Anaerobic Biodegradation of Biofuels (Ethanol and Biodiesel) and Proposed Biofuels (n-Propanol, n-Butanol, iso-Butanol)

Cherri Adair and John T. Wilson
U.S. EPA/ORD/NRMRL
R.S. Kerr Center, Ada, OK

Seventh International Conference:
Remediation of Chlorinated and Recalcitrant Compounds

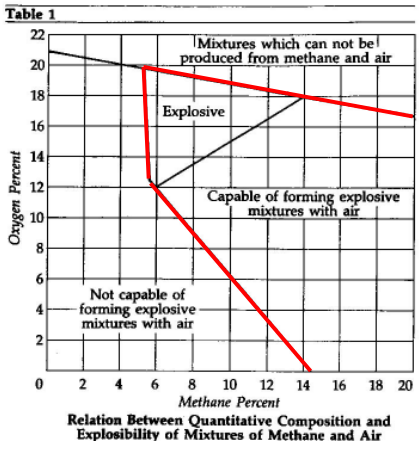
May 24-27, 2010, Monterey, California

Why do we care?

Toxicity of the compounds

Production of methane leading to-

- potential for formation of explosive mixtures
- potential to expedite vapor intrusion of BTEX compounds



30 CFR § 57.22003

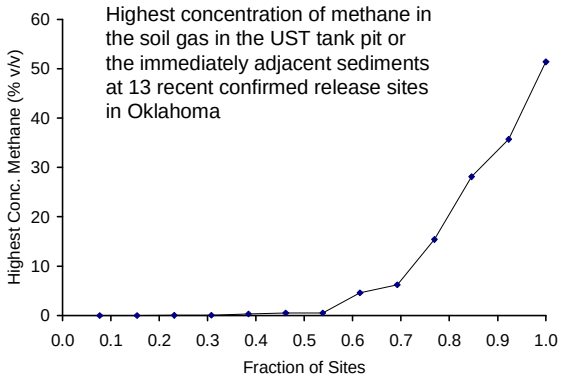
Mine Category or subcategory.

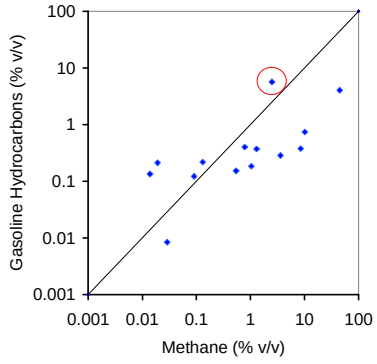
Table 1

See MSHA Illus. 27

Relation Between Quantitative Composition and

Explosibility of Mixtures of Methane and Air



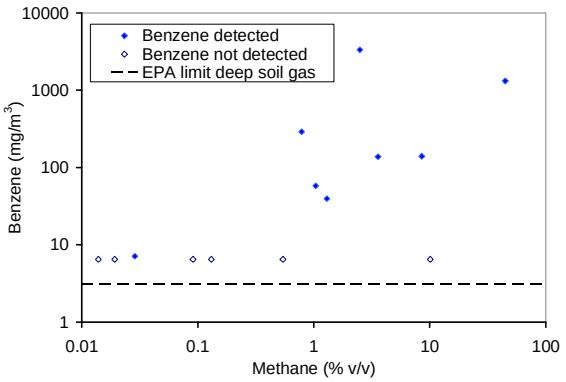


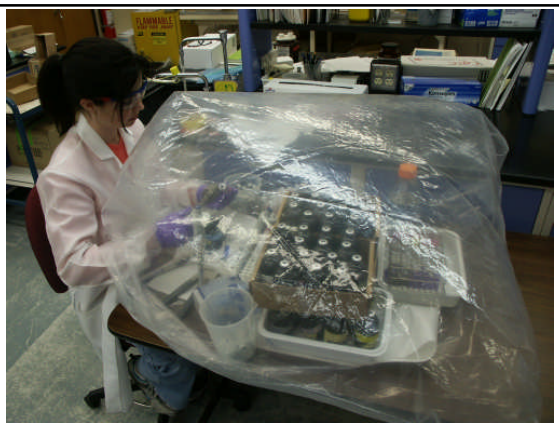
At higher concentrations of hydrocarbon vapors,

