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The Wastewater Insight

Environmental Leverage INC.

BOD5-CBOD-NBOD?

What is the Difference in BOD, BOD5, C-BOD and N-BOD, I am so confused, I thought there was only one way to measure BOD?

BOD technically stands for Biological Oxygen Demand

BOD5 means the test has been run for 5 days.

C-BOD means only the Carbonaceous Biochemical Oxygen Demand

N-BOD means Nitrogenous Biochemical Oxygen Demand

BOD5 typically includes C-BOD and N-BOD unless one or the other is inhibited.

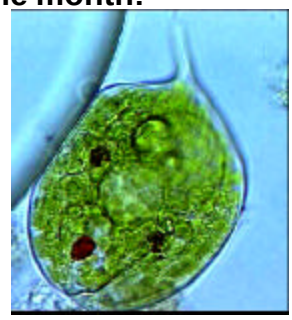
What are the main differences of C-BOD vs. BOD5? There are too many terms and it is getting confusing to me. . . . .
There are two completely different tests-a C-BOD test and a BOD5 test. Many times a C-BOD vs. BOD5 test is needed due to conditions at a plant. In some places where the nitrification of ammonia may not be complete (i.e., incomplete conversion of ammonia (NH3) to nitrate (NO3)) or where too high levels of amines or ammonia are present, false BOD readings may occur. This can occur in municipal lagoons, chemical plants or refineries. For lagoon (pond) treatment systems or other situations where this may occur, it is recommended that a Carbonaceous Biochemical Oxygen Demand (CBOD or Inhibited BOD) should be reported and used in place of 5-day Biochemical Oxygen Demand (BOD5). A special chemical is added to kill the autotrophic bacteria so Nitrification is inhibited so that only the oxidation of COD occurs.

The biochemical oxygen demand (BOD) test tries to closely model an aerobic wastewater treatment system and the natural aquatic ecosystem. It measures oxygen taken up by the bacteria during the oxidation of organic matter. The test usually runs for a five-day period, but can run 7 or 10 days as well, depending on specific sample circumstances.

This conversion of carbon to cells is the synthesis reaction requiring about 0.5 to 0.6 lb O2/lbBOD (KgO2/Kg BOD). If the process is continued, a second oxygen demand is exerted for oxidizing the cells or digesting (stabilizing) the cells. This second phase is endogenous respiration, and requires an additional 0.8 to 0.9 lb O2/lb BOD (Kg/Kg). Pounds (kg) total oxygen required for carbonaceous BOD removal can range from 0.7 lb/lb (kg/kg) BOD for high rate activated sludge with short detention of Biomass (low sludge age) up to 1.5 lb/lb (kg/kg) BOD for extended aeration with long detention of Biomass (MLSS, i.e., (long sludge age) in the bio system.

We started this month out with a new

Mystery Bug of the month!



Check out our website for more photos of our new mystery bug
WWW.EnvironmentalLeverage.com

N-BOD means Nitrogenous Biochemical Oxygen Demand - All forms of 'reactive nitrogen' in urine and proteins (urea, uric acids, ammonia, amino acids, nitrates) are nutrients for algae and aquatic plant growth.

The nitrogenous waste in municipal and industrial sewage is used by autotrophic bacteria and they use a significant amount of oxygen as an energy source and convert ammonia to nitrates. This phenomenon is called N-BOD or Nitrogenous Biochemical Oxygen Demand. The nutrient enrichment 'pollution' contributes to the eutrophication of lakes, rivers and water bodies when discharged in a final effluent.

The TKN (Total Kjeldahl Nitrogen) test measures the amount of reactive nitrogen (ammonia and organic nitrogen) in the sample that can be used by autotrophic bacteria and when they do, require oxygen, thus exerting a N-BOD, which would be equal to 4.6 x TKN mg/l.

Theoretically you can calculate Total Biological Oxygen Demand of any influent = 1.5 x BOD5 + 4.6 x TKN.

While Carbonaceous BOD theoretically should require ~1.5 parts of O2 per part of BOD to be removed, Nitrogenous BOD is significantly higher.
For nitrogenous BOD the demand for oxygen is 4.6 lb O2/ lb BOD (4.6Kg/Kg) removed. To achieve nitrogenous conversion of

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ammonia to nitrate requires longer aeration time with low food to microorganism ratio, i.e., much sludge MLSS (M) with low food supply (F). This condition
results in a long sludge age, which promotes nitrification.

