

**EFFECT OF AGING ON THE
BIOAVAILABILITY OF TOLUENE
SORBED TO MUNICIPAL SOLID WASTE
COMPONENTS**

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Introduction

- Landfills are the major waste disposal option in the United States and throughout the world.
- Unlined landfills are a source of groundwater contamination.
- Most studies concerning bioavailability of sorbed organics have been conducted in soils and sediments.
- Little information is available on the bioavailability of organics sorbed to municipal solid waste (MSW).

Major Components of MSW

- Cellulose plus Hemicellulose (40-60%)
- Lignin (~15%)
- Protein (~2.5%) and Lipid (less than 3%)
- Poly (vinyl chloride) (PVC) (~0.6%)
- High density polyethylene (HDPE)
(~2.3%)

Source: Hilger, H. H. and Barlaz, M. A.[2001] Manual of Environmental Microbiology. 2nd Ed. Am. Soc. Microbiol.; Washington D. C. p 696-718

Mechanisms Involved In Aging Process

- Sorption to hard/glassy organic carbon
- Diffusion into hydrophobic micropores
- Humification
- Noncovalent interactions

Objectives

- Develop an experimental technique to determine the bioavailability of volatile organic compounds.
- Investigate the effect of aging and sorbent decomposition on bioavailability.
- Investigate the effect of cellulose, hemicellulose decomposition on toluene bioavailability.

Method Development

Sorbent Selection

- High Density Polyethylene (HDPE)
- Poly (vinyl chloride) (PVC)
- Office Paper (fresh and degraded)
- Newsprint (fresh and degraded)
- Rabbit Food (fresh and degraded)

Anaerobic Bioavailability Test

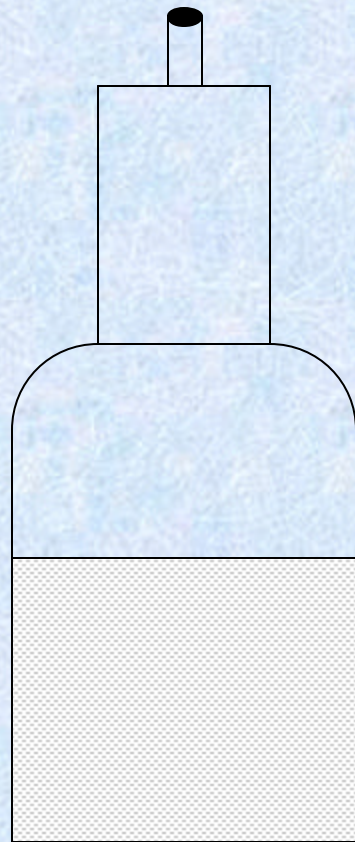
[Pelton MS thesis, 2000]

- O-xylene and newsprint served as contaminant and sorbent.
- Samples were aged in serum bottles.
- Biodegradation rate was slow when sorbent was present.

