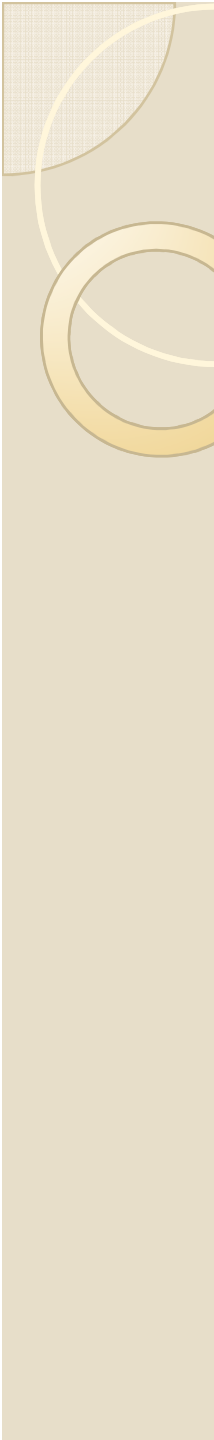




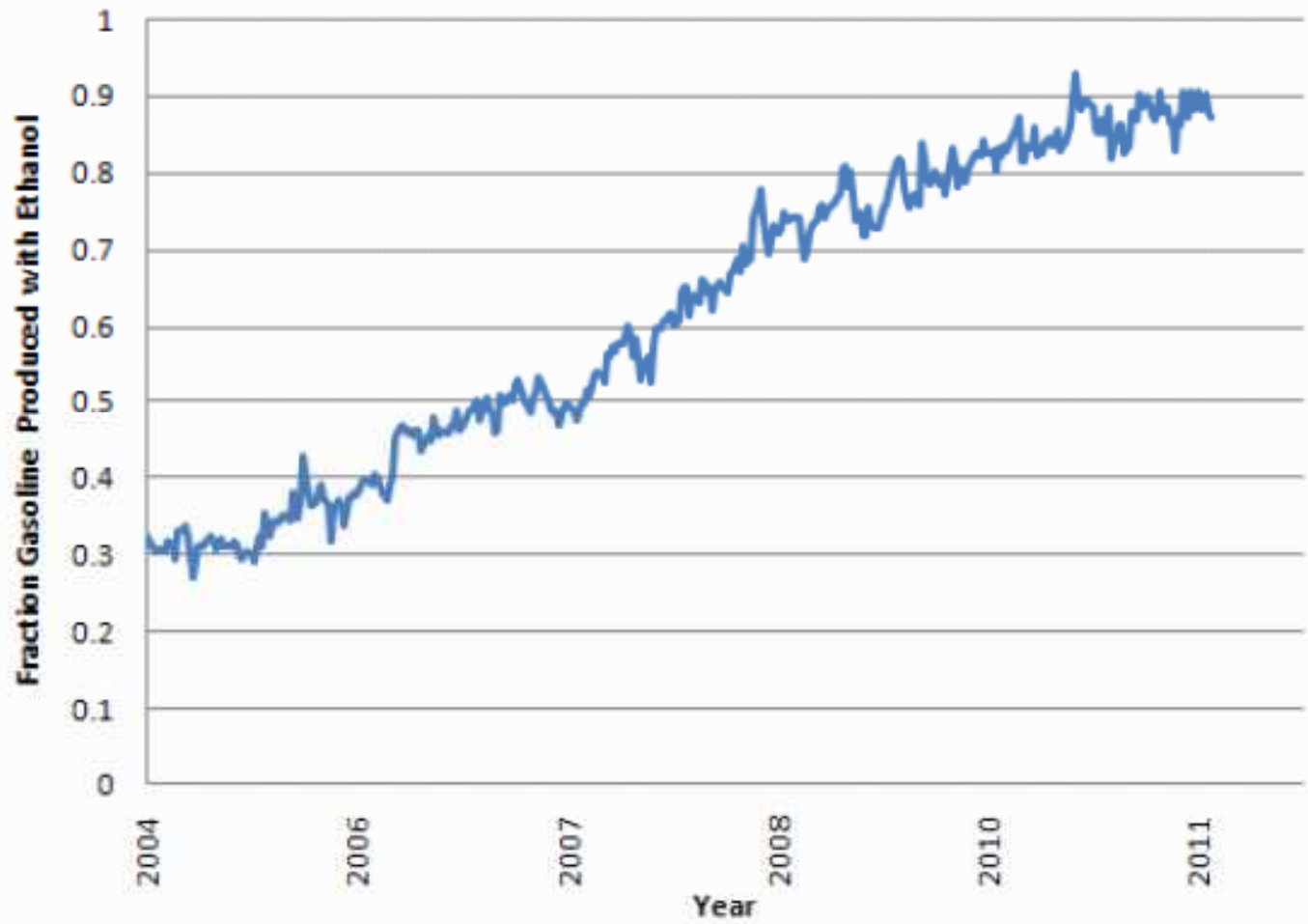
Impacts of Ethanol Blend Releases on Groundwater Aesthetic Quality and Microbial Community

