limit_of_detection

Tony Ni

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Why the Limit of Detection (LOD) Value is Not an Appropriate Specification for Automotive Emissions Analyzers

- Very specific study on checking the reliability of analyzers (for vehicle emissions) at low concentrations.
- Generally, you want to have a low LOD value
- The general form of the equation used to determine LOD is of the form:

$$LOD = k * s_{zero}$$

  where "k is the constant for defining LOD" and s_{zero} is the standard deviation of the zero/blank"
- 2 or 3 SDs is often what is used, refer to picture (I think it's neat)
- Limit of quantification (LOQ) and limit of detection (LOD) are often concepts which are mixed up
- LOQ is the "minimum value that users of analytical instrumentation can report a value"

A Model of Measurement Precision at Low Concentrations

- Article focusing on the precision of measurements at low concentrations, seeks to explore how effective the total variance model performs
- The method detection limit (MDL) is a "method's ability to determine an analyte in a sample matrix, regardless of its source of origin" - it is estimated from data
- Background noise always exists, even when there is no analyte present
- EPA definition of method detection limit is as follows: "method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99
- In the total variance model – we can't measure the actual analyte concentration. We have to estimate it from the measured concentrations. These measurements innately contain random errors. Palleton (look for source? 1985) suggests that at low concentrations, total error consists of: background noise b_i and analytical error a_i – both of which are random, independent, and normally distributed with mean 0 (refer to diagram in paper, nice figure/picture)

Statistical methods for assays with limits of detection: Serum bile acid as a differentiator between patients with normal colons, adenomas, and colorectal cancer

- THIS SOURCE LOOKS REALLY GOOD. BACKSOURCE FROM HERE AND FIND MORE FROM THIS PAPER'S CITATIONS

- There are many different ways that researchers are dealing with detection limits, which are ubiquitous in the scientific realm. Substitution, nonparametric methods, and maximum likelihood methods are all ways to combat this problem.
- Substitution is the worst way, nonparametric ways do better, maximum likelihood methods are the best

A Study of the Precision of Lead Measurements at Concentrations Near the Method Limit of Detection

- Study involving generating collection of measurements on samples near the limit of detection. Gave 5 labs samples of lead with low concentrations and asked them to measure them, forbade them from recording values as "less than MDL" and they had to record a number.
- Method Detection Limit (MDL) is often misunderstood – it isn't involved with bias, it only deals with precision.
- Throwing away/Discarding values that are below of the LOD gets rid of tons of useful information
- The MDL is a statistical concepet more so than a chemical concept. It is a statistic which is estimated from the given data.
- The way that chemists/researchers report low concentrations are varied and not standardized. Some may report: "ported. They may report the datum to the data analyst as (1) trace, (2) the letters ND (not detected), (3) the numerical value of MDL itself, (4) a "less than" value, that is, the numerical value of the MDL preceded by a "<" sign, (5) zero, (6) some value between zero and the MDL, for example, one-half the MDL, (7) the actual measured concentration even if it is below the MDL (that is, whether the value is positive or negative), (8) the actual measured value followed by the MDL in parenthesis, or (9) the actual measured value with a statement of its precision (for example, 2 ± 4 Mg/L, where the $\pm$ value indicates the pre cision of the estimate). The last three methods are the best."
- Paper emphasizes not throwing away ANY numerical values, but doesn't reallyl talk about how to perform statistical analysis with these values...

Real-time detection of intentional chemical contamination in the distributional system

- "80
- "Miller and Miller (2000) defined the LOD as being equal to blank + 3(SD)":

$$Limit of Detection = \gamma_B \ + 3\sigma_B$$

- Note: in their case, the blank is 0 because they are measuring the different between normal/control/baseline conditions against the contaminant
- Recommends using artificial neural networks with large datasets (to help detect contamination)
- The rest of the article focuses on their experiment to try to detect contamination in real-time.

A Distribution-Based Multiple Imputation Method for Handling Bivariate Pesticide Data with Values below the Limit of Detection

- Study exploring different options to handle LOD laboratory data – specifically with regards to multiple imputation methods for left-censored data. They concluded that "the distribution-based MI method" worked well for bivariate data where the values were < LOD.
- LOD entries still contain information that a lot of people don't realize – specifically information that the values is between 0 and the LOD.
- Lots of different approaches has already been done to handle this (they cited Helsel 2005b, 2010)
- Substitution methods are easy to implement, but are biased (common values: LOD/2, LOD/sqrt(2), LOD) but are discouraged b/c results in estimates of parameters being biased
- What this study used was distribution-based multiple imputation methods – they used MLEs to estimate distribution parameters based on all datas (< LOD and those not). They repeatedly imput the values to create multiple complete sets of data, and then analyzed each one individually
- Mathematically, they created a log-likelihood function with all the data, then derived MLEs of each parameters on multiple bootstrapped datasets. Each bootstrap data gives different estimates for the mean, sd, etc. (refer to article for math)

When Nothing Is Something : Understanding Detection Limits

- There are many different forms of detection limits, ranging from: thresholds at which something can be detected (instrument detection limit) or the limit to which a lab reports a value based regulatory requirements (reporting limit).
- Detection limits are constantly changing: as technology improves, so too does our ability to accurately measure substances.
- Reporting limits can often be used be misleading as non-statisticians may often interpret ND (non-detect) as nullity, when in fact it only means that the measurement falls below a certain limit.
- The rest of the paper focus on environmental law practices and cases in which LOD has played a role in.

Lowering the detection limit for arsenic: Implications for a future practical quantitation limit

- States can set their own regulatory standards regarding the maximum contaminant levels for chemicals. (own thoughts: maybe this is another issue...)
- Rest of the article is focused on chemical instruments in measuring things, not relevant...

Estimating Population Distributions When Some Data Are Below a Limit of Detection by Using a Reverse Kaplan-Meier Estimator

Statistical tests for latent class in censored data due to detection limit

A Simple Definition of Detection Limit