BOD Techniques (3rd of 3 BOD articles)

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The first article of this series reviewed what quality control measures are needed to validate a Biological Oxygen Demand, or BOD, analysis. The second article covered pH adjustment, dechlorinating samples, calibrating dissolved oxygen (DO) probes to the barometric pressure, and sources of bubbles in the BOD bottles. This third and final article in the series will focus on the results of BOD analyses.

You've set up the perfect BOD analysis. The sample was pH adjusted properly, there were no bubbles in the bottle after five days, your blank, standard, and seed all came out within acceptable limits. Then why are there three different results for the three dilutions of the same sample?

There are a several reasons that these types of errors happen. The first is incorrect dilution choices. The second is the fault of the sample (yes, we can blame the sample sometimes!). However, both types of errors can be reduced or even eliminated with a little bit of planning.

Dilution errors:

All samples must be mixed well prior to diluting in BOD bottles. If the sample has large particulate matter, as found in raw wastewater for example, you must ensure that these particles do not settle out while multiple dilutions are made. You may need to continuously mix the sample to keep the particles evenly distributed. Otherwise the BOD dilutions can give widely varied results. If a series of dilutions for a sample shows two results that are close and one result that is way off, report the average of the two that are close in value. For example: A series of raw wastewater BOD dilutions calculate to 235 mg/L, 245 mg/L, and 390 mg/L. Average the 235 mg/L and 245 mg/L results. Most likely the high value (390 mg/L) was the result of an uneven distribution of oxygen-demanding particles in the sample dilution.

Choose dilutions that produce a DO decrease in the BOD bottle of at least 2 mg/L, but retains an oxygen residual of more than 1 mg/L after a five-day incubation period. If the DO in a bottle did not decrease by more than 2 mg/L, drop that measurement and calculate the remaining dilutions. Likewise, if the oxygen residual in a bottle is less than 1 mg/L, drop that measurement and calculate the remaining dilutions. For example: the initial DO for four dilutions of a single sample is 8.5 mg/L. After a five-day incubation the oxygen residual is 7.9 mg/L, 5.7 mg/L, 4.3 mg/L, and 0.5 mg/L (representing a dissolved oxygen change of 0.6 mg/L, 2.8 mg/L, 4.2 mg/L, and 8.0 mg/L respectively). Since the first dilution did not decrease the required 2 mg/L, do not use this dilution in the calculation of the sample's average BOD value. Also, the fourth dilution left an oxygen residual less than 1 mg/L and should not be used in the calculation of the sample's average BOD value.

Occasionally a series of dilutions will all be bad. Either none of the dilutions will give a DO decrease of 2 mg/L or all dilutions will use up almost all the dissolved oxygen in the bottle. If the sample is "weak" in BOD and all the dilutions use very little oxygen (a change of less than 2 mg/L), take the lowest dilution and calculate it out as if it had dropped 2 mg/L. For example, the initial DO of a BOD sample is 8.5 mg/L for three dilutions of 3%, 4%, and 5%. After a five-day incubation, the residual oxygen level is 8.0 mg/L, 7.5 mg/L and 7.0 mg/L (for a DO change of 0.5 mg/L, 1.0 mg/L, and 1.5 mg/L respectively). Since none of the sample dilutions meet the 2 mg/L DO change, calculate the lowest diluted sample (the 5% diluted sample) as if the change

was 2 mg/L rather than the 1.5 mg/L measured value. Then report the result as “less than (<) this calculated value.”

Calculations where all dilutions have an oxygen residual of less than 1 mg/L are done similarly. But in these cases, calculate the result using the highest diluted sample as if the oxygen residual is 1 mg/L and report as “greater than (>) this calculated value.”

While the greater than (>) and less than (<) designations on results are the best you can do under the circumstances, it is best to avoid it all in the first place by developing a series of dilutions where at least one sample will fall within the proper range. Even if you know, for example, that the BOD result for the final effluent is less than the permit limit, you should still strive for accuracy. You cannot add, subtract, multiply, or divide “less than” or “greater than” signs. Especially when these sample results must be used in calculations to determine plant loadings or removal rates.

Blame the sample:

Sometimes the sample may be toxic to the bacteria, or seed, that break down the wastes. This is often seen as decreasing BOD results on a sample coinciding with decreasing dilution rates. For example, three dilutions (1%, 2%, 3%) of an industrial wastewater sample gives results of 450 mg/L, 375 mg/L, and 250 mg/L respectively. This indicates a level of toxicity in the sample. In these cases, calculate the BOD value using the most diluted sample (450 mg/L) since this shows the least effect of toxicity.

This article concludes the series on BOD analyses. It takes lots of knowledge, time, and experience to get the test to work properly. And then there will be times that the bugs in the BOD bottle will do as they want anyway. Hopefully, the information presented in these articles will help you in your laboratory to achieve greater BOD accuracy. As usual, check your federal, state, and local regulations. You may have additional regulations or reporting requirements that you must meet.

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