Jie Ma, Yi Zhang, Brent P. Stafford,
William G. Rixey, Pedro Alvarez





Fraction of U.S. Gasoline Produced with Ethanol



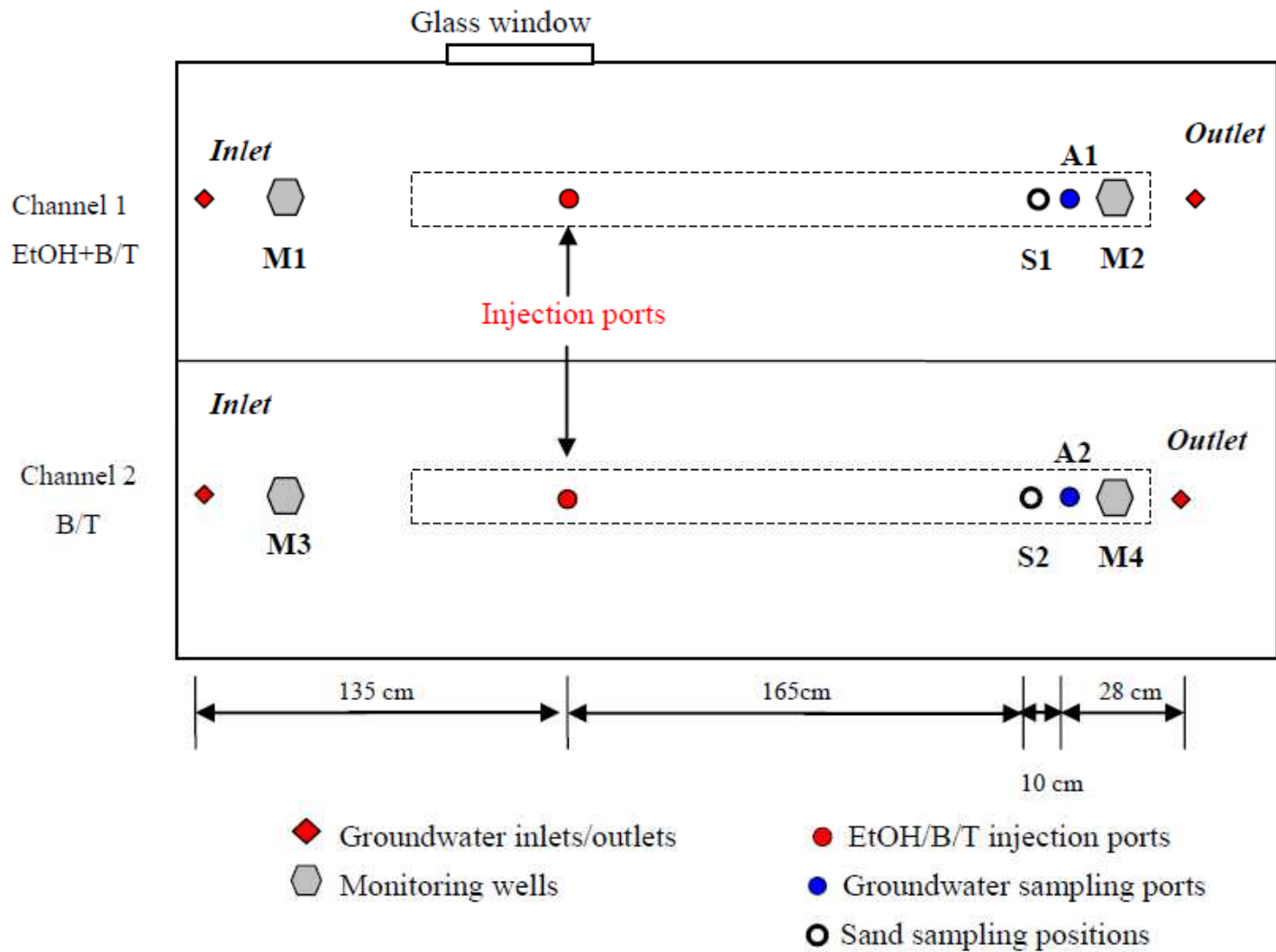
Rice Tank

Channel 1:
10% ethanol
50 ppm benzene
50 ppm toluene

Channel 2:
50 ppm benzene
50 ppm toluene



Plan View of Rice Tank





Monitored Parameters

(10 Months, 2009/8-2010/6)

- Chemicals :
 - CH₄
 - Volatile Fatty Acids
