Bacteria Holding Time and Degradation

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Back in 2002-03
Collaborated with water boards to provide data for discussions to overcome sample hold time road-blocks to conducting fecal indicator bacteria monitoring.

Research
Quantify the effect of sample hold time so we can standardize data and assess remote waters.

Most of the State’s waters are > 6 hr from a laboratory
...and unless we can either control the weather or implement the 24 hour work day and outlaw weekends, they can be >24 hours from getting analyzed!

Decay Studies
• 15 streams enrolled
• Rangeland to Ag/Urban
• Joint with CVRWQCB – 5 streams, DMF & Colilert
• Samples analyzed <3 hr: then ~6, 12, 24, 48, 72, 96hr, 4 C
cfu/100mL = a + b * time

Putah Creek – Initial Study

Lab
Sample Site

Generic E. coli (cfu/100ml) plotted by hold time (hr). Data are from 5 trials conducted on Putah Creek, Davis, CA Oct-Dec, 2002. Samples held at 4 C.
Effect (p<0.0001) of holding time at 4 C on generic E. coli and fecal coliform in samples from Putah Creek, Davis, CA. Samples processed within 1 hour of collection and at hold times ~6, 12, 24, 48, 72, 96 hr. Data are from 5 trials, Oct-Dec 2002.

\[
\begin{align*}
\ln(FC) &= 5.7 - 0.01 \times \text{(hold time hr)} \\
\ln(E.coli) &= 4.6 - 0.008 \times \text{(hold time hr)}
\end{align*}
\]

Effect (p<0.0001) of holding time at 4 C and analysis method on generic E. coli in samples from 5 creeks. Samples processed within 3 hour of collection and at hold times ~6, 12, 24, 48, 72, 96 hr.

\[
\begin{align*}
\text{DMF: } \ln(E.coli) &= 5.5 - 0.006 \times \text{(hold time hr)} - 0.14 \\
\text{Colilert: } \ln(E.coli) &= 5.5 - 0.006 \times \text{(hold time hr)} - 0.0
\end{align*}
\]

But not all samples experienced decay.
Hold times out to 24 hours may have limited

\[ E_{\text{FC}}(t) = \beta_0 \times 10^{\beta_1 t} \]

where \( E_{\text{FC}}(t) \) is the observed \( E. coli \) concentration at time \( t \), \( \beta_0 \) is the initial concentration, \( \beta_1 \) is the fitted decay coefficient(s) generated by the linear mixed effects model described above.

In order to adjust the concentration in each water sample tested, we first assumed the following basic model,

\[ \log_{10}(E_{\text{FC}}(t)) = \log_{10}(E_{\text{FC}}(t=0)) + \beta \times t \]

where \( E_{\text{FC}}(t=0) \) was the fitted or expected concentration at the initial time of collection, and \( \beta \) was the fitted decay coefficient(s) generated by the linear mixed effects model described above.

The decay process was for water samples held at approximately 4 ºC. Once obtained, equation (2) was used to adjust each sample to a single 24-hour standard, whereby the raw data signified a first or second-order time-dependent decay process for the observed \( E. coli \) concentration in each water sample tested.

\[ \log_{10}(E_{\text{FC}}(t=x)) = \log_{10}(E_{\text{FC}}(t=0)) + \beta \times (t=x-24) \]

where \( E_{\text{FC}}(t=x) \) was the observed log10 concentration at \( t=x \) hour, \( \beta \) was the fitted decay coefficient(s) generated by the linear mixed effects model described above.

\[ \log_{10}(E_{\text{FC}}(t=0)) = \log_{10}(10^{\beta_0}) = \beta_0 \]

where \( E_{\text{FC}}(t=0) \) was the modeled log10 concentration at the initial time of collection.

\[ E_{\text{FC}}(t=24) = E_{\text{FC}}(t=0) / 10^\beta \]

where \( E_{\text{FC}}(t=24) \) was the fitted or expected decay coefficient raised to the power of 10 which allowed us to model observed concentration at \( t=24 \) hour, and \( \beta \) was the fitted decay coefficient(s) generated by the linear mixed effects model described above.

\[ R^2 \approx 0.62 \]

\[ P = 0.35 \]

Summary

- We can account for the decay of indicator bacteria resulting from hold time.
- Hold times out to 24 hours may have limited decay for many streams/samples.
- Will each waterbody require a unique curve?

Looks like at a minimum that unique curves will be required for “types” of streams (i.e. range v. ag v. urban).