Integrated management of wastewater and domestic organic waste in small communities

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Wastewater treatment approaches

Centralised WWT

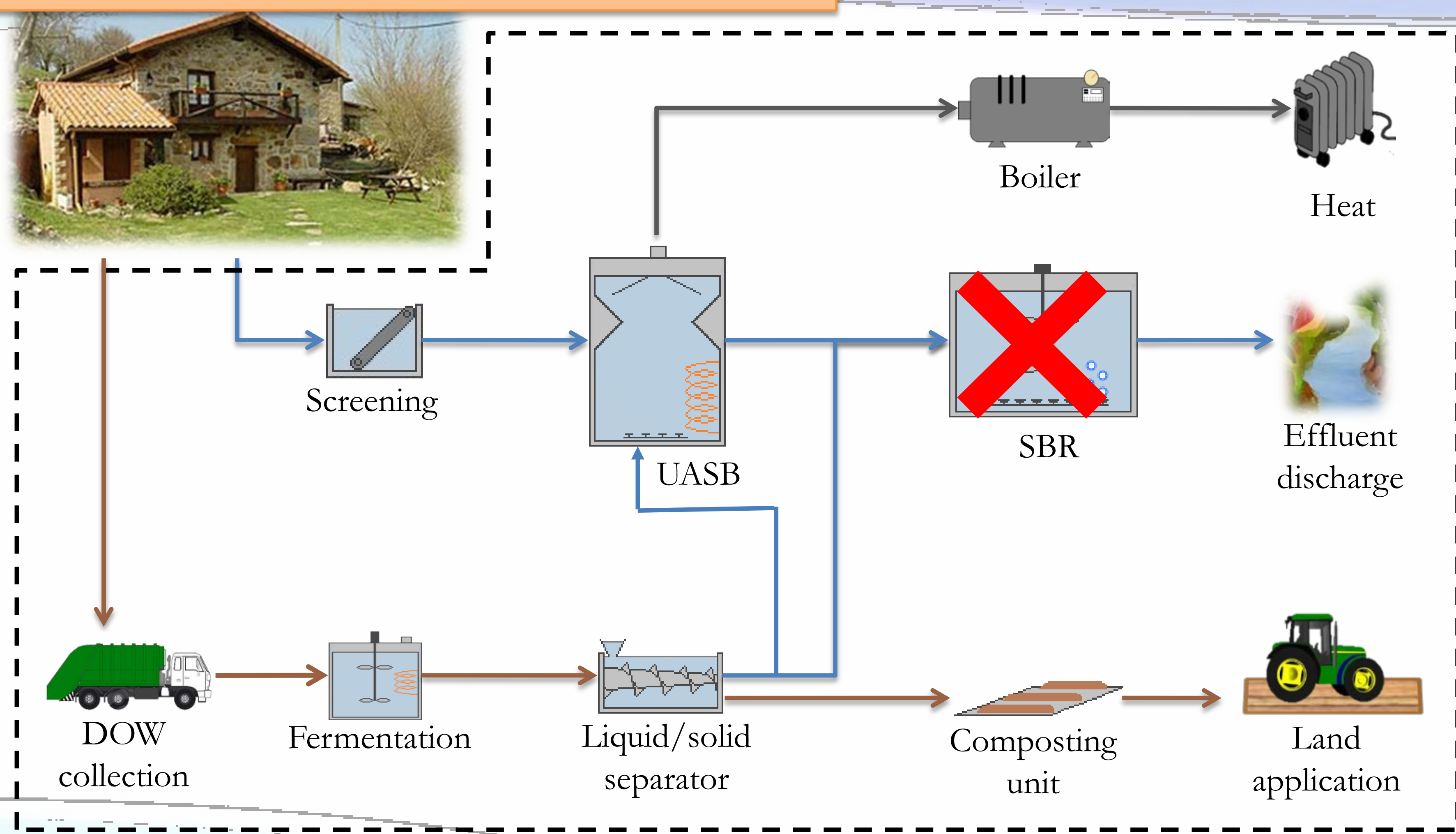
Decentralised WWT

- ✓ Criteria for selection of the most suitable approach:
  - Cost effectiveness
  - Feasibility of management system
  - Specific conditions of the target area

…co-treatment of domestic …ic waste and wastewater

Objective:

