Human indicator persistence in the environment

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State-of-the-Science: Fecal Source Identification and Associated Risk Assessment Tools
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Fecal Indicator Bacteria: a chain of inference

Fecal Indicator Bacteria → Waste → Human Waste → Pathogens → Disease

qPCR HF183 → Human Waste

Epidemiology
What is this HF183 “human marker”?

DNA
- Extractable
- Amplifiable
- Specific to human waste

Bacterial taxon

Domain: *Bacteria*
Phylum: *Bacteroidetes*
Class: *Bacteroidetes*
Order: *Bacteroidales*
Family: *Bacteroidaceae*
Genus: *Bacteroides*
Species: *dorei* (?)

(Haugland et al, 2010; Boehm et al., in rev. 2012)

HF183 Marker: Short History

- Discovery: Bernhard & Field (2000)
- qPCR assay(s)
  - Seurinck et al. (2005)
  - Haugland et al. (2010)
- Comparison w/ other human markers, e.g.
  - Van De Werfhorst et al. (2011)
  - Boehm et al. (in rev. 2012)
Abundant in human fecal sources

- *Bacteroides* spp.
  - 30% of human fecal isolates
  - Human feces: up to $10^{10}$ / gram (dry)

- HF183 marker
  - Sewage or septage: $10^5$ to $10^9$ copies / liter
  - Human feces: $10^7$ copies / gram (wet)

Application in Field Studies

(Sercu et al., 2009; Sercu et al. 2011; Murray et al. 2011, WERF Report U2R09; Mission Study Report, 2011)
Geosyntec Consultants, 2009; Sercu et al., 2012, in revision)
Interpreting low levels of human marker in environmental waters

1. low levels are due to decay and/or dilution of target feces
2. low levels are due to cross reactivity with non-target feces (but requires lots of non-target feces in water if a 'd' in 'd')

We can’t dismiss low levels of source-associated markers in environmental waters.

### HF183: Rapid Decay

<table>
<thead>
<tr>
<th>Environment</th>
<th>Location</th>
<th>Reference</th>
<th>$K$ (day$^{-1}$)</th>
<th>Half life (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>fresh-light</td>
<td>Oregon-lab</td>
<td>Walters &amp; Field, 2009</td>
<td>-1.7</td>
<td>0.4</td>
</tr>
<tr>
<td>fresh-dark</td>
<td>Oregon-lab</td>
<td></td>
<td>-1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>marine-dark</td>
<td>Oregon-lab</td>
<td>Green et al., 2011</td>
<td>-2.02</td>
<td>0.3</td>
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<tr>
<td>marine-light</td>
<td>Oregon-lab</td>
<td></td>
<td>-0.25</td>
<td>2.8</td>
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<tr>
<td>fresh-dark</td>
<td>Oregon-lab</td>
<td></td>
<td>-1.34</td>
<td>0.5</td>
</tr>
<tr>
<td>fresh-light</td>
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<td></td>
<td>-1.39</td>
<td>0.5</td>
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<tr>
<td>freshwater</td>
<td>Florida</td>
<td>Liang et al., 2012</td>
<td>-0.73</td>
<td>1</td>
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<td>seawater</td>
<td>France</td>
<td>Jeanneau et al., 2012</td>
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<td>0.7</td>
</tr>
<tr>
<td>freshwater</td>
<td>France</td>
<td></td>
<td>-1.39</td>
<td>0.5</td>
</tr>
</tbody>
</table>

![Graph](image1.png)  

$K$ (day$^{-1}$)
Persistence scenarios

Bacterial cells

- Introduced (HF183)
  - storm drains (dry weather)
- Attenuate (*Bacteroides*)
  - Predated upon
  - Die
  - Settle
- Establish
  - low diversity background (*E. coli*)
- Colonize (*Bacteroidetes* biofilms)
- Grow (*Bacteroides*)
  - nM oxygen (up to 5%)

eDNA (generic)

- Accumulates
  - biofilms
  - soils
  - sediments
- Moves
  - even in soils, by capillarity
- Protected by clays
  - PCR-amplified from clays

(Van Elsas et al., 2012; Baughn et al. 2004; Meehan et al.; 2012; Gomez-Alvarez et al., 2012; Besemer et al.; 2009) (Whitchurch et al. 2002; Steinberger et al. 2005; Pietramellara et al., 2009; Dell ‘Anno et al., 2004; Ceecherini et al. 2007; Demaneche et al., 2001; Alvarez et al., 1998)
Outstanding Issues

• Systematic understanding: decay in field conditions
• Relationship to regulated indicators, & pathogens
• How environmental factors govern
  – sunlight, temperature, salinity, predation, O₂
• How to use data (field samples & conditions), plus knowledge of decay (rates, and factors) to diagnose (a condition or event)?
  – statistical approaches and/or modeling
Moving forward

- **SIPP MST studies**: more field HF183 examples
- SIPP-proposed fecal “aging” study
  - Addressing open questions
  - Relating to pathogen taxa (community analysis)
- **SIPP MST guide forthcoming**
- However: HF183 marker is **already useful** in the context of a well-designed fecal source tracking study
  - Management actions need not wait
Tools for Tracking Human Fecal Pollution in Urban Storm Drains, Creeks, and Beaches

Dye entering Mission Creek (Santa Barbara, CA) after being flushed down toilets in nearby businesses. A private sewer lateral serving six businesses was found to be leaking into a storm drain.

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