- Geochemical Fingerprints :
 - Temperature, pH, DO, ORP, Conductivity
- Genes (by qPCR):
 - 16s rRNA Gene
 - *mcrA*, *fhs*, *PHE*
- Pyrosequencing
 - Phylogenetic Composition

Seasonal Variation of CH₄ Generation

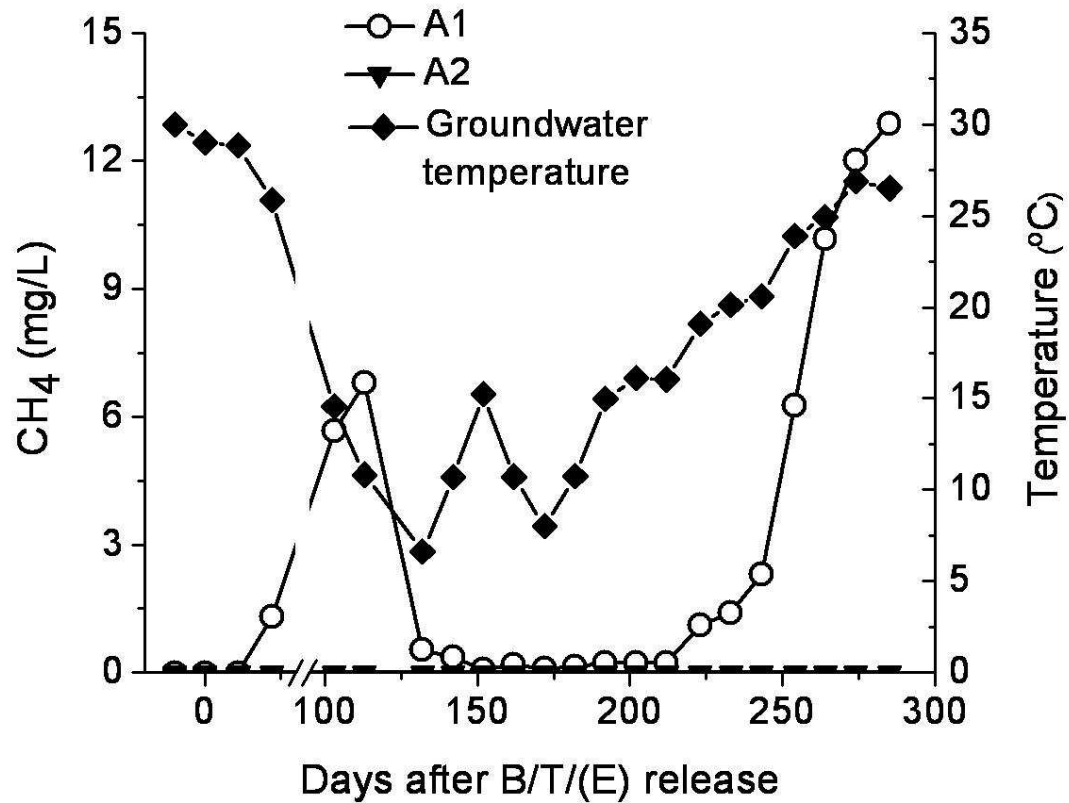


Figure 2. Methane concentrations at A1 (in Channel 1, exposed to ethanol and B/T) and A2 (in Channel 2, exposed to B/T alone).