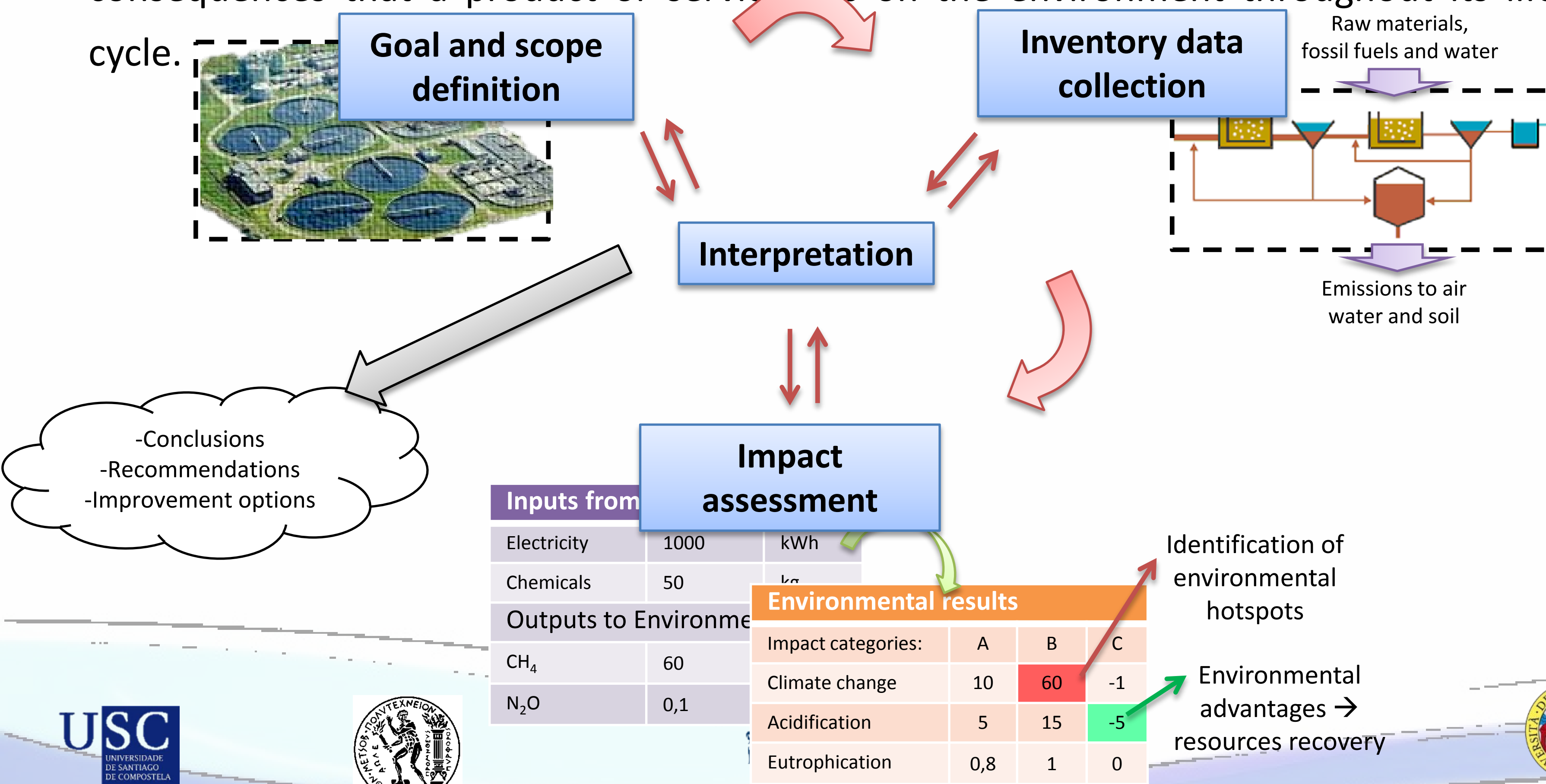
Environmental evaluation of an integrated scheme for the decentralised co-treatment of domestic wastewater and DOW.



