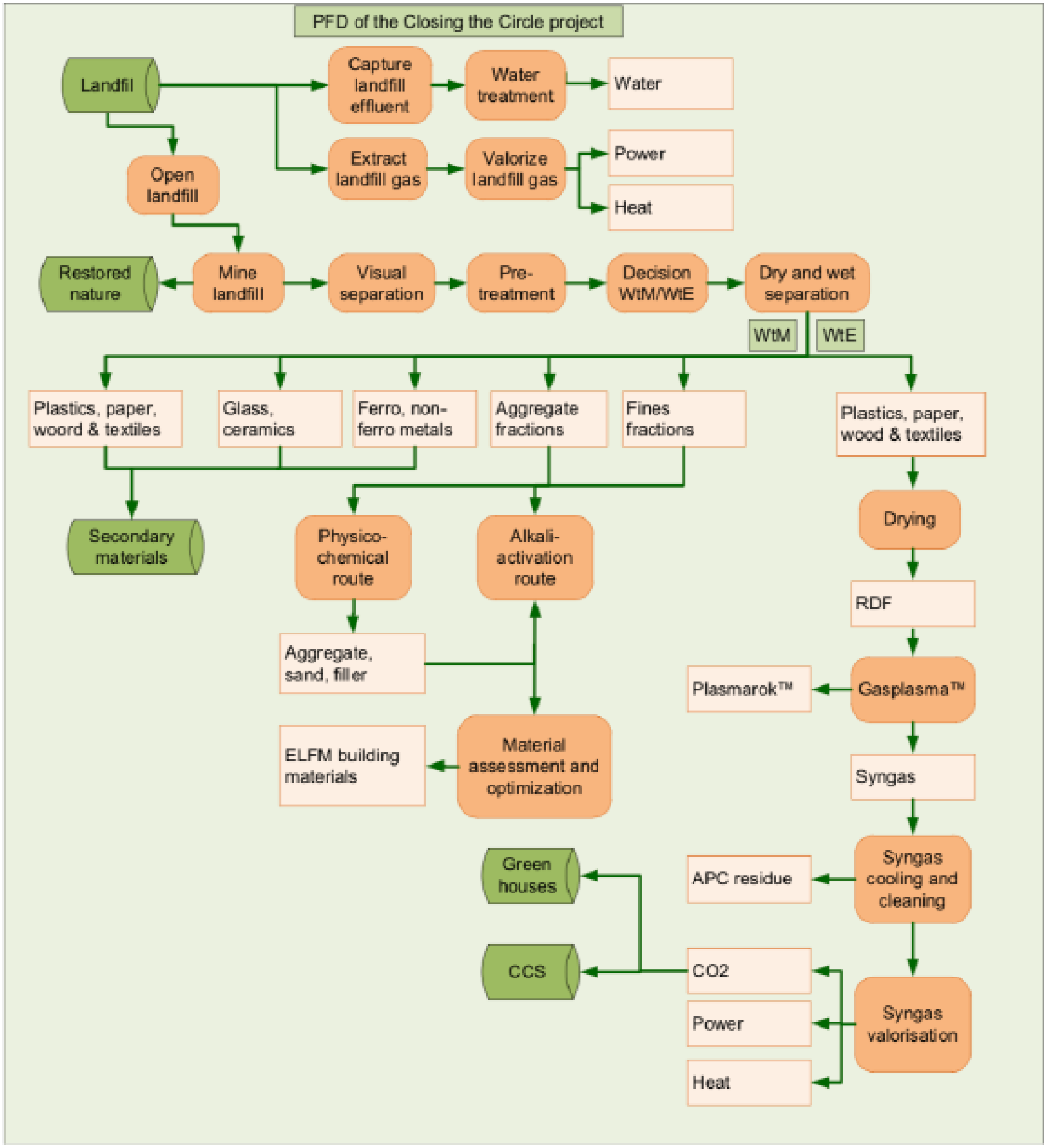
Landfill Mining

Environmental drawbacks of landfilling



- Global warming contributor
- Soil pollution contributor
- Groundwater pollution contributor

Example of Landfill Mining on the Remo Landfill (Belgium)



Landfill Mining advantages

- CO_2 equivalent savings
- New green energy sources
- Region's materials autonomy improvement
- Soil and groundwater pollution sources reduction
- New construction materials
- Jobs creation
- Land reclamation

Source: Jones, et al., 2013

Landfill Mining applications