Seasonal Variation of Acetate Generation

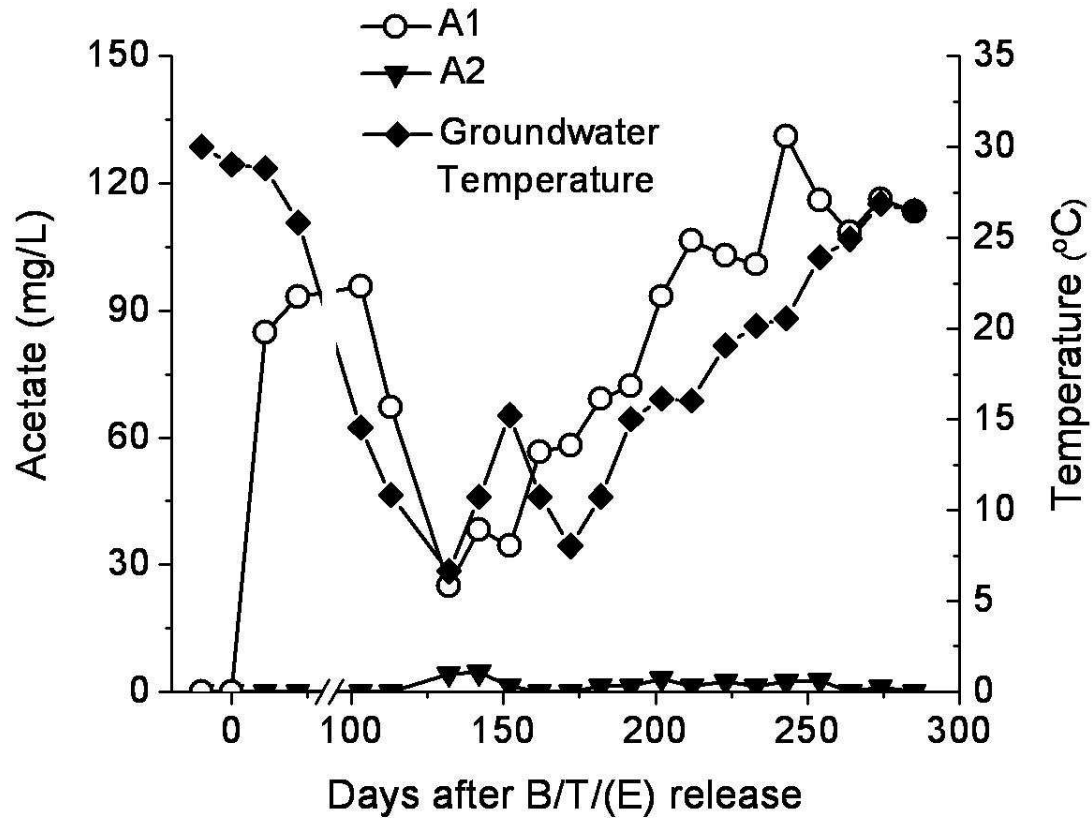


Figure 3. Acetate concentrations at A1 (in Channel 1, exposed to ethanol and B/T) and A2 (in Channel 2, exposed to B/T alone).