Methodology

Data collection based on existing pilot schemes and literature data

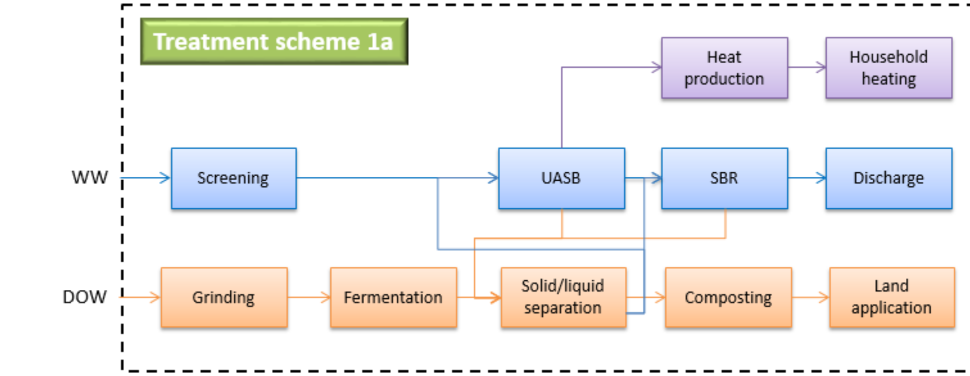
Life Cycle Assessment (LCA) → comprehensive evaluation of the environmental consequences that a product or service has on the environment throughout its life cycle.

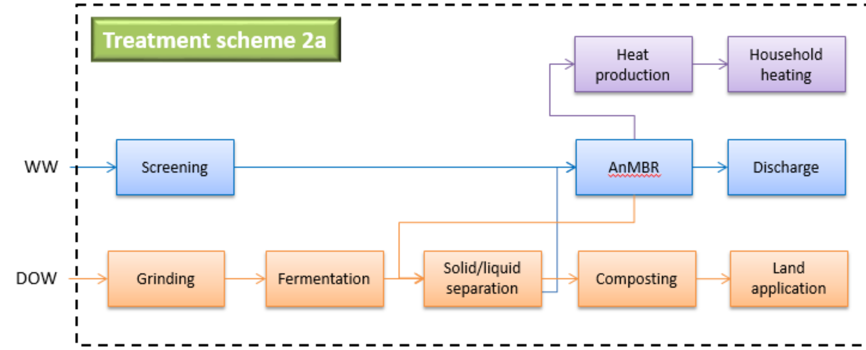


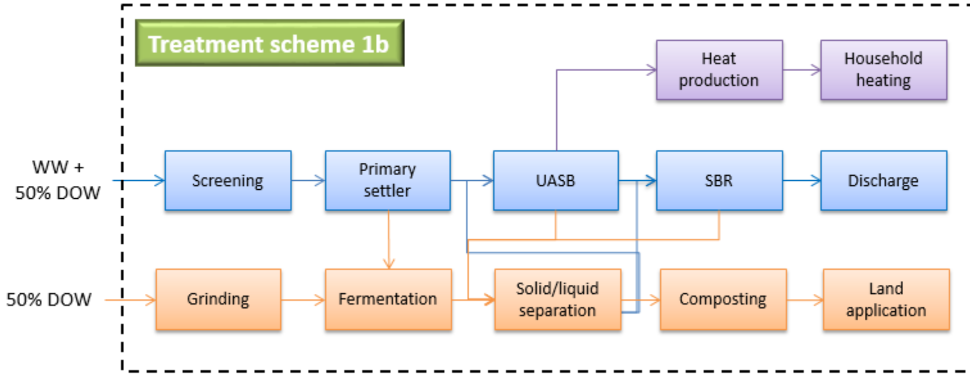
Impact categories:	A	B	C
Climate change	10	60	-1
Acidification	5	15	-5
Eutrophication	0,8	1	0