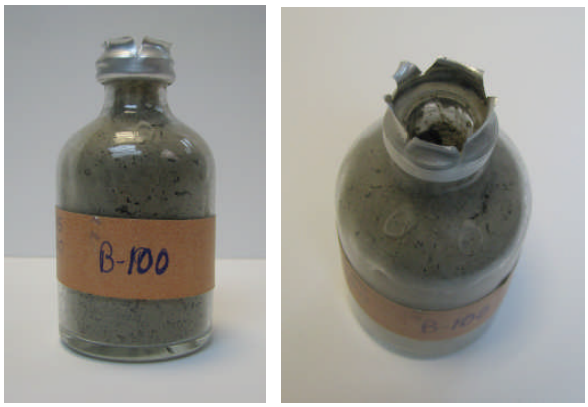
most of the hydrocarbon vapors were methane.

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

Biodegradation of 10% methane by volume can consume all of the oxygen in soil gas, preventing aerobic biodegradation of benzene vapors.



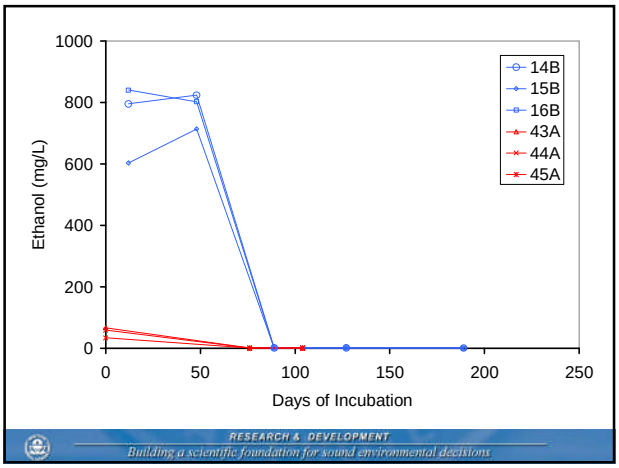


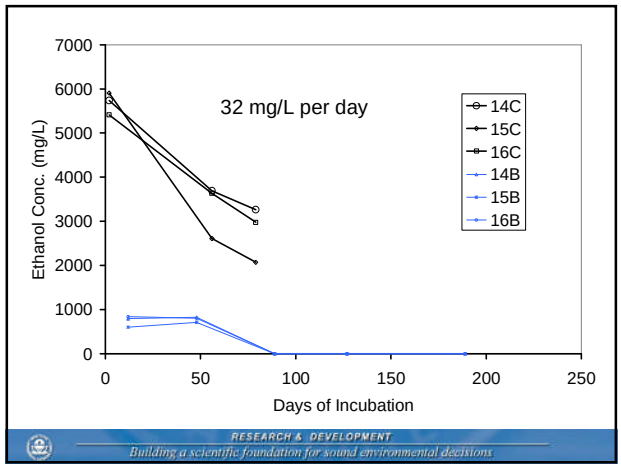


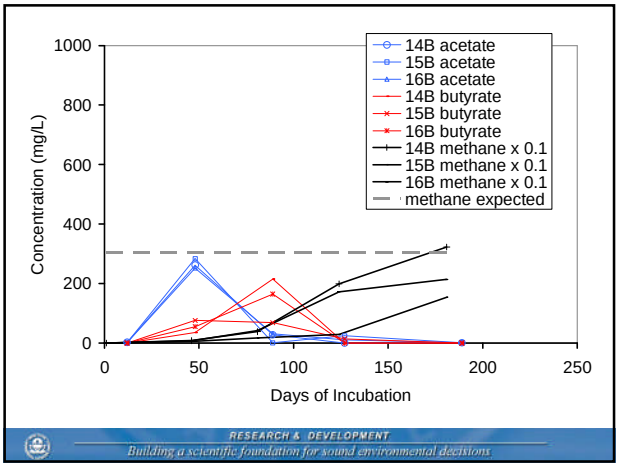
Background Production of Methane in Sediment

	Methane Production (mg/L)		
Treatment	Day 0-6	Day 7-74	Day 75-105
No Alcohol added	0.51	3.23	1.03
No Alcohol added + $SO4^{-2}$	0.51	1.23	0.21
Autoclaved Control	0.08	0.11	0.02

	Ethanol (mg/L)		Methane (mg/L)	
			Total Expected	Total Measured
Treatment	Day 0	Day 110	Day 105	
Ethanol	63.3	<0.94	21.7	39.2
Ethanol + $SO4^{-2}$	63.3	<0.94	21.7	22.6
Autoclaved	73.3	64.5	3.05	0.2