Seasonal Variation of Butyrate Generation

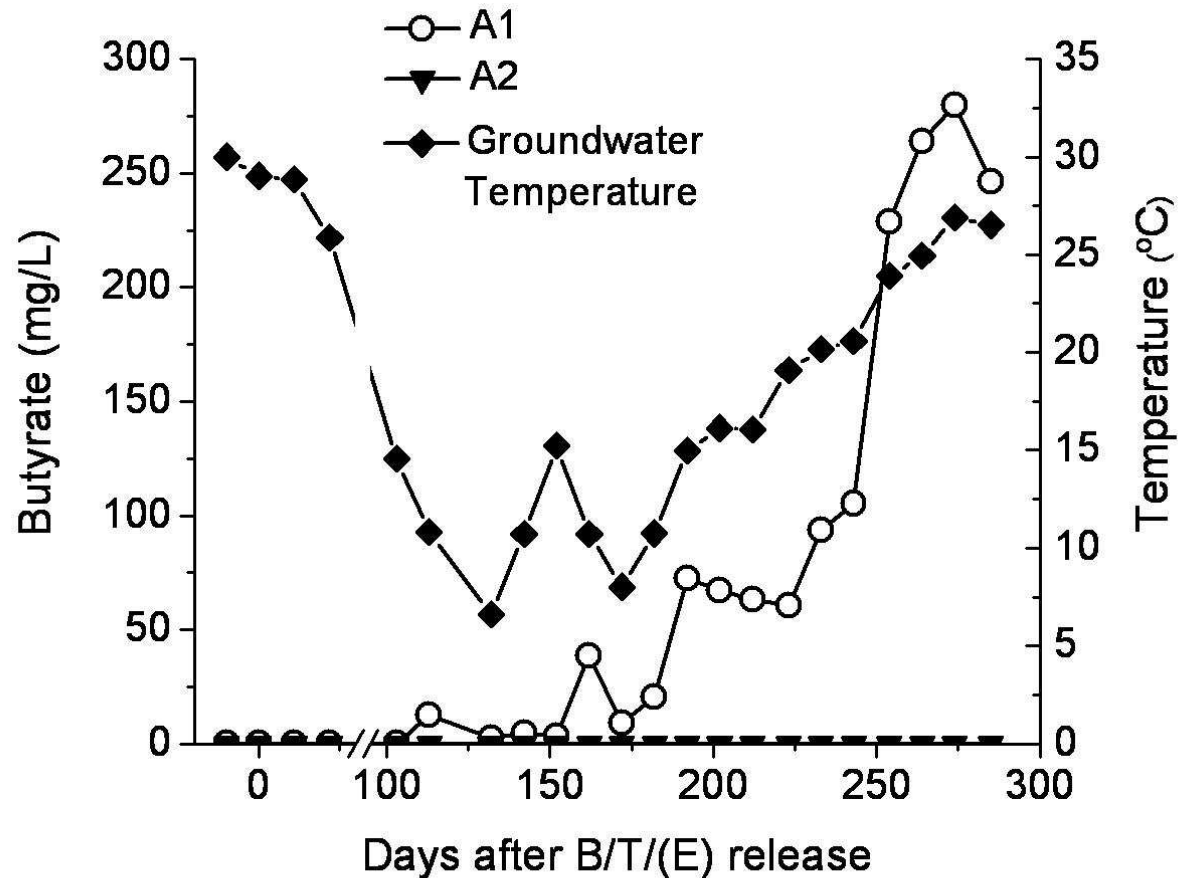


Figure 4. Butyric acid concentrations at A1 (in Channel 1, exposed to ethanol and B/T) and A2 (in Channel 2, exposed to B/T alone).

Equations for Odor Quantification

$$C_{\text{HA}} (\text{mol/L}) = \frac{C_{\text{aq}} (\text{mg/L}) \times 10^{-3} (\text{g/mg})}{\text{MW} (\text{g/mol}) \times (1 + K_{\text{a}}/10^{-\text{PH}})} \quad (1)$$

$$C_{\text{gas}} (\text{ppm}_v) = \frac{C_{\text{HA}} (\text{mol/L}) \times 10^3 (\text{L/m}^3) \times K_{\text{H}} (\text{atm} \cdot \text{m}^3 / \text{mol})}{1 \text{ atm}} \times 10^6 \quad (2)$$