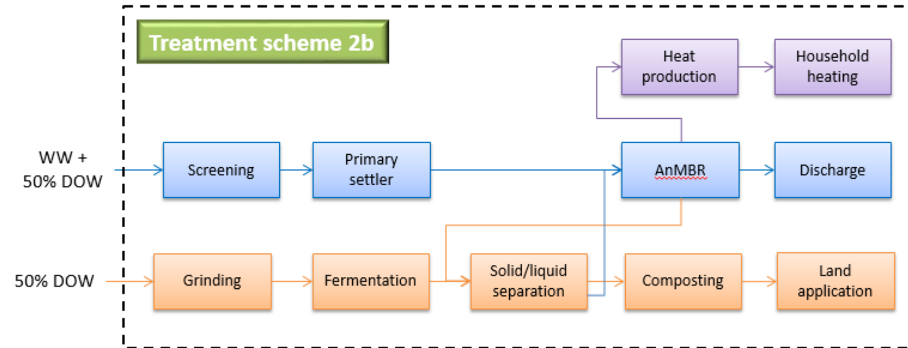
Waste collection systems

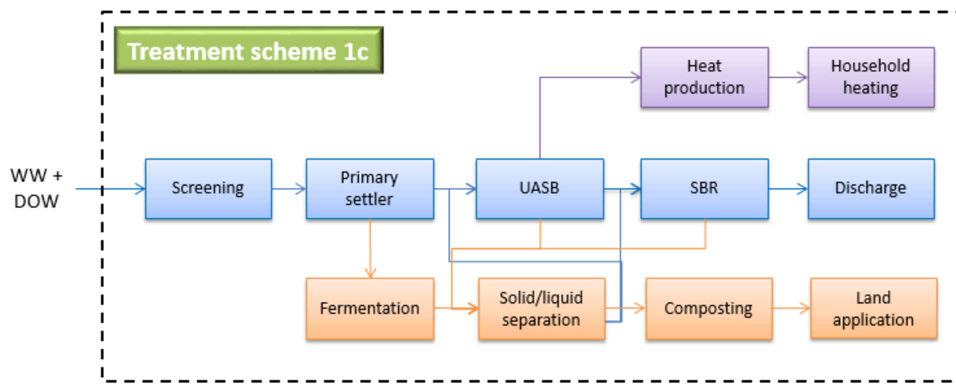
- Source separation of DOW and transportation to local treatment plant
- Food waste disposers (FWDs) for the integration of wastewater and waste at source
- 50% implementation of FWDs and 50% source separation of waste transportation to local waste facility.

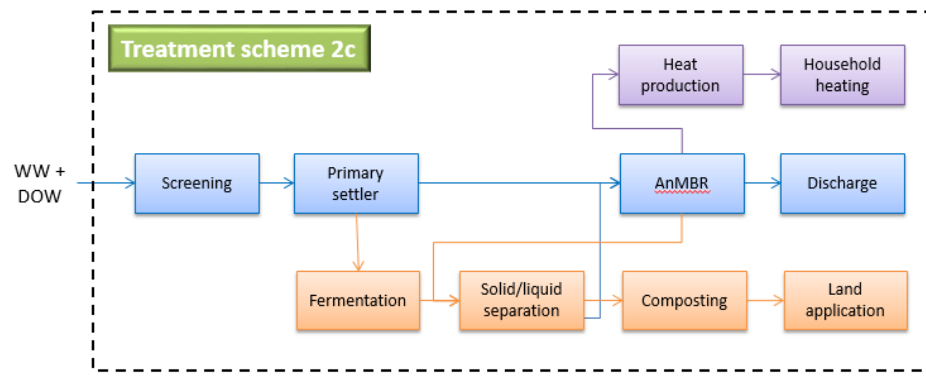

Treatment scheme 1a
WW
DOW
Screening
UASB
SBR
Discharge
Heat production
Household heating
Grinding
Fermentation
Solid/liquid separation
Composting
Land application


Treatment scheme 2a
WW
DOW
Screening
AnMBR
Discharge
Heat production
Household heating
Grinding
Fermentation
Solid/liquid separation
Composting
Land application


Treatment scheme 1b
WW + 50% DOW
50% DOW
Screening
Primary settler
UASB
SBR
Discharge
Heat production
Household heating
Grinding
Fermentation
Solid/liquid separation
Composting
Land application


Treatment scheme 2b
WW + 50% DOW
50% DOW
Screening
Primary settler
AnMBR
Discharge
Heat production
Household heating
Grinding
Fermentation
Solid/liquid separation
Composting
Land application