Here is a math example of the Total Biological Oxygen Demand:
What are the oxygen depletion 'pollution' values of raw sewage and what are the treatment efficiencies of different sewage treatment plants

Raw municipal sewage commonly has the following values:
BOD5 = 200 mg/l (still assumed to be C-BOD5)
TKN = 40 mg/l.
Total BOD = 1.5 x BOD5 + 4.6 x TKN = 300 + 184 = 484 mg/l

How you run your tests, how quickly you run your tests, if you have algae in the sample, if you use correct seed vs. plant MLSS can all impact the test results.

Wait a minute slow down. Why should all those factors make a big difference?
Let's take one at a time. If you pull a sample and send it off to a lab and it takes overnight, you already will have a lower BOD in your bottle. The bacteria in the sample bottle will grow. Your bottle is not sterilized. Most of the facultative bacteria that degrade the carbon compounds in the system have a life span of twenty minutes to two hours. If your sample is shipped off to an outside lab and the test is not run immediately, the real results will be lower since degradation will have occurred in the bottle. Endogenous respiration may take up more oxygen than the initial degradation of the carbons you are trying to measure. Another thing to consider, if the sample sits too long and goes septic, there may be a false higher oxygen demand.

Algae in a sample can give a false BOD reading. It will die off in the bottle, re-release some of the BOD and give a higher reading than was initially present.

What type of seed are you using to run the BOD test?
Some plants use a prepared BOD seed tablet.
Many plants use their own MLSS when running a BOD test onsite.
The problem with this is standardization. What if you have a ton of filaments in your mlss at a given point. You are using 1-2 mls of MLSS in your testing. In reality you are only getting so many active bacteria that will grow in your BOD testing. What if you have a very young sludge, what if you have a very old sludge, what if your TSS is lower on one day than the other. All of these variables can change the test results in spite of the fact that you are using the same volume of mlss for each test. The same volume of mlss does not mean the same quality or number of bugs in the 2 mls for each test. Some days you might get better activity and other days less depending upon the current status of your bacteria in your system.

Ok, so how do you get around that - there are companies that manufacture BOD seed tablets. These BOD seed tablets are a

blend of specialized microbial cultures in an easy-to-use capsule. They are designed to provide a uniform standard for the degradation of both industrial and municipal waste in BOD_5 analysis.

B.O.D. seed increases accuracy and consistency in B.O.D. testing and eliminates costs associated with collecting and maintaining an acclimatized seed. Each B.O.D. seed capsule contains specialized microbial cultures to provide a broad range of organisms suitable for most types of industrial and municipal wastewater. One capsule of B.O.D. seed provides enough acclimatized seed for up to 250 B.O.D. tests daily, at a cost of pennies per test and in strict accordance with "Standards Methods" as established by the U.S.E.P.A.
This is an easy way to eliminate any inconsistencies in testing.

All BOD is not the same! What do you mean by that? Well most municipalities have the same flow and the same influent BOD typically 100-150 ppm. Therefore, there should never be problems? Yet why do they have problems?
Ok, suppose it is a big football weekend, everyone has pizza and beer this weekend. Next weekend, everyone is out cleaning their yards, using fertilizer, and weed killer, washing off their utensils, the following weekend, everyone is cleaning their carpets! The total load to the plant may still have been 150 with dilution factors, but some of the major chemistry that is coming down may have
changed. There may be more grease, which can cause filaments or biocides, surfactants, etc. All BOD is not the same! What would you rather eat, pizza and ice cream or broccoli? It is the same to the bacteria, some compounds are very quickly digested, others take more time, or multiple strains of bacteria to break apart the compounds and work on only a small piece at a time.

All BOD really means is the total amount of oxygen consumed, not whether it is simple sugars, or hard to degrade ring compounds! A BOD at a food plant with 150ppm has totally different chemistry than a BOD of 150ppm at a chemical plant.

Also remember that BOD is typically a 5-day test. If you have a holding time of 24-48 hours, you may be in trouble if it takes up to 5 days to degrade all the organics!

Think about what you are doing at your plant, what you are trying to accomplish what you are measuring and are these tests relevant. All these variables may make things easier to run your plant.

Toxicity- what causes it and why does it happen in my plant?