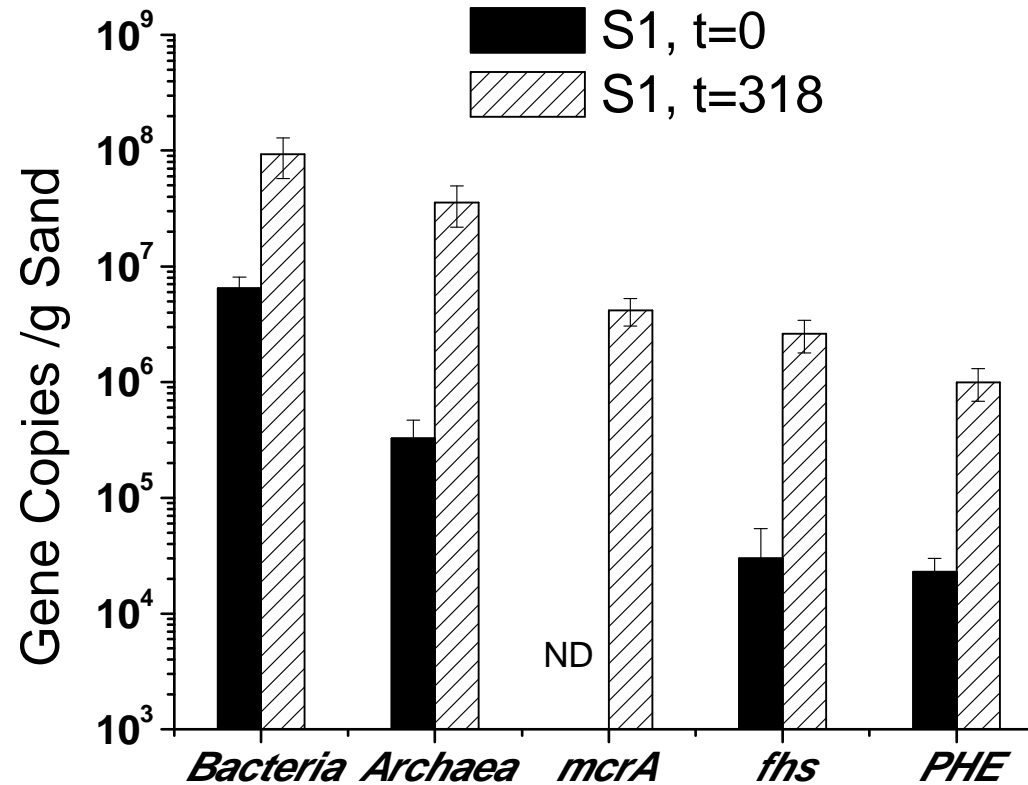
$$\text{Threshold Odor Number (TON)} = \frac{C_{\text{gas}} (\text{ppmv})}{\text{Odor Threshold Value}} \quad (3)$$

Aesthetic Impacts of Fuel Ethanol

(In NSDWR the SMCL for odor is TON = 3)

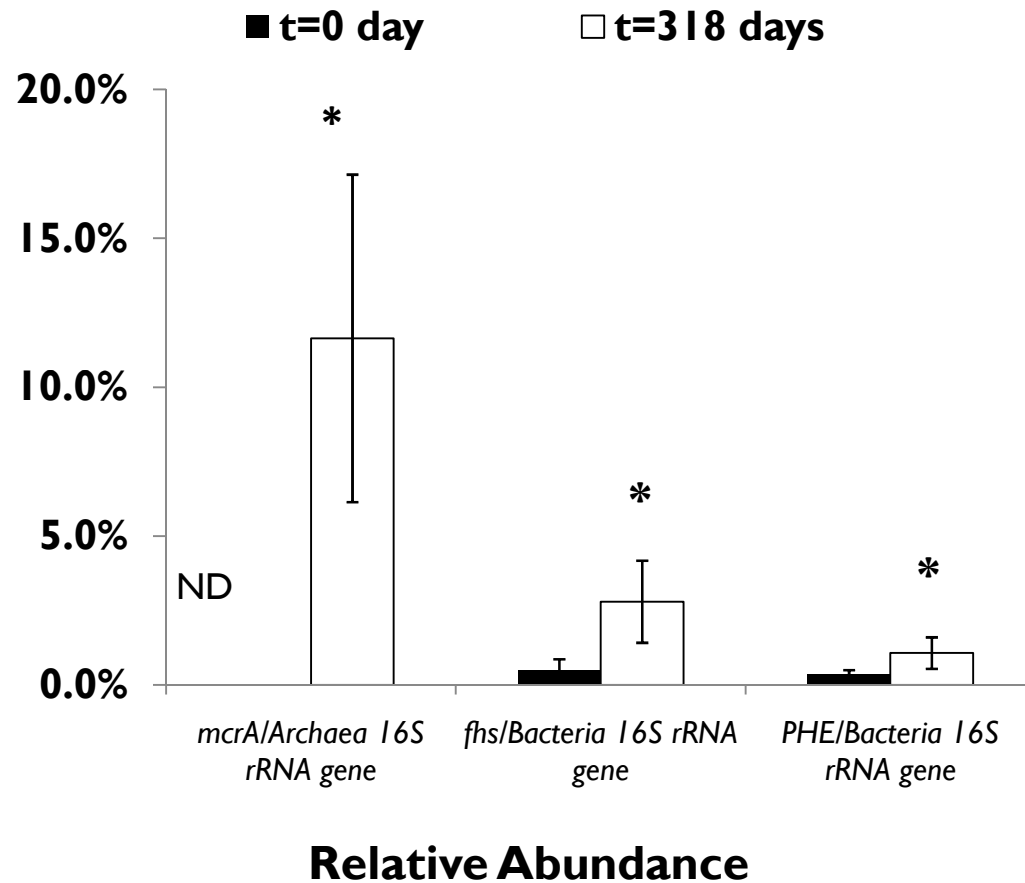
VFAs	Measured C_{aq} (mg/L)	C_{gas} (ppm _v)	Odor threshold value (ppm _v)	Threshold odor number (TON)
<i>Summer (sampled at A1; May 29th; 26.9 °C)</i>				
Acetic acid	116	$1.10 \cdot 10^{-1}$	1	0.1
Propionic acid	7	$2.49 \cdot 10^{-2}$	0.0057	4.4
Butyric acid	280	1.04	0.001	1045
<i>Winter (sampled at A1; Jan 8th; 6.6 °C)</i>				
Acetic acid	25	$2.66 \cdot 10^{-4}$	1	< 0.1
Propionic acid	4	$2.15 \cdot 10^{-4}$	0.0057	< 0.1
Butyric acid	3	$1.92 \cdot 10^{-4}$	0.001	0.2