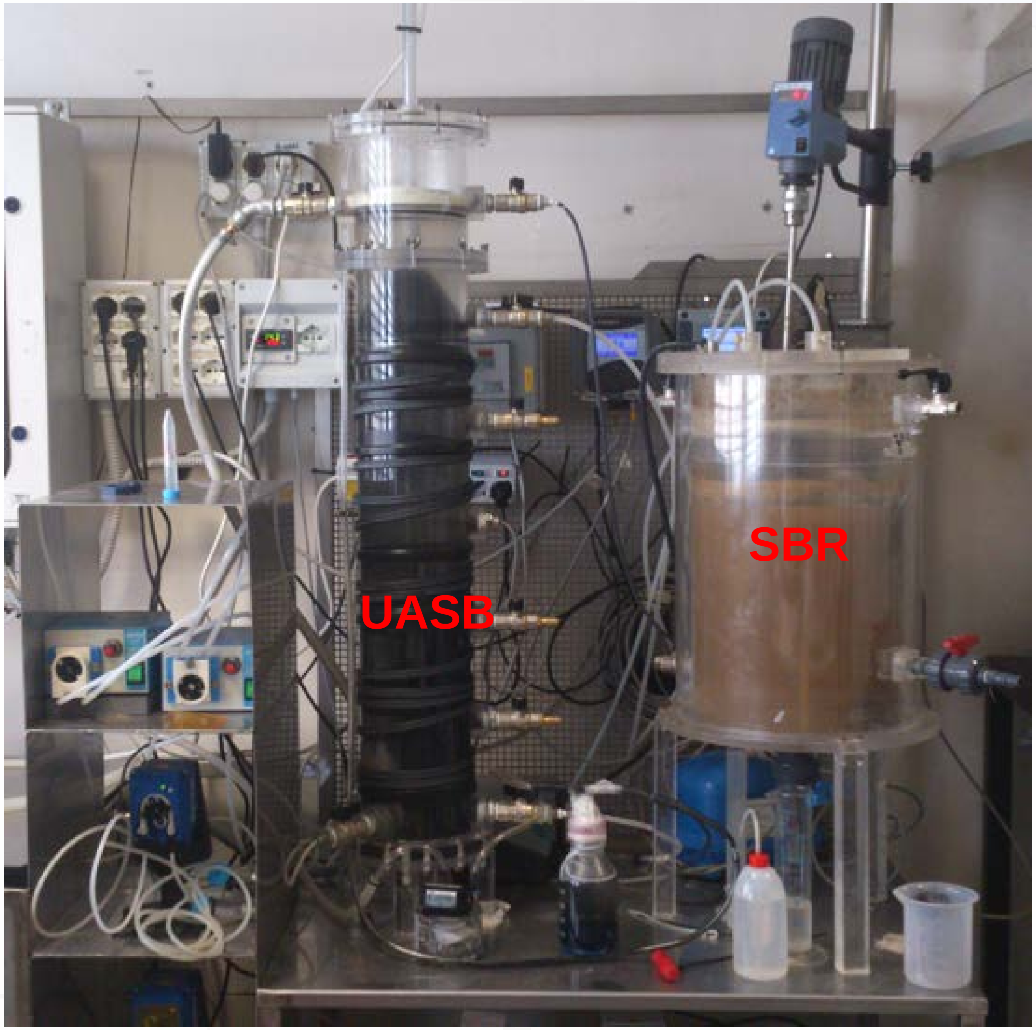

Treatment scheme 1c
WW + DOW
Screening
Primary settler
UASB
SBR
Discharge
Heat production
Household heating
Fermentation
Solid/liquid separation
Composting
Land application


Treatment scheme 2c
WW + DOW
Screening
Primary settler
AnMBR
Discharge
Heat production
Household heating
Fermentation
Solid/liquid separation
Composting
Land application

Main assumptions

Parameters	Unit	Scenario 1a	Scenario 2a
Population served	PE	2,000	2,000
Wastewater flow	$m^3\ d^{-1}$	400	400
COD	$g\ COD\cdot PE^{-1}\cdot d^{-1}$	120	120
N	$g\ N\cdot PE^{-1}\cdot d^{-1}$	12	12
P	$g\ P\cdot PE^{-1}\cdot d^{-1}$	1.8	1.8
DOW treatment	$kg\cdot d^{-1}$	500	500
TS	%	25	25
COD	$mg\ COD\cdot gTS^{-1}$	1200	1200
N	$mg\ N\cdot gTS^{-1}$	25	25
P	$mg\ P\cdot gTS^{-1}$	3	3

UASB-SBR pilot plant



UASB Param.	Value
HRT_{UASB}	9.5-10 h
$V_{recirculation}$	$10 \times Q_{feed}$
Temperature	22±3°C
Q_{feed}	38-41 L/d
SRT	Minimal waste
OLR	1-1.2 $kgCOD/m^3d$

SBR Param.	Value
SRT	18 d
vNLR	0.19 kgN/m^3d

Ferment. Param.	Value
Source	DOW
TS	6 %
OLR	20 VS/m^3d
HRT	3 d

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Why and how to apply the short-cut pathway?