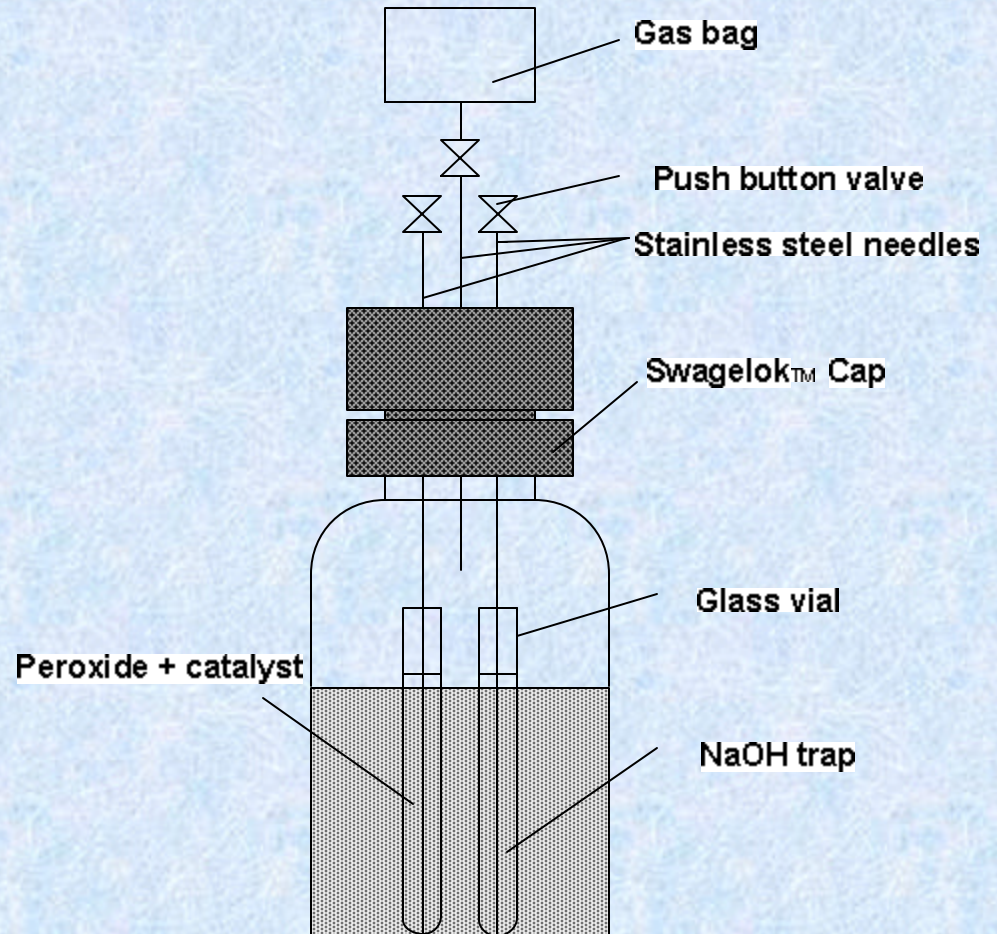
Bioavailability Test Protocol

- Age volatile organics in sealed ampoules without losses.
- Assess bioavailability in an aerobic system.
 - *Pseudomonas Putida* F1
 - Oxygen supply and oxygen demand
 - Monitoring mineralization
- Quantify ^{14}C remaining in solid.

Experimental System



Aging



Biodegradation

Analysis of Residual ^{14}C at Termination of Bioavailability Test

- Benzyl alcohol extraction to measure sorbed ^{14}C .
- NaOH extraction to remove ^{14}C associated with humic substances.
 - Humic acid
 - Fulvic acid
- Combustion to measure non-extractable ^{14}C .