Microbial Genotype Changes



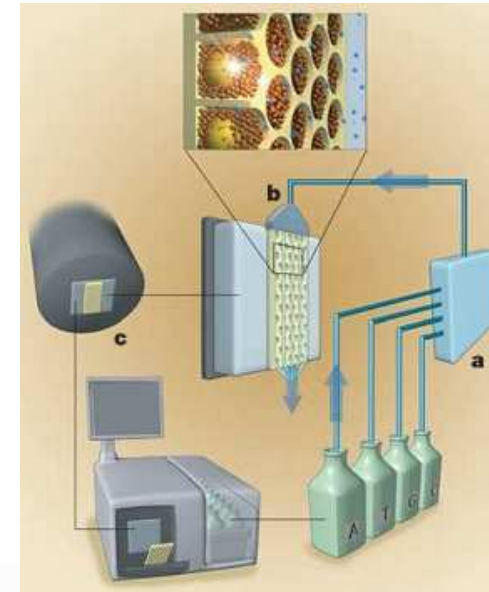
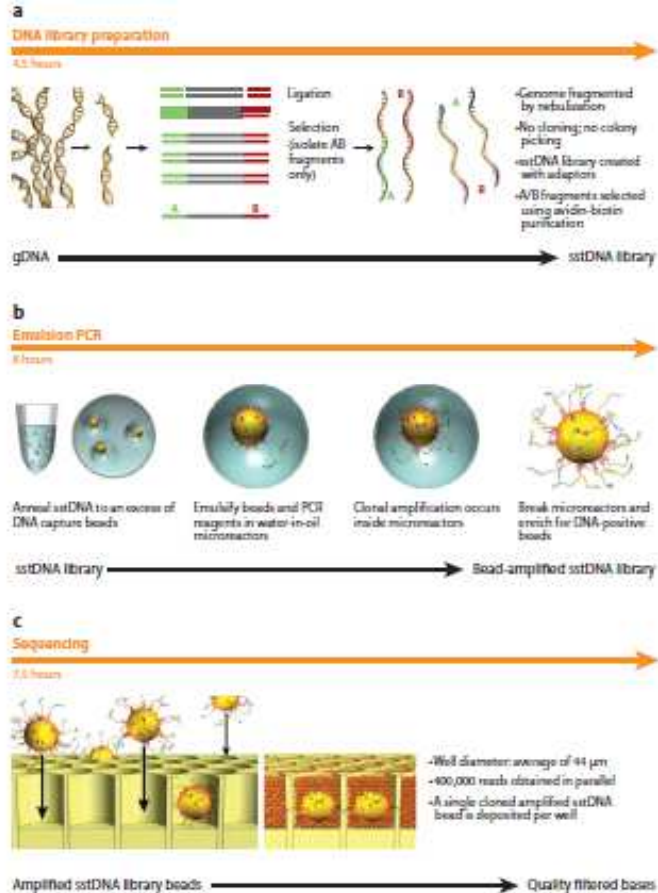
Absolute Abundance