Nitritation | **Denitritation**

$NH_4^+ \rightarrow NO_2^- \rightarrow$ ~~NO_3^-~~ | $NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

AOB ~~NOB~~

Pathway

Autotrophic bacteria | Heterotrophic bacteria

Short-cut nitrification/denitrification (SCDN)

FA > 1 mg NH_3-N L^{-1}

FNA > 0.02 mg HNO_2-N L^{-1}

DO: 0.5-1.5 mg L^{-1}

T: 30-40ºC

pH > 7.5

AOB growth
NOB wash-out

Advantages

- Up to 25% lower oxygen demand
- Up to 40% less external carbon source
- 30 – 40% less sludge production
- The possible enhanced P bioremoval

SC	Technology WW	Technology DOW	Nitrogen removal	EBPR	Where is carbon source applied
0	UASB-SBR	SS, Fermentation & Composting	SBR Nitritation/ denitritation	Yes	SBR for N and P removal
1a	UASB-SBR	SS, Fermentation & Composting	SBR Nitritation/ denitrification	No	SBR for N removal and for UASB
1b	Primary settling, UASB-SBR	50% SS, 50% FWDs, fermentation, composting	SBR Nitritation/ denitritation	No	SBR for N removal and for UASB
1c	Primary settling, UASB-SBR	100% FWDs, Fermentation, Composting	SBR Nitritation/ denitritation	No	SBR for N removal and for UASB
2a	AnMBR	SS, fermentation, composting	No	No	AnMBR
2b	Primary settling, AnMBR	50% SS, 50% FWDs, fermentation, composting	No	No	AnMBR
2c	Primary settling, AnMBR	100% FWDs, Fermentation, Composting	No	No	AnMBR

Bioprocesses

- When conventional nitrification/denitrification is applied the fermentation liquid is enough to remove nitrogen.
- When nitritation/denitritation is applied the fermentation liquid suffices to remove nitrogen and phosphorus or to remove nitrogen and to be fed to the UASB process to increase biogas production.
- The implementation of FWDs marginally increases the COD load of the fermentation liquid and thus the COD load fed to the UASB compared to source separation and local treatment of DOW .