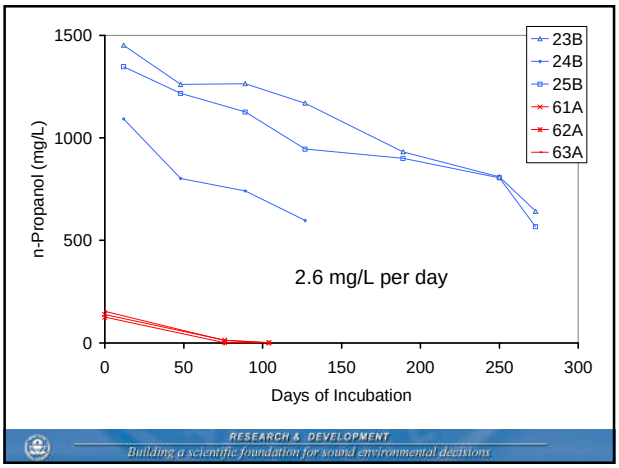


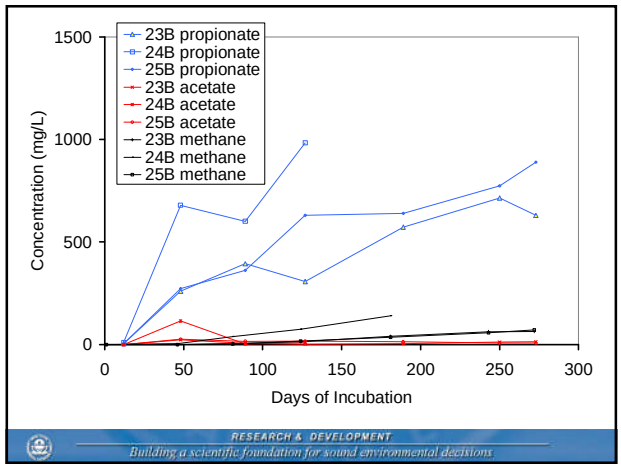




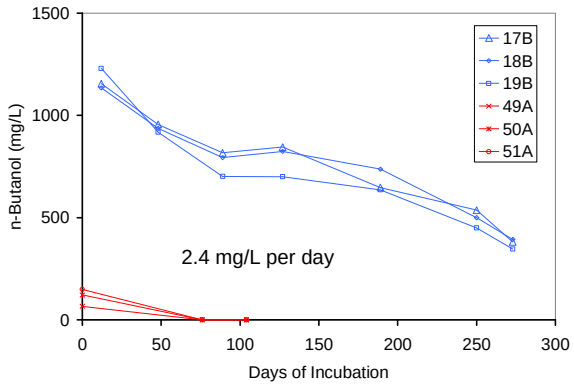
	n-Propanol (mg/L)		Methane (mg/L)	
			Total Expected	Total Measured
Treatment	Day 0	Day 110	Day 105	
n-Propanol	143	<1.17	84.9	25.5
n-Propanol + SO_4^{-2}	143	<1.17	84.9	0.7
Autoclaved	132	169		0.2

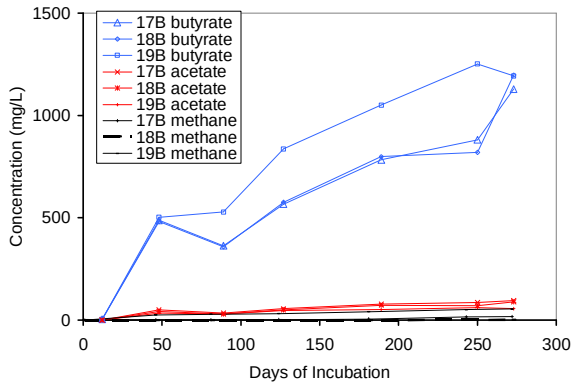
RESEARCH & DEVELOPMENT
Building a scientific foundation for sound environmental decisions