Sorbent Oxygen Demand

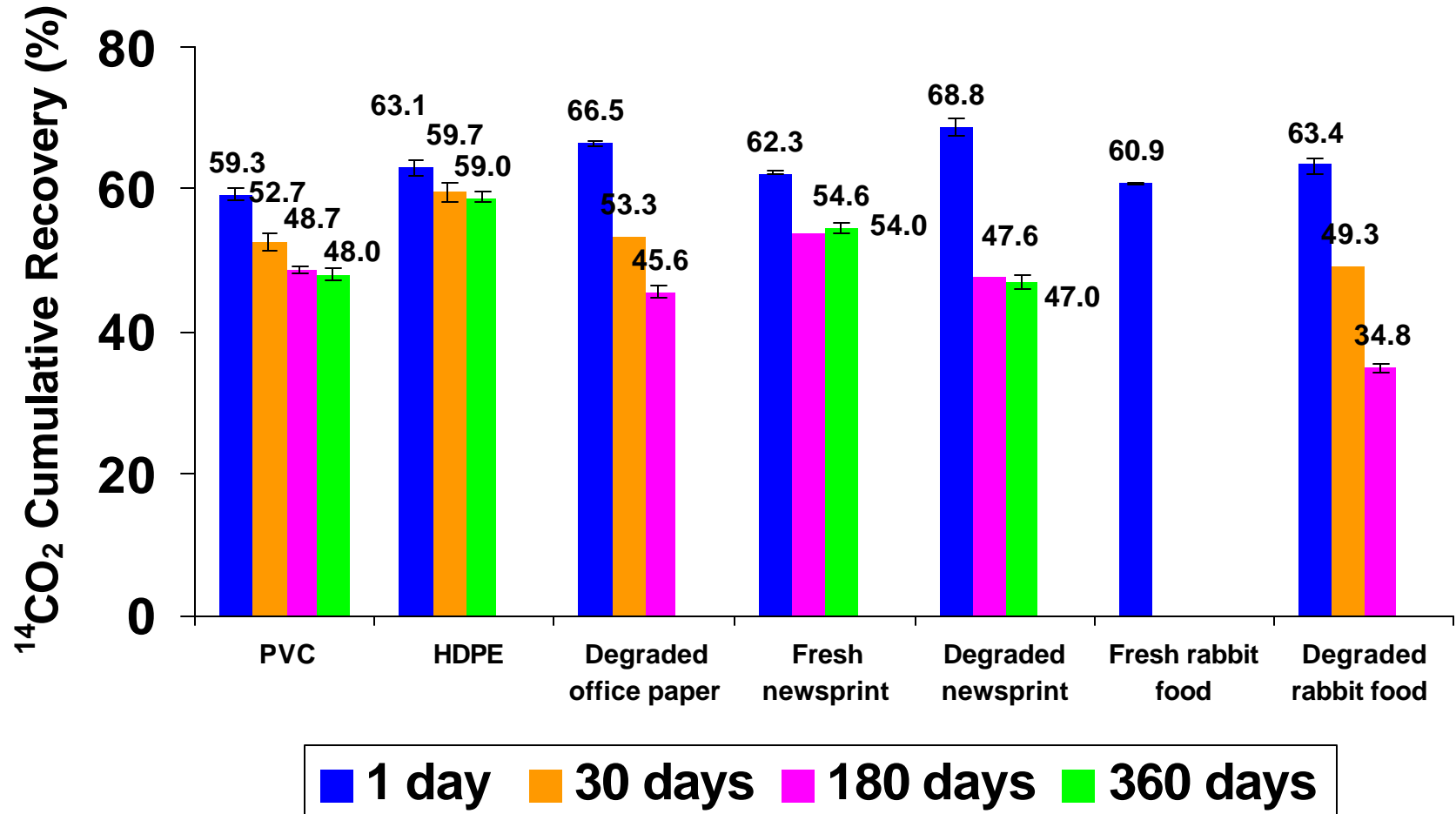
Sorbent	f_{oc}^a	% C degraded ^b
Fresh office paper	0.373	1.18
Degraded office paper	0.278	1.95
Fresh newsprint	0.451	0.81
Degraded newsprint	0.455	0.78
Fresh rabbit food	0.423	34.53
Degraded rabbit food	0.329	6.89

^a From Wu et al. [2001]

