Cellulose bioavailability in waste refuse

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IN SEARCH OF A NEW STABILITY CRITERION FOR MSW

CELLULOSE
HEMICELLULOSE
Half-life = 15 years
Contribute to 90 % of the total methane production

ACTUAL TESTS ASSESSING MSW BIODEGRADATION POTENTIAL	
Respiration activity [1, 6, 7]	O_2, CO_2
Methanisation test (BMP) [1, 2, 3, 4, 5]	CH_4, CO_2
BDO_5/COD [9]	O_2
(Fermentable) volatil solids [9]	-
Physical analysis of the chemical state [8]	NMR, FTIR

OUR STRATEGY

Development of an enzymatic test that specifically targets the cellulose bioavailability in MSW

Bioavailability = cellulose accessibility for microbial degradation

Test = cellulases-mediated hydrolysis of MSW cellulosic materials

$$(C_6H_{10}O_5)_n + n\,H_2O \xrightarrow{\text{cellulases / hemicellulases}} n\,C_6H_{12}O_6$$

40 h at 40 °C

cellulose / hemicellulose ß measured by HPLC (after acid hydrolysis)

monosaccharids ß measured by HPLC

Determination of cellulose bioavailability = Percentage of cellulose hydrolysed

CONCLUSIONS

A new method has been used to test specifically the biological reactivity of cellulose in MSW samples. This test is based on the enzymatic hydrolysis of cellulosic material by a mixture of cellulase and hemicellulase enzymes. It gives a good correlation when it is compared to a BMP test. It is also fast, simple and it allows a large set of trials.

For the samples tested, the cellulose bioavailability did not depend on the degree of lignification (cellulose-to-lignin ratio) however, it seemed to depend on the cellulose content. With respect to this, waste did not show any reactivity for cellulose content lower than 5 %.
On the other hand, the humic acids that might accumulate in old MSW did not seem to obstruct the cellulose accessibility.

Experiments of waste degradation at different moisture contents pointed out that the hydrolytic step, of which the other steps depend, is strongly influenced by moisture. It also appeared that a lack of nitrogenized co-substrate might limit the methanisation process.

References

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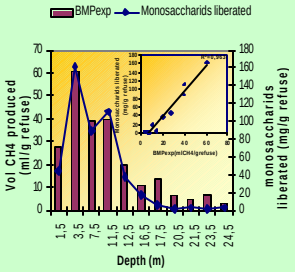
Acknowledgements

The study was granted by the French talking community of Belgium - *Direction de la Recherche Scientifique - Action de Recherche Concertée.*

Comparison between the enzymatic test and a biochemical methane potential assay

☞ Analysis with both assays of refuse samples extracted from different depths of a belgian landfill



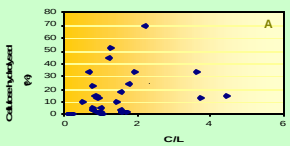
❶ Good correlation betwen the enzymatic test and the BMP assay

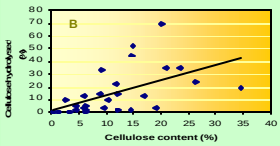
❷ Cellulose bioavailability decreases for samples coming from deeper levels (older MSW).

❸ Samples still have a potential of evolution even after 15 years.

Relationship between cellulose bioavailability and cellulose - lignin- humic acids contents

☞ Relationship between the cellulose bioavailability in waste and the degree of lignification C/L (A) and the cellulose content (B). C/L is the cellulose-to-lignin ratio.



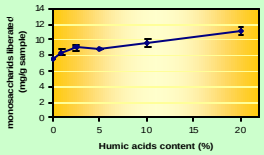


❶ The susceptibility of cellulose to enzymatic hydrolysis is not related to the degree of lignification (C/L) of the waste.

❷ The cellulose bioavailabilty seems to be only related to the cellulose content however the relationship is relatively weak (R^2 significant for $P < 0,05$).

❸ No cellulose degradation is observed under a content of 5 % cellulose.

☞ Evolution of the enzymatic bioavailability of a pure cellulose sample when the humic acids contents surrounding the cellulose increases.

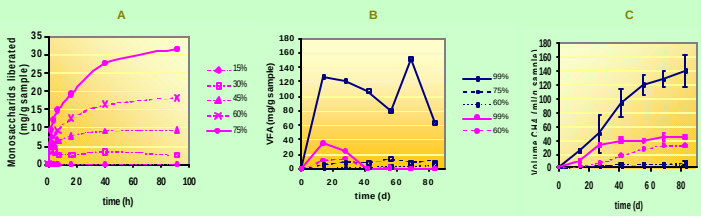


❹ Humic acids do not seem to impede the cellulose accessibility.

Influence of moisture content on biological activity

☞ Influence of moisture content on A. the cellulose enzymatic degradation (enzymatic test)
B. Volatil Fatty Acids (VFA) production (BMP test)
C. methane production (BMP test)

☞ Samples tested at different moistures (% wet weight) are **pure cellulose** of whatman paper n°1 (blue marks) and a **refuse sample** at 20 % of cellulose (pink marks).



❶ The enzymatic tests show that the cellulolytic activity rises markedlywhith the moisture content.

⑦ The BMP tests show that the production of VFA and CH_4 are also influenced by the moisture content. In comparison with the refuse sample, the lower production of VFA and CH_4 under 99 % of moisture for pure cellulose samples can be explained by the lack of nitrogenised co-substrate.