Can an electronic nose assess the biomethanation process?

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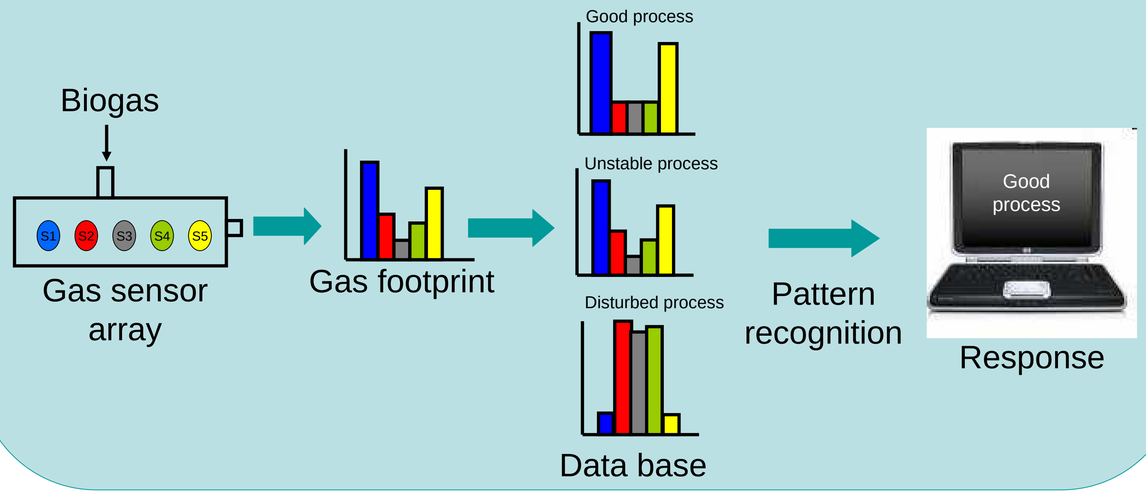
E-nose Concept

Also called gas sensor array, an e-nose employs various complementary gas sensors, in order to improve selectivity.



Objective

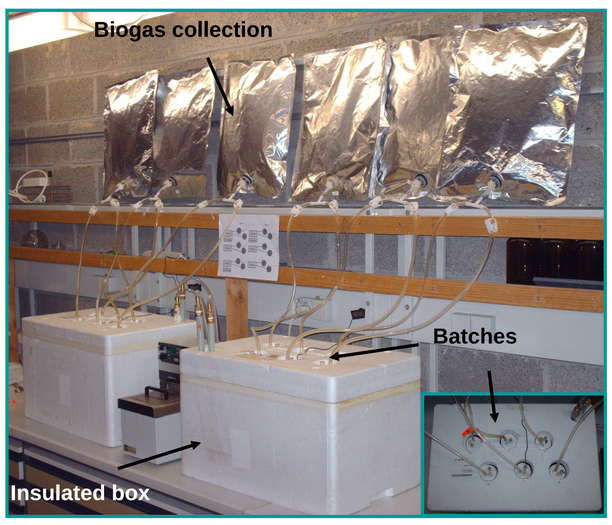
Anaerobic digestion technology is a trendy solution for a more sustainable world. It produces biogas, a mixture of methane and carbon dioxide used in combined heat and power unit to produce renewable energy.

This technology is now adapted in farm plants in Belgium. Because of the diversity of substrates and **sensitivity of the anaerobic digestion process to overload**, most of the reactors are under-loaded to avoid process disturbance, resulting in lower gas yield.

E-nose technology offers the possibility of a new **robust**, **simple**, **sensitive** and **low cost tool** for biogas production monitoring in order to **optimize the process** and **increase gas yield** in small scale agricultural plants.

Material and methods

System of anaerobic batches

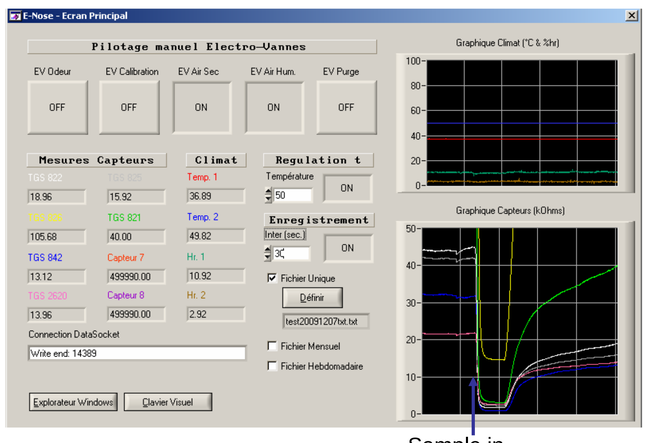


Twelve anaerobic batches of 1.5 L in are put in an insulated thermostatic bath. Batches were inoculated with sludge (5% TS) from the wastewater treatment station of Schifflange (Luxembourg).

Temperature regulated at 38 ± 1°C
Three load strategies :
1. Control : 1 g sucrose batch^{-1}.day^{-1}
2. Slow load increase : 1 to 5 g sucrose batch^{-1}.day^{-1}
3. Punctual overloads : 1 g sucrose batch^{-1}.day^{-1} and one punctual overload a week of 3, 9 and 12 g sucrose batch^{-1}.

Experiment duration : 3 weeks

Measured variables



Daily analyses :

Chemical analysis

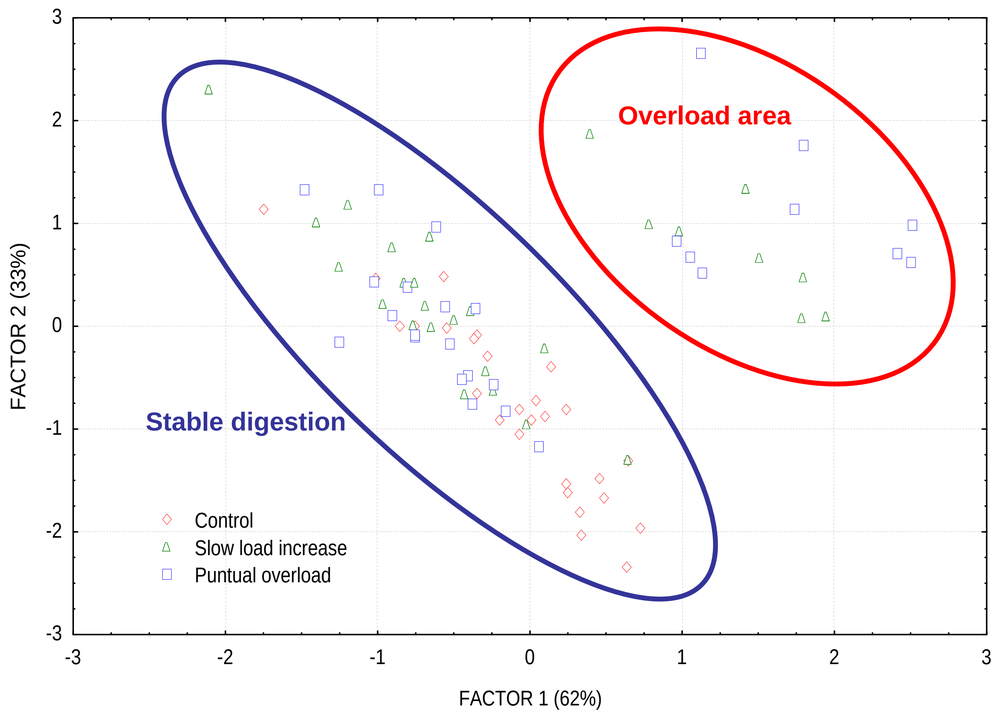
-COV composition and concentration (GC-MS[1])
-[CH_4] and [CO_2] (IR[2] sensors)
-[H_2S], [CO] (EC[3] gas sensors)

Electronic nose analysis

6 TGS sensors (tin oxide sensors)
Sensors chamber regulated at 50°C
Dilution rate of biogas : 25x in air (10% RH at 37°C).
Biogas input of 9 minutes.

Results and discussion

Principal component analysis of the e-nose normalized data (6 variables, 83 observations)



95% of the variance explained

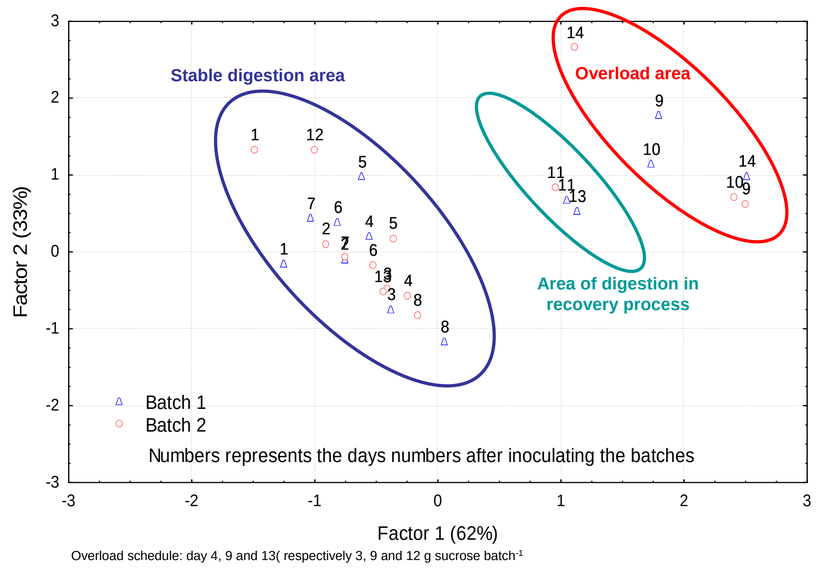
Two groups of data detected:

-overload area

> 4 g sucrose.day^{-1}

-stable digestion

< 4 g sucrose.day^{-1}



Overload schedule: day 4, 9 and 13(respectively 3, 9 and 12 g sucrose batch^{-1}

Intermediate situation observed in the punctual overload data set:

-Days following the overload

→ **Recovery process detected**

Conclusions

E-nose was able to:

1. Detect overload of the system

2. Suggest disturbed digestion and recovery time of the batches to return to a stable digestion

Future trends

Electronic nose demonstrated its potential in biomethanation process monitoring. The tool was able to discriminate overload situations. Nowadays, anaerobic digestion control is only able using high-tech analysis, such as VFA determination by GC-MS or HPLC. Results of these analyses are expensive and available one week after sampling. E-nose allows to avoid this delay by on-line control but it needs to be tested in conditions closer to the real situation.

[1] Gas chromatography – Mass Spectrometry (GC-MS)
[2] Infrared (IR)
[3] Electrochemical (EC)