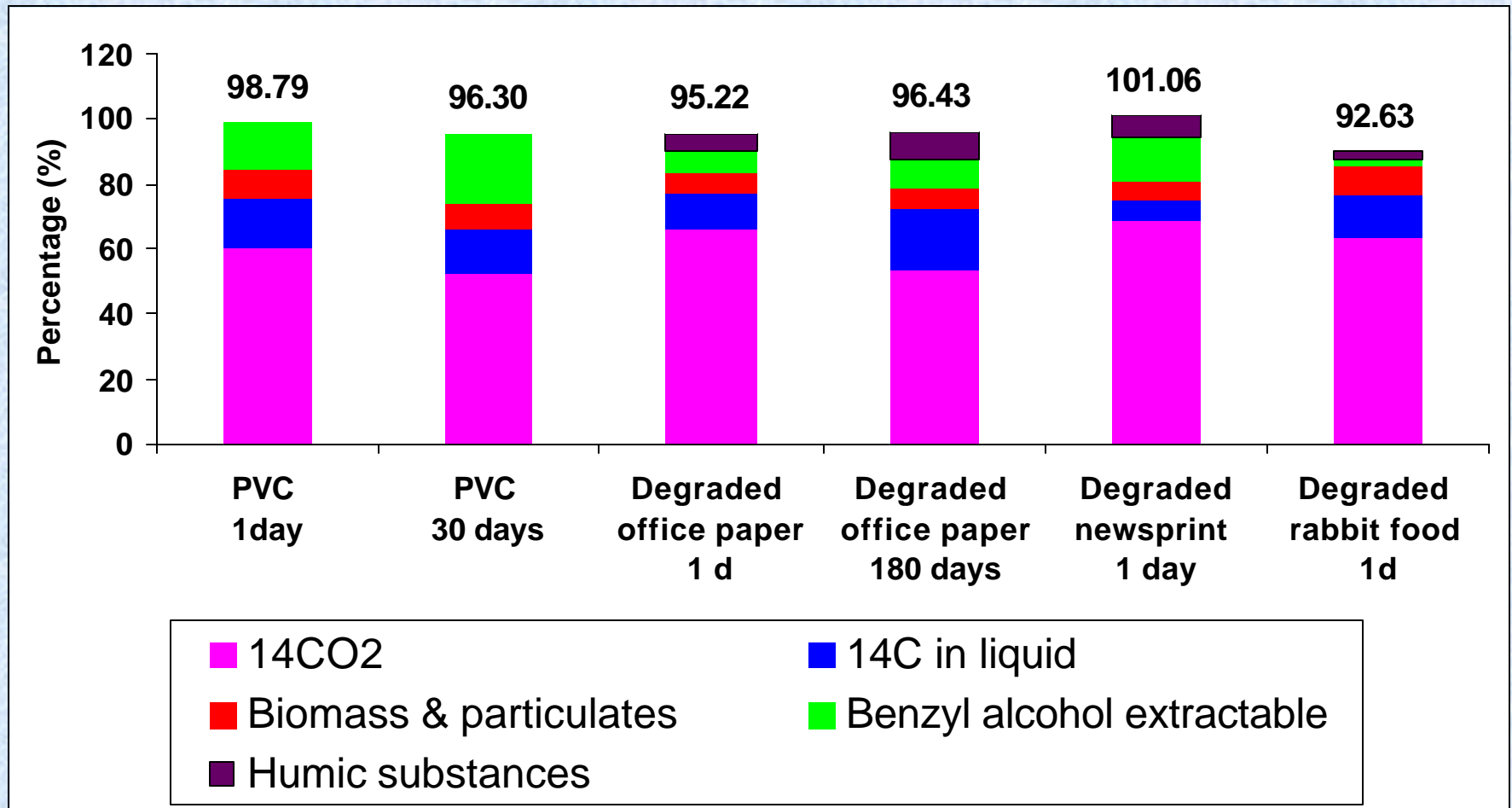
^b Ratio of cumulative inorganic carbon produced to carbon content of each material