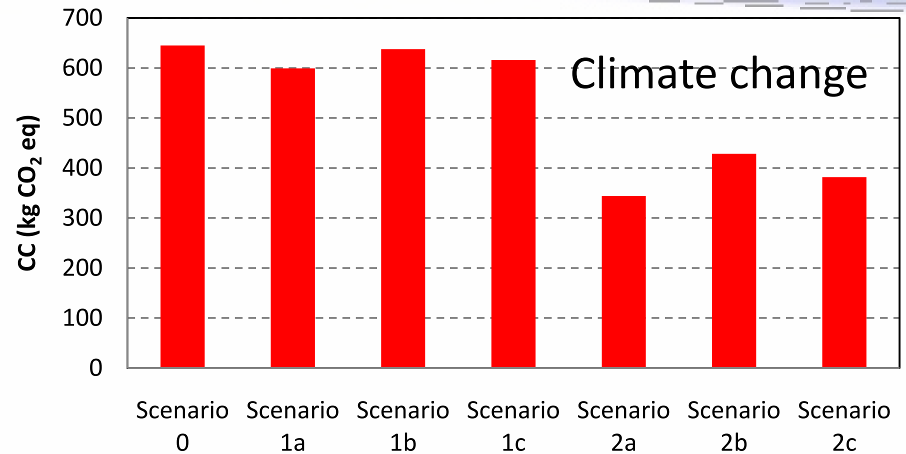
Comparing scenarios

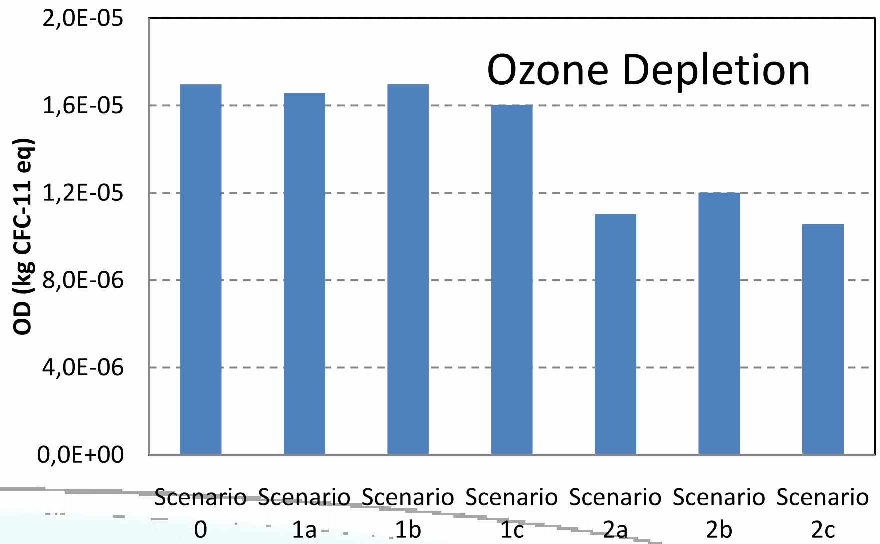
Parameters	SC0	SC1a	SC1b	SC1c	SC2a	SC2b	SC2c
Methane (m^3/d)	59	67	66	71	96	93	100
Heat production (kWh/d)	564	641	628	680	911	887	954
Fermentation liquid fed to UASB (%)	0	30	45	40	100	100	100
SBR aeration energy requirements (kWh/d)	133	132	134	137	-	-	-
Treated effluent N (mg/L)	9.6	9.6	9.6	9.9	63	63	62
Treated effluent P (mg/L)	1.9	7.5	7.8	8.0	8.5	9.0	9.4

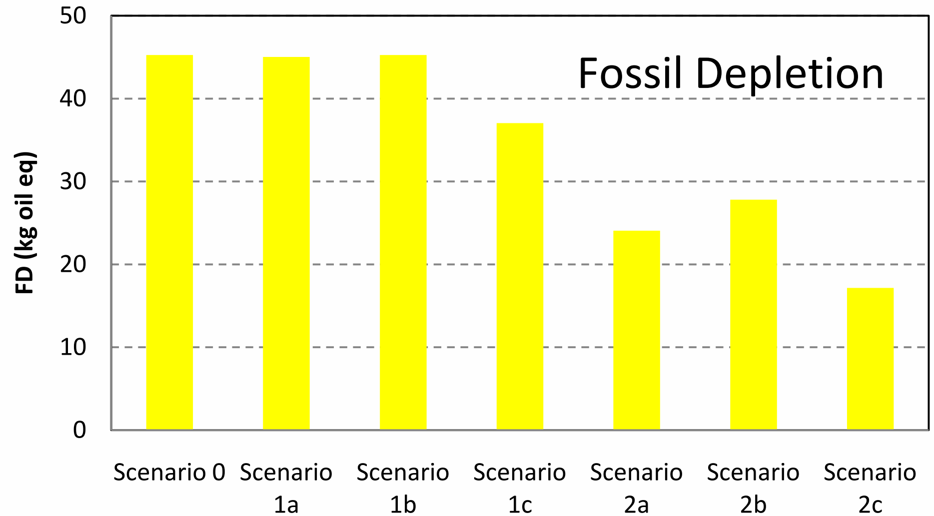
Impact categories considered

- Climate change (CC)
- Ozone depletion (OD)
- Fossil depletion (FD)
- Terrestrial acidification (TA)
- Freshwater eutrophication (FE)
- Marine eutrophication (ME)

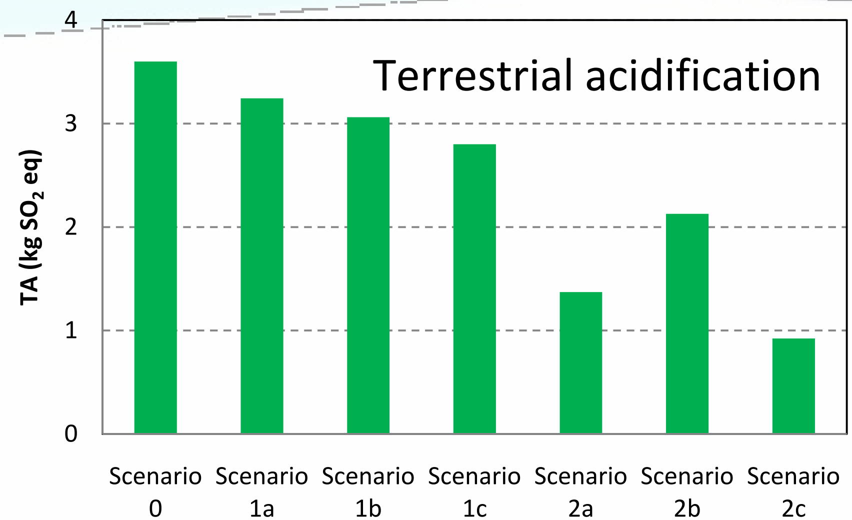
Environmental assessment of alternative schemes

