

Supplementary Material (SM)

Table S1 Decay rates of human-associated assay markers and general *Enterococcus*, *E. coli* or *Bacteroidales* assay markers extracted from studies that tested decay of human sources.

Reference	Setup	Light	Water matrix	Assay (target)	Decay model		
Jeanneau et al. 2012	Sewage 18.5 °C aerobic	dark	freshwater	HF183SYBR (qPCR Human <i>Bacteroidales</i>) ENT (culturable <i>Enterococcus</i>) EC (culturable <i>E. coli</i>)	Chick-Watson or biphasic Chick-Watson (Natural log-transformed)		
					^a Portion of first phase ($\pm 2 \times \text{se}$)	^b 1 st phase decay rate ($\pm 2 \times \text{se}$), day ⁻¹	R ² ($\pm 2 \times \text{se}$)
					1	-1.39 $\pm$ 0.04	0.90 $\pm$ 0.02
					0.99 $\pm$ 0.00	-0.79 $\pm$ 0.24	0.99 $\pm$ 0.00
					0.99 $\pm$ 0.00	-0.41 $\pm$ 0.04	0.96 $\pm$ 0.00
			seawater	HF183SYBR (qPCR Human <i>Bacteroidales</i>)	1	-1.03 $\pm$ 0.16	0.78 $\pm$ 0.06
				ENT (culturable <i>Enterococcus</i>)	0.99 $\pm$ 0.02	-0.72 $\pm$ 0.32	0.97 $\pm$ 0.02
				EC (culturable <i>E. coli</i>)	1	-1.32 $\pm$ 0.16	0.90 $\pm$ 0.04
Green et al. 2011	Sewage 12.8 °C aerobic	sunlit	freshwater	HF183Taqman (qPCR Human <i>Bacteroidales</i>) HumM2 (qPCR Human <i>Bacteroidales</i>) ENT-QPCR (qPCR <i>Enterococci</i>)	Delayed Chick-Watson (Natural log-transformed)		
					^c Lag phase (95% CI), days	^b Decay rate (95% CI), day ⁻¹	R ²
					3.089 (2.913~3.289)	-3.194 (-3.668~-2.811)	0.988
					2.741 (2.540~2.905)	-0.904 (-1.071~-0.721)	0.963
					1.521 (1.226~1.777)	-1.071 (-1.202~-0.944)	0.976
			seawater	HF183Taqman (qPCR Human <i>Bacteroidales</i>)	4.332 (3.519~5.012)	-0.578 (-0.827~-0.378)	0.869
				HumM2 (qPCR Human <i>Bacteroidales</i>)	4.387 (3.462~5.229)	-0.236	0.855

		dark	freshwater	<i>Bacteroidales</i>		(-0.368~-0.147)	
				ENT-QPCR (qPCR <i>Enterococcus</i>)	2.281 (1.596~2.884)	-0.652	0.929
				HF183Taqman (qPCR Human <i>Bacteroidales</i>)	2.872 (2.666~3.055)	(-0.794, -0.523)	
				HumM2 (qPCR Human <i>Bacteroidales</i>)	3.639 (3.008~3.925)	-3.083	0.973
				ENT-QPCR (qPCR <i>Enterococcus</i>)	1.578 (0.951~2.291)	(-3.502~-2.662)	
			seawater	HumM2 (qPCR Human <i>Bacteroidales</i>)	5.884 (5.77~5.911)	-5.666	0.387
				ENT-QPCR (qPCR <i>Enterococcus</i>)	5.884 (5.77~5.911)	(-16.350~-1.232)	
				HF183Taqman (qPCR Human <i>Bacteroidales</i>)	5.884 (5.77~5.911)	-0.900	0.92
				HumM2 (qPCR Human <i>Bacteroidales</i>)	3.464 (2.170~5.366)	(-1.140~-0.721)	
				ENT-QPCR (qPCR <i>Enterococcus</i>)	5.658 (5.401~5.854)	-4.660	0.986
							NA ^d
							0.921
							(-3.286~-2.077)
Walters & Field, 2009	Human feces 13 °C aerobic						Chick-Watson for exponential phase only (Natural log-transformed)
		sunlit	freshwater		Exponential phase, days	^b Decay rate (95% CI), day ⁻¹	
				HF183SYBR (qPCR Human <i>Bacteroidales</i>)	4~10	-1.7	
				ENT-IDEXX (culturable <i>Enterococcus</i>)	3~10	(-2.1~-1.4)	
				EC-IDEXX (culturable <i>E. coli</i>)	0~14	-1.6	
						(-2.2~-0.90)	
		dark	freshwater	HF183SYBR (qPCR Human <i>Bacteroidales</i>)	4~10	-0.47	
				ENT-IDEXX (culturable <i>Enterococcus</i>)	3~10	(-0.76~-0.18)	
				EC-IDEXX (culturable <i>E. coli</i>)	0~14	-1.4	
						(-1.7~-0.98)	
						-0.97	
							(-1.2~-0.74)
							-0.29
							(-0.80~0.21)
Walters et al. 2009	Sewage 17 °C aerobic						Chick-Watson (Natural log-transformed)

			^b Decay rate (95% CI), day ⁻¹
sunlit	seawater	BacHum (qPCR Human <i>Bacteroidales</i>)	-1.30 (-2.37~-0.219)
		ENT-QPCR (qPCR <i>Enterococcus</i>)	-0.278 (-0.410~-0.145)
		ENT-MF (culturable <i>Enterococcus</i>)	-2.21 (-5.48~1.06)
dark	seawater	BacHum (qPCR Human <i>Bacteroidales</i>)	-0.264 (-0.462~-0.066)
		ENT-QPCR (qPCR <i>Enterococcus</i>)	-0.241 (-0.344~-0.138)
		ENT-MF (culturable <i>Enterococcus</i>)	-0.907 (-1.32~-0.493)

^a In biphasic first-order model, the two phases are the two portion of the population that has different decay rates. The first phase is the predominant part of the population.

^b only decay rate of 1st phase is listed because it accounts for 0.99 portion of the population. Standard error determined from the three model-fitted decay rates of the triplicate microcosms rather than from the model fitting performance on measured concentration. 95% confidence interval is assumed to be mean $\pm$ 2se.

^c 95% confidence interval determined from the model fitting performance on measured concentration.

^d limited time points were used to fit the first-order decay function, R² calculation not reliable.

Table S2 The ratios of concentrations of the human-associated assays (HF183Taqman) and concentrations of several general fecal markers including ENT-MF, ENT-IDEXX, ENT-QPCR, EC-MF, EC-IDEXX and EC-QPCR for singleton samples. '-' indicates that the human marker was below the lower limit of quantification and '*' indicates that the general marker was too high to be quantifiable so that the ratio could not be calculated. *Italic* indicates the ratio for human is only about 1 order of magnitude higher than the ratio for the other source in doubletons listed in table 1.

Singleton	HF183Taqman /ENT-MF	HF183Taqman /ENT-IDEXX	HF183Taqman /ENT-QPCR	HF183Taqman /EC-MF	HF183Taqman /EC-IDEXX	HF183Taqman /EC-QPCR
cow	9.48×10^{-2}	7.04×10^0	5.80×10^{-2}	1.23×10^0	*	1.70×10^{-2}
deer	2.13×10^0	1.01×10^0	3.03×10^{-2}	5.91×10^{-2}	1.36×10^{-2}	3.14×10^{-3}
dog	-	-	-	-	-	-
horse	-	-	-	-	-	-
pig	-	-	-	-	-	-
human	1.94×10^4	7.79×10^3	5.74×10^2	<i>1.15×10^1</i>	6.08×10^0	5.33×10^{-1}
septage	1.37×10^2	4.93×10^2	4.01×10^{-1}	2.94×10^2	1.22×10^2	2.21×10^0
sewage	9.45×10^1	1.51×10^2	8.74×10^{-1}	3.13×10^1	8.15×10^0	4.81×10^0

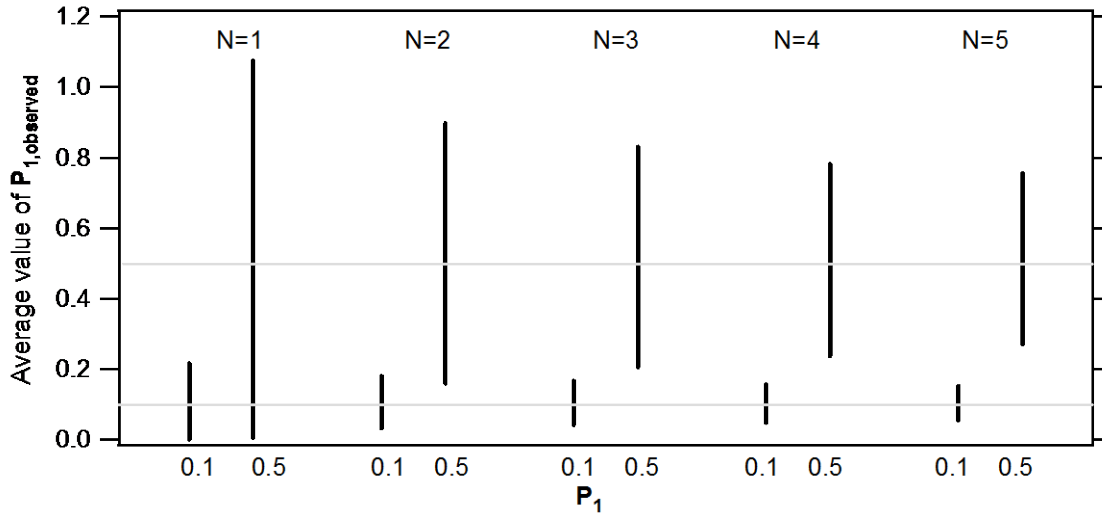


Figure S1 95% confidence interval of average value of $P_{1,observed}$ calculated from multiple samples at $\sigma_M = 0.2$ and $\sigma_{1_feces} = 0.5$. N is number of samples. True P_1 value of 0.1 and 0.5 are evaluated. When the confidence intervals for P_1 of 0.1 and 0.5 does not overlap at $N \geq 3$, one can distinguish a site with <10% or >50% of contribution from human source.