Results and Discussion

Effect of aging on $^{14}\text{CO}_2$ production



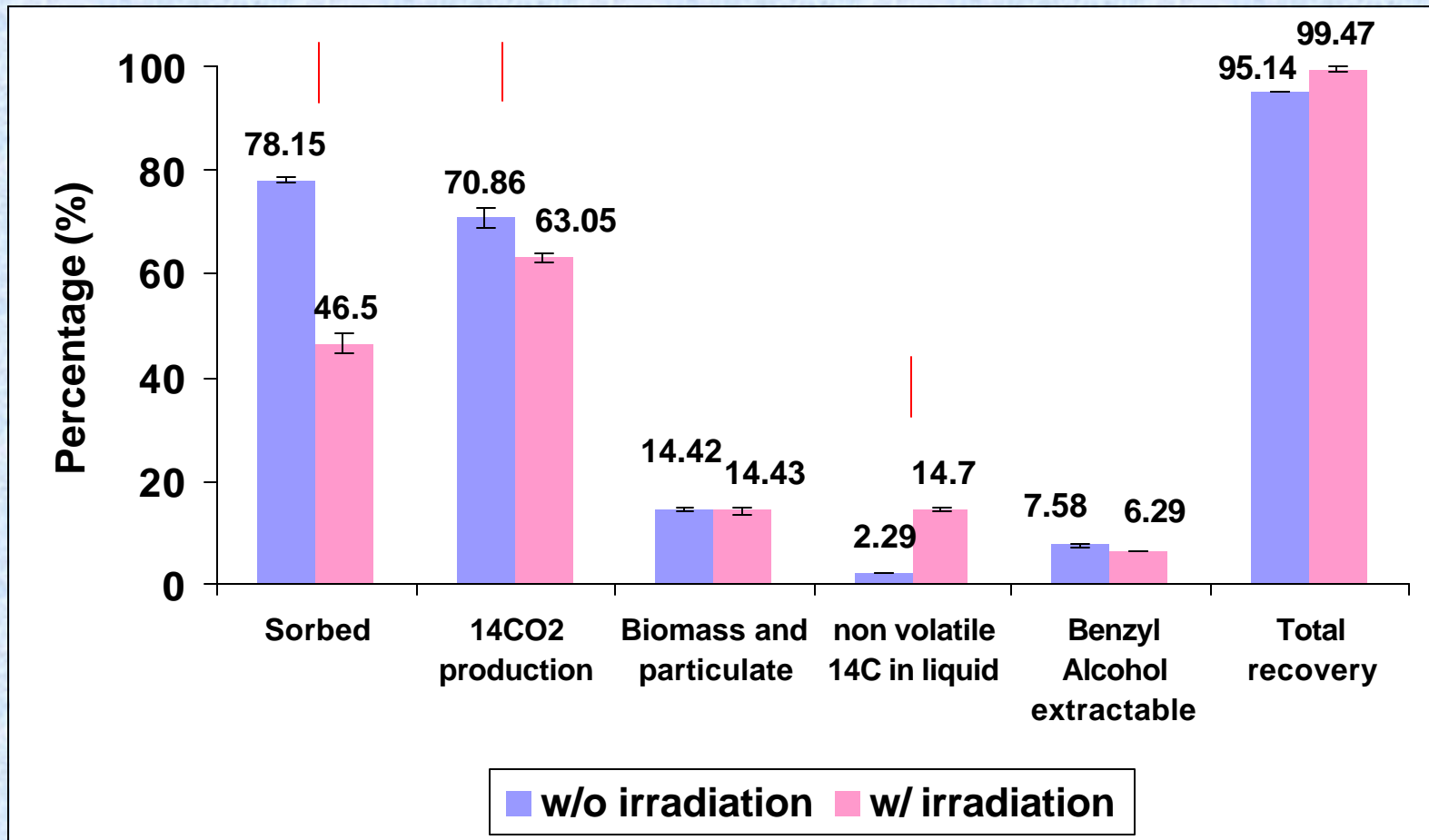
Distribution of radioactivity at termination of bioavailability test