Microbial Genotype Changes

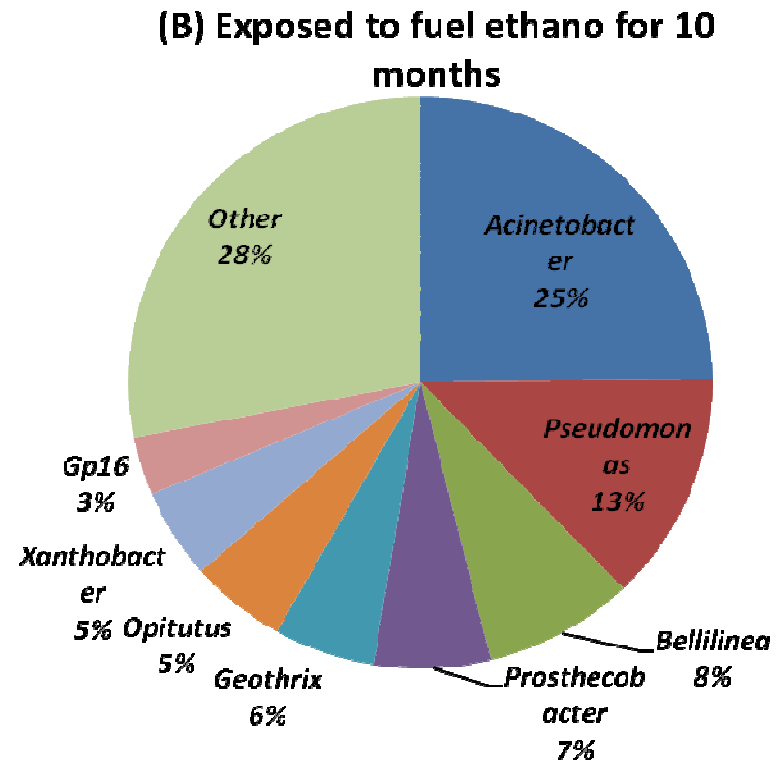
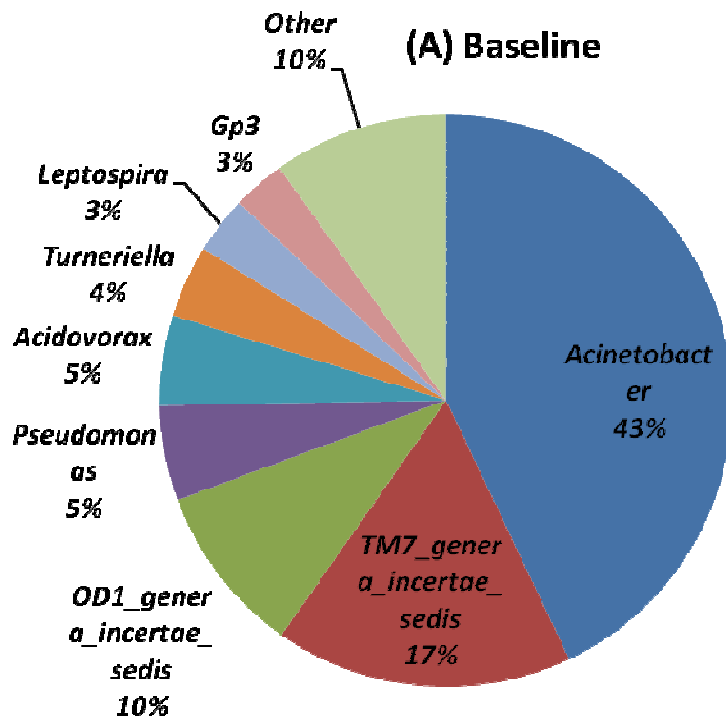


Metagenomics Technology

Who is there ? What they are doing?



The Changes of Community Composition



Anaerobic *bacteria*: ***Bellilinea***, ***Geothrix***, ***Opiritutus*** (*Acetogen*?)

Xanthobacter contains several facultative anaerobic species

Pseudomonas includes species that metabolize chemical pollutants



Conclusions

- Temperature significantly affects biodegradation of ethanol blends. Methane and VFAs generation varied seasonally.
- VFAs could cause serious aesthetic problems.
- Ethanol stimulate the microbial growth and change the community composition



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