LOD Calculator User Manual

Elliot Topper

June 2024

1 Background

Limits of Detection (LODs) are calculated to describe the limitations of analytical measurements. In microbiology specifically, LOD gives the number of Colony-Forming Units, or CFUs, that can be detected by the approach used. While there is no universally accepted equation or definition for LOD in microbiology, Sharp, Parker, and Hamilton (2023) proposes the use of extra-Poisson distributions to calculate LOD within a specified Type II error rate (β). This model depends on a Coefficient of Variation (CV), which is calculated based on the mean μ and standard deviation σ of the distribution of CFUs in the sample. These are estimated using $\hat{\mu}$ and $\hat{\sigma}$, respectively and the resulting $\hat{CV}$ can be used in the following formula to calculate L_{plate}, the LOD per plated volume. $L_{original}$ is the population LOD per mL.

$$d = \frac{1}{\hat{CV}^2} \tag{1}$$

$$L_{plate} = k \times L_{original} \geq \left(\frac{d}{\sqrt[nd]{\beta}} \right) - d \tag{2}$$

When $\hat{CV} = 0$, the equation can be expressed as:

$$L_{plate} = k \times L_{original} \geq -\frac{\ln \beta}{n} \tag{3}$$

2 Application

LOD Calculator is a web application developed for computing the LOD for a microbial method given a set of user-defined parameters. The application is feature-rich, allowing the end user to calculate LOD in several ways. The application is also developed with performance, security, and accessibility features in mind.

3 Features

The following summary of features is displayed on the LOD Calculator site:

3.1 Parameters

The LOD Calculator uses 4 (or 5) parameters to calculate LOD:

- **Coefficient of Variation (CV)** - Calculated as σ/μ of the sample; defines the relative variability of the distribution
- **Mean (μ)** - Mean of the distribution of CFUs; calculated from sample data
- **Standard Deviation (σ)** - Standard Deviation of the distribution of CFUs; calculated from sample data

- **Type II Error Rate (β)** - Rate of false negatives desired, provided as a proportion between 0 and 1; increasing β allows a higher chance of error in the resulting LOD
- **Number of Independent Experiments (n)** - Number of experiments conducted, provided as a counting number
- **Dilution Factor (k)** - Dilution factor used for creating the sample, provided as a percentage from 0 to 1

Each of these parameters affects the LOD calculation.

3.2 Options

There are two options for operating the calculator:

- **Sample / Population calculation ($L_{original}$ / L_{plate})** - Toggles calculation between LOD per mL (default) and LOD per plated volume ($k = 1$)
- **CV / Mean mode** - Toggles control of CV vs σ/μ for calculations

3.3 Operation

The calculator supports two modes: Graph Mode and Discrete Calculation Mode.

3.3.1 Graph Mode

Graph Mode can be accessed by selecting any of the listed parameters to be displayed as the independent variable on the graph.

All other available parameters will become visibly accessible to be modified as desired, within a given range. Altering the value of any variable will dynamically update the graphical view, allowing for live updates to the graph.
Variables can be changed via sliders with discrete values, or by entering values in the corresponding boxes. The resulting graph will graph the chosen x variable against the calculated LOD, with all other parameter values being statically set to those chosen values.

3.3.2 Discrete Calculation Mode

Discrete Calculation Mode can be accessed by selecting "Calculate Discrete Value".

In this mode, any values can be input for the 4 previously mentioned parameters for an experiment.
The last box will show the LOD value given these parameter values.

PDF Output Discrete Calculation Mode provides the option to export a calculated LOD as a PDF file. Selecting "Download Report" in this mode will generate and download a PDF containing the current input and output values.