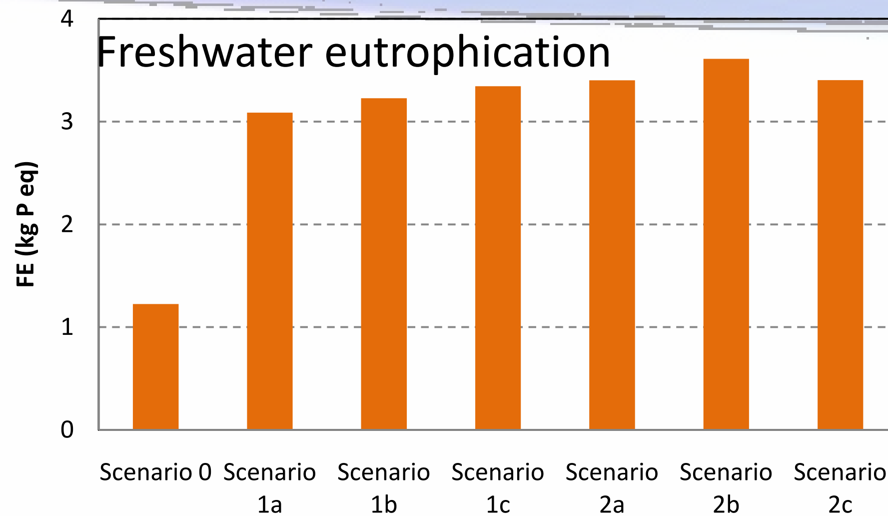


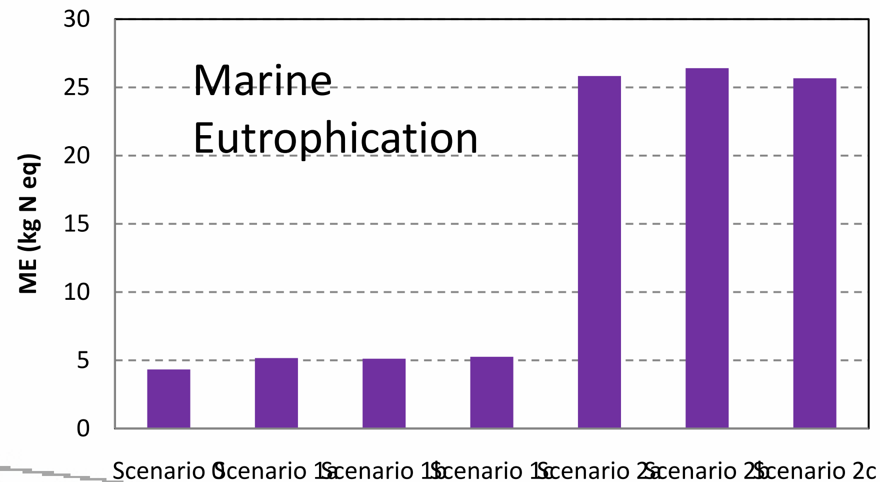




Environmental assessment of alternative schemes







Conclusions

- **Environmental hotspots**
  - Electricity production
  - Direct emissions: composting unit
  - Discharge of the treated effluent
- **With conventional nitrification/denitrification the DOW carbon source is enough only to remove nitrogen while with nitritation/denitritation both N and P can be removed**

- Specific **environmental advantages**
  - Heat from biogas → avoided fossil-based heat

- Among the **different alternatives schemes** exanimated:
  - AnMBR consumes less electricity → better environmental profile for energy-related categories
  - Removal of nitrogen in the SBR → better environmental results in terms of eutrophication-related categories

Aknowledgements

- ✓ This research was supported by the EU project:
  LIVE-WASTE (LIFE12 ENV/CY/000544)
  ManureEcoMine (ENV.213.6.3-2)

- ✓ The authors would like to thank the **COST Action ES1202** for a grant for a **Short Term Scientific Mission** to L. Lijó.

Treatment schemes proposed