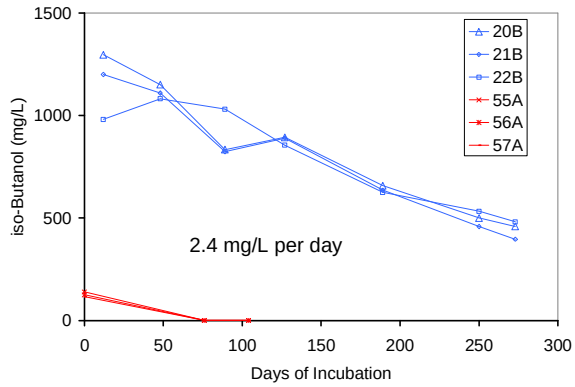


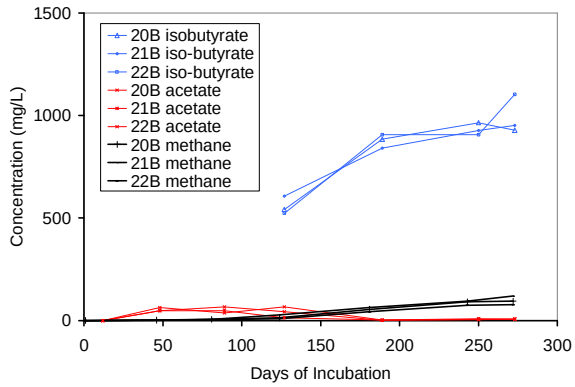
	Butanol (mg/L)		Methane (mg/L)	
			Total Expected	Total Measured
Treatment	Day 0	Day 110	Day 105	
Butanol	144	<0.37	93.1	49.5
Butanol + SO_4^{-2}	144	<0.37	93.1	0.3
Autoclaved	132	123	5.29	0.2





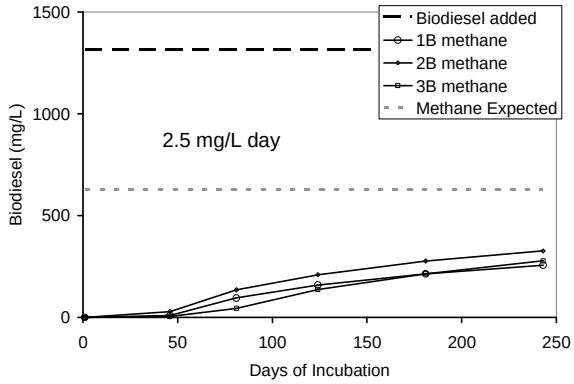
	iso-Butanol (mg/L)		Methane (mg/L)	
			Total Expected	Total Measured
Treatment	Day 0	Day 110	Day 105	
iso-Butanol	130	<0.40	84.3	55.5
iso-Butanol + SO_4^{-2}	130	<0.40	84.3	2.0
Autoclaved	125	124	0.73	0.2

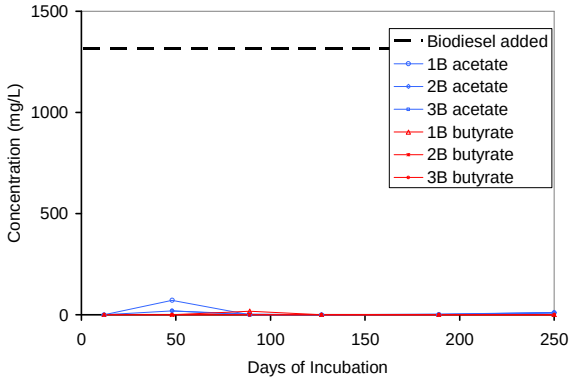




	Methane (mg/L)		
Treatment	Day 0-6	Day 7-74	Day 75-105
Biodiesel	0.44	24.12	30.81
Biodiesel + SO_4^{-2}	0.04	17.83	16.32
Autoclaved	0.05	0.15	0.07

Biodiesel makes methane as readily as the simple alcohols.





At low concentrations (near 100 mg/L) all the alcohols fermented to methane within two months. Sulfate had no effect on methane production from ethanol, but prevented methane production from *n*-propanol, *n*-butanol and *iso*-butanol.

At higher concentrations (near 1000 mg/L) ethanol rapidly fermented to methane at a rate near 30 mg/L per day. The rate of fermentation of *n*-propanol, *n*-butanol and *iso*-butanol was slower, near 3 mg/L per day, and the fermentation stopped at the corresponding fatty acid.

At concentrations near 1000 mg/L, the rate of fermentation of biodiesel to methane was near 3 mg/L biodiesel per day.

Biofuel	pH
Ethanol	5.6 to 6.3
n-Propanol	6.2
n-Butanol	5.9 to 6.0
iso-Butanol	6.0 to 6.1