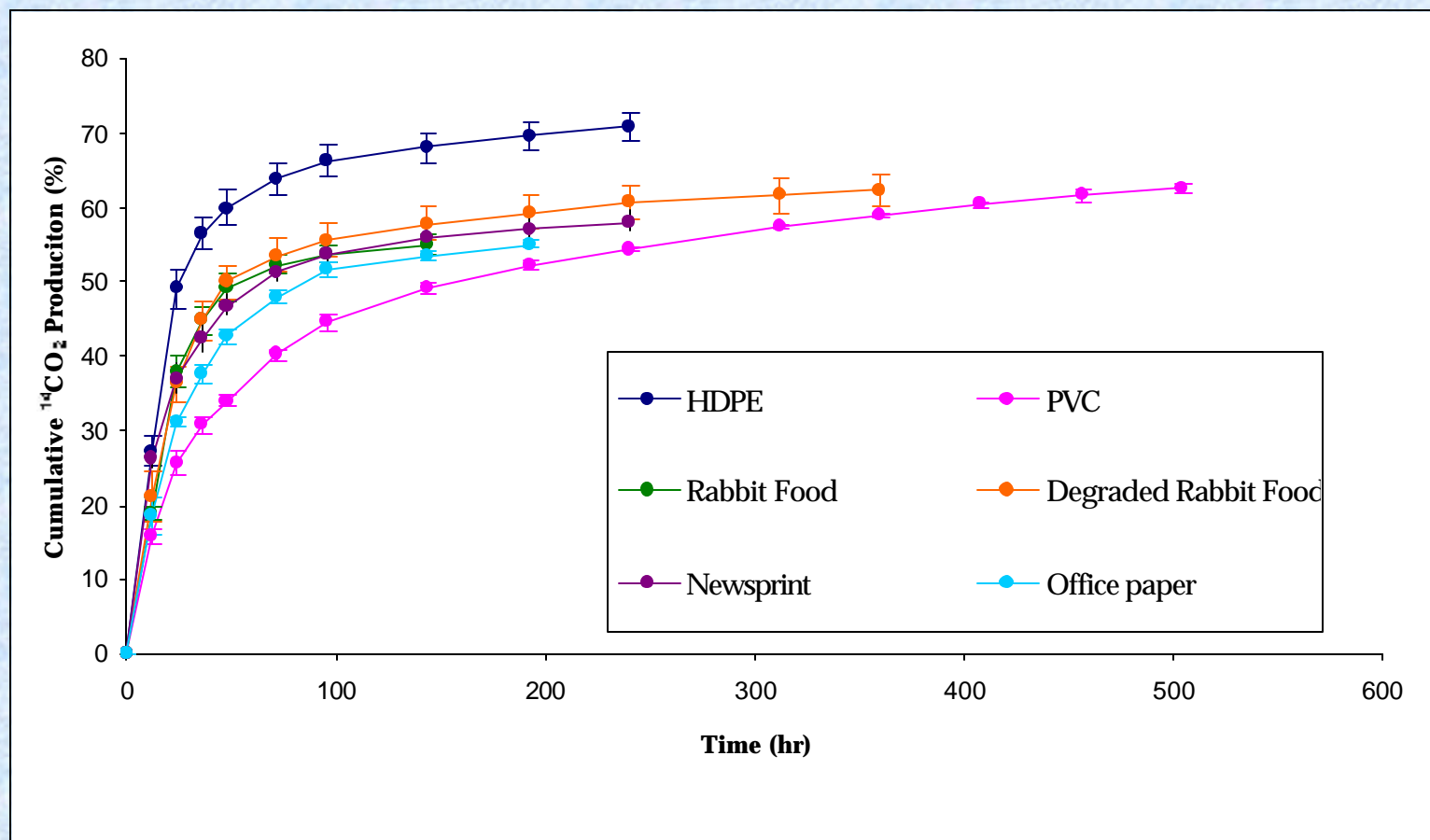
Effect of ? Irradiation-Radiolysis

- Toluene was converted from a spargeable compound to a mixture of non-spargeable compounds after gamma irradiation.
- ^{14}C -toluene was not the only initial compound leading to the results presented.
- Currently, the bioavailability test protocol has been revised to eliminate the gamma-irradiation of toluene.

Comparison of toluene bioavailability with and without gamma irradiation



Bioavailability of toluene after 1 day aging



Conclusions

Conclusions

- Gamma irradiation can cause radiolysis of toluene.
- The extent of biodegradation varied among sorbents and is related to the respective chemical characteristics of sorbents.
- Diffusion through a relatively soft, rubbery matrix is usually fast.
- Diffusion through rigid structure and micropores is very slow.
- Heterogeneous biopolymers have both fast and slow desorption sites.

Future Work

- Reevaluate the effect of aging on toluene bioavailability.
- Determine the effect of enzymes (cellulases plus hemicellulase) addition when $^{14}\text{CO}_2$ production stops.

Q & A