This is a key question to many operators. With the right species of bacteria, very rarely is something "toxic". Usually it is a matter of the right amount of time and sufficient numbers of bacteria to adequately degrade a compound. Bacteria can degrade almost all organic compounds except for triple bond compounds if given the right conditions and the length of time required. Most of the time though, there is not enough bacteria or there is too short of a time in a given system to degrade the compounds sufficiently before it passes out the end of the system. Violations occur or foaming occurs in the system and operators assume their bacteria are dead and there is something toxic. Usually, the case is the opposite and there is too much food but just not enough time. On the other hand, if the loading is inorganic compounds, toxicity can occur. Here are some of the inorganic compounds that may be causing problems to your system.

Inhibition to wastewater treatment by specific compounds (sulfide, sulfur, sulfates, ammonia, nitrite, and nitrate) is usually minor if at all if the biomass in the system has been allowed to acclimate. According to the EPA "Gold Book" (Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program) used by

municipalities to set up their permit levels for local industries sending wastewater to the POTW.

Sulfides - for activated sludge use 25 to 30 ppm, for anaerobic digesters use 50 ppm as the maximum tolerated level. The main problem with sulfides, however, is not that they inhibit the biomass so much as that they tend to form acids with water and are, therefore, very corrosive to the concrete and steel. Also, sulfides would react instantly with chorine, consuming 4.2 parts chlorine per part sulfide (expensive).

Sulfates - Again, EPA Gold Book uses 500 ppm as max. level for anaerobic digesters, no limit for activated sludge systems. The only problem that there seems to be in some cases, is where additional salinity sulfates are added to water, and where the salinity is over 6200, it is toxic to some of the fresh water bioassay species such as daphnia.

Sulfur - No data, no experience as to what the level would be, assuming that at some very high level it would inhibit heterotrophic bacteria (carbon degraders), but not autotrophs (sulfur degraders).

Ammonia - The Gold Book says 480 parts of ammonia for a maximum level in an activated sludge system, 1500 parts for an anaerobic digester. However, bacteria acclimate to ammonia levels, and 1,600 ppm is usually considered the actual top end for acclimated toxicity. The toxicity of amines and other N compounds) is highly pH dependent, the higher the pH the more toxic. At a pH of say 6.8 the ammonia is 100% NH4 (none toxic and very stable). At a pH of 11.0, the ammonia is 100% NH3-N and is very toxic and will readily air strip (not stable). So, acclimation is the key here. There are cases of systems that normally only see ammonia levels of 10 to 20 ppm react to sudden shock loads of 50 ppm. On the other hand, steel mill coker waste streams will typically see well over 250 ppm all the time and have no problem with nitrification. Also, ammonia will react vigorously with chlorine, using about 10 parts of chlorine per part of ammonia.

Nitrite/Nitrates - No references as to inhibition levels. Usually, not inhibitive. Nitrates instead give the bacteria an alternative oxygen source when free O2 runs out, thereby, reducing septicity.

Amines - Amines can be inhibitive, in particular to nitrification. Even at low levels if the nitrifiers are not acclimated to the particular amine species. Usually, nitrifiers are not killed by amines, but the time required to stabilize the amine byproduct in ammonia can be severely extended. Often times, amines are overlooked in the nitrogen balance and will finally break down in the clarifier by the carbonaceous bacteria, thereby not allowing the nitrifiers sufficient time to degrade the ammonia, and violations occur on ammonia not due to toxicity, but due to the time and numbers game. With the right species of bacteria, very rarely is something "toxic". Usually it is a matter of allowing for the right amount of time and the correct number of bacteria needed to break down any organics.

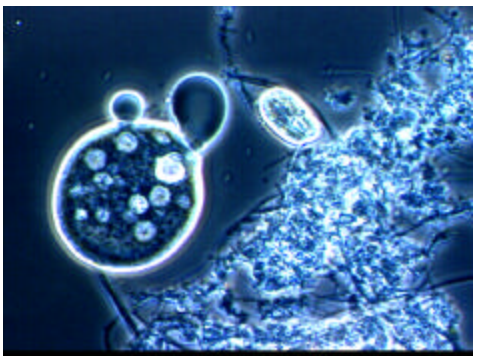
Bacteria can degrade almost all organics except for triple bond compounds if given sufficient conditions. Most of the time, there are not enough bacteria or too short of a time in a given system to degrade the compounds sufficiently before it passes out the end of the system.

Oