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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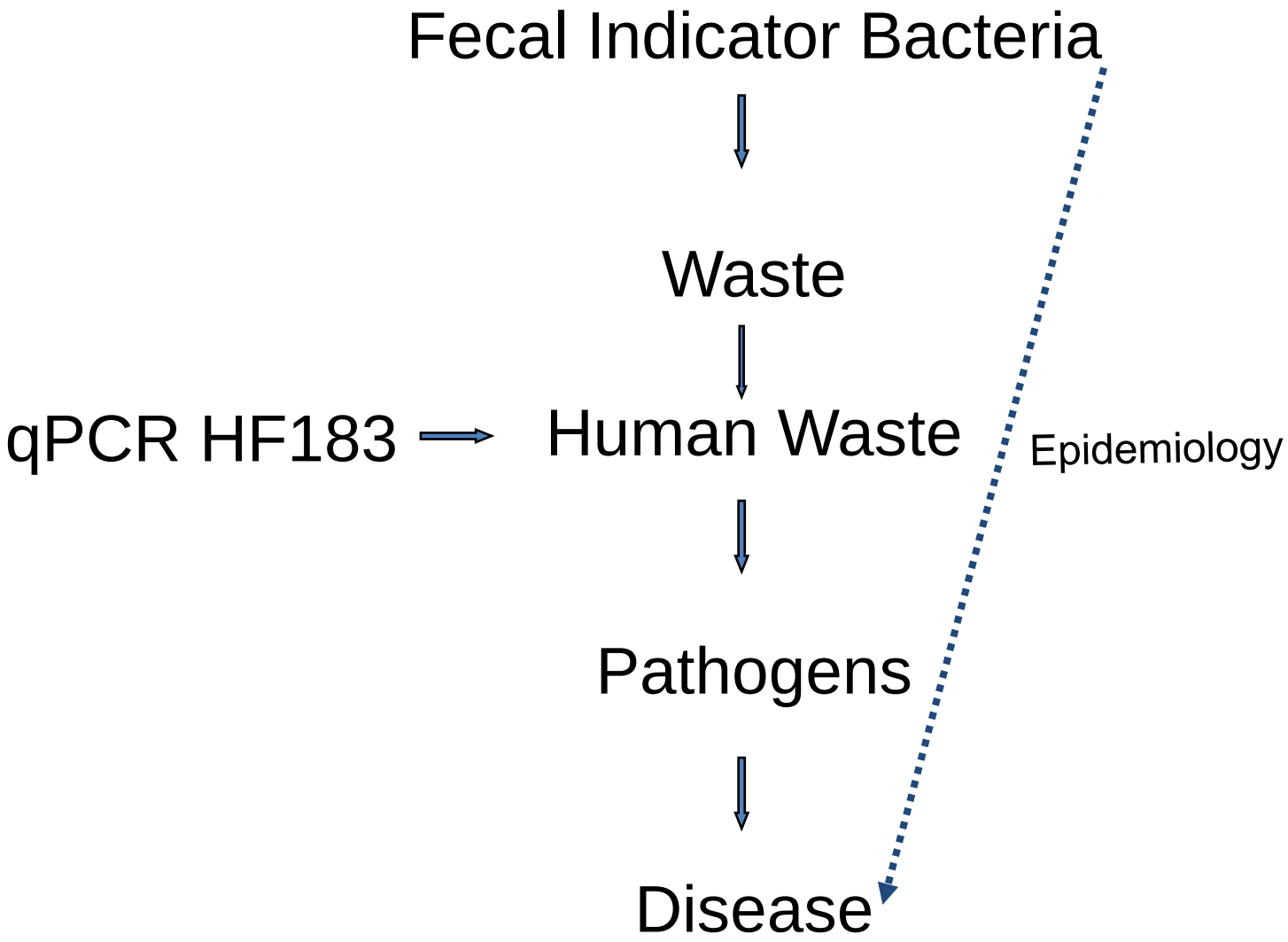
Fecal Indicator Bacteria: *a chain of inference*



What is this HF183 “human marker”?

DNA

- Extractable
- Amplifiable
- Specific to human waste

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

Bacterial taxon

Domain: *Bacteria*

Phylum: *Bacteroidetes*

Class: *Bacteroidetes*

Order: *Bacteroidales*

Family: *Bacteroidaceae*

Genus: *Bacteroides*

Species: *dorei (?)*

(Carrero-Colón et al. 2010. Taxonomy, Phylogeny and Physiology of Fecal Indicator Bacteria. A chapter in **The Fecal Indicator Bacteria** edited by Michael Sadowsky and Richard Whitman. ASM Press. 328 pages; Haugland et al, 2010; Bakir et al. 2006)

HF183 Marker: Short History

- Discovery: Bernhard & Field (**2000**)
- X-method performance: Field et al. (**2003**)
- 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**)

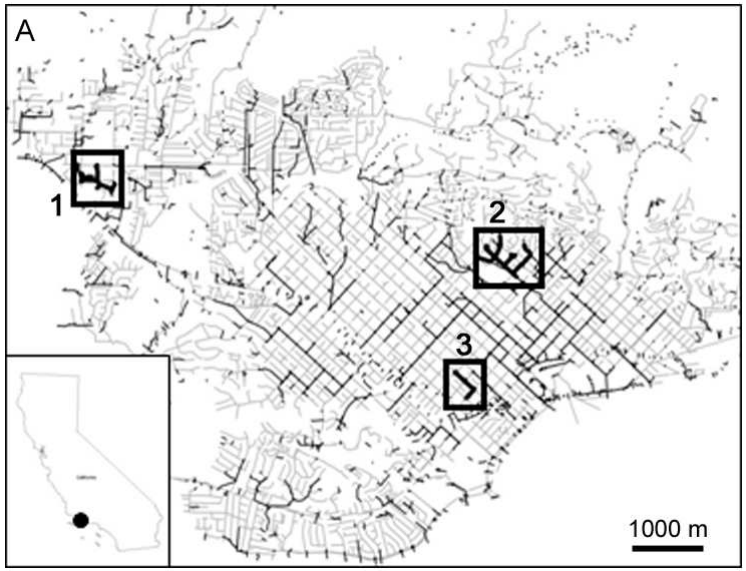
Abundant in human fecal sources

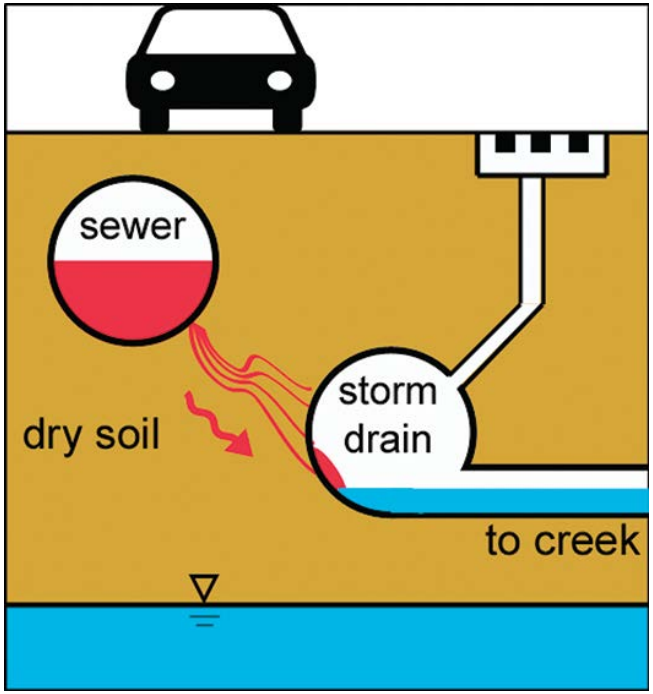
- *Bacteroides* spp.
  - 30% of human fecal isolates
  - Human feces: up to 10^{10} / gram (dry)

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

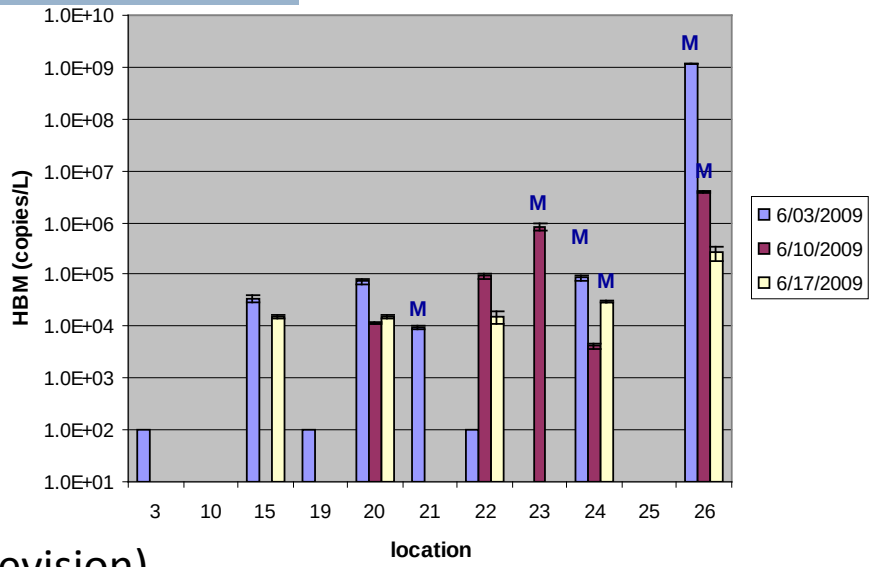
(Carrero-Colón et al. 2010. Taxonomy, Phylogeny and Physiology of Fecal Indicator Bacteria. A chapter in **The Fecal Indicator Bacteria** edited by Michael Sadowsky and Richard Whitman. ASM Press. 328 pagesHaugland et al., 2010; Layton et al., in rev. 2012)

Application in Field Studies





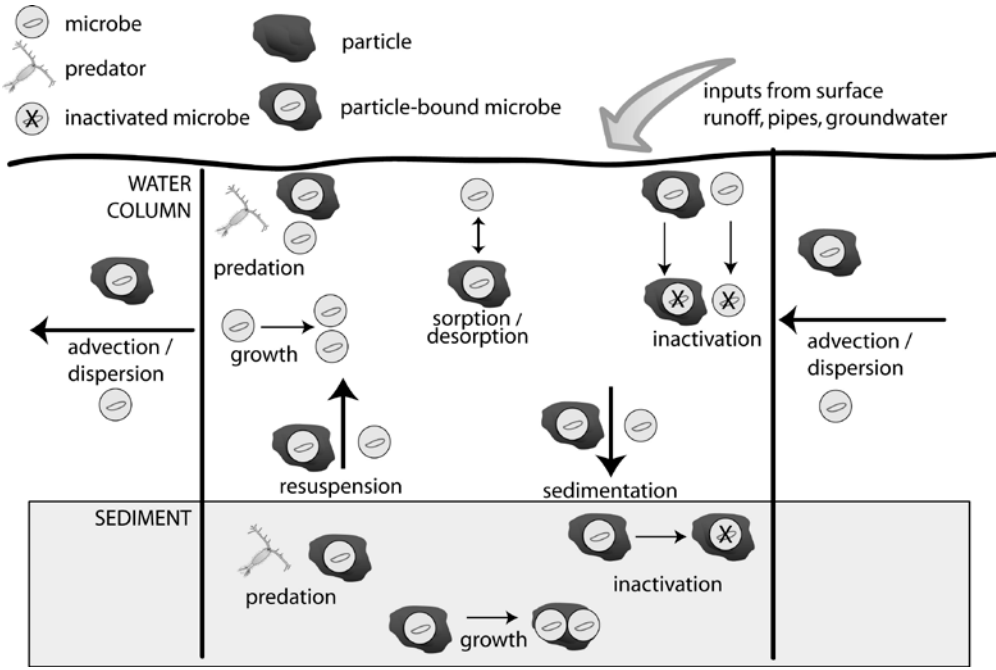
(Sercu et al., 2009; Sercu et al. 2011; Murray et al. 2011, WERF Report U2R09; Mission Study Report, 2011)



Geosyntec Consultants, 2009; Sercu et al., 2012, in revision)

Interpreting low levels of human marker in environmental waters

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

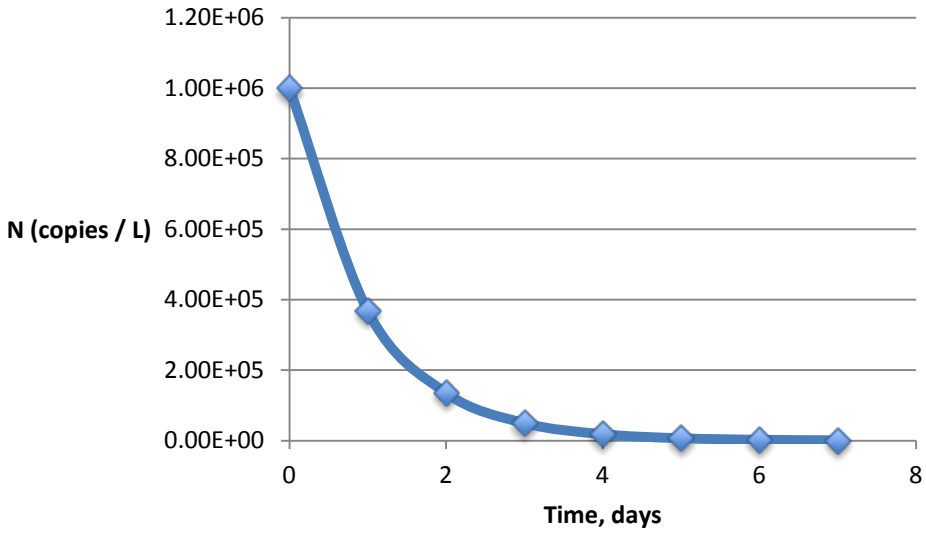


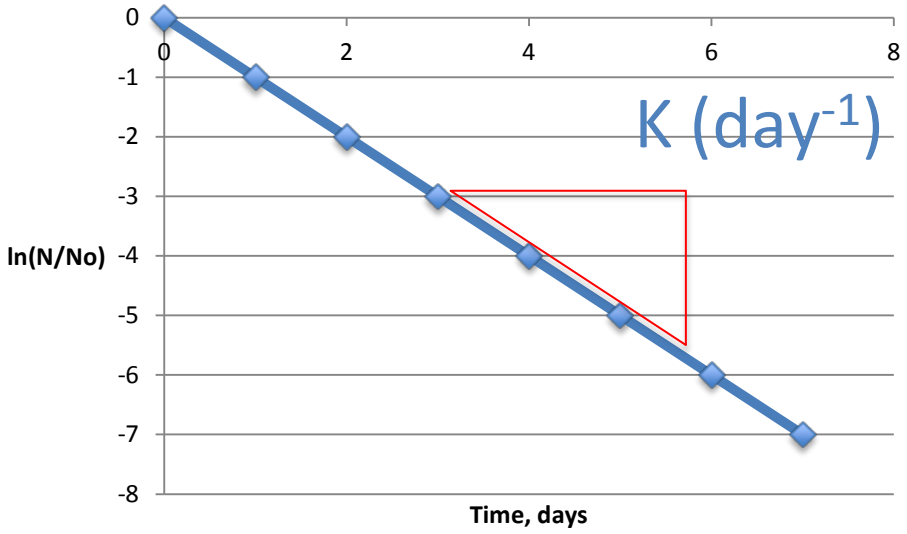
We can't dismiss low levels of source-associated markers in environmental waters.

(M. N. Byappanahalli, M. B. Nevers, A. Korajkic, Z. R. Staley, and A. K. Harwood. 2012. Modeling Fate and Transport of Fecal Bacteria in Surface Water. A chapter in **The Fecal Indicator Bacteria** edited by Michael Sadowsky and Richard Whitman. ASM Press. 328 pages.)

HF183: Rapid Decay

Environment	Location	Reference	K (day^{-1})	Half life (d)
fresh-light	Oregon-lab	Walters & Field, 2009	-1.7	0.4
fresh-dark	Oregon-lab		-1.4	0.5
marine-dark	Oregon-lab	Green et al., 2011	-2.02	0.3
marine-light	Oregon-lab		-0.25	2.8
fresh-dark	Oregon-lab		-1.34	0.5
fresh-light	Oregon-lab		-1.39	0.5
freshwater	Florida	Liang et al., 2012	-0.73	1
seawater	France	Jeanneau et al., 2012	-1.03	0.7
freshwater	France		-1.39	0.5





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, O_2
- 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.

- *Sources*
- *Tools*
- *Strategies*

City of Santa Barbara, Creeks Division

In partnership with:

University of California, Santa Barbara

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(David Macaulay. 1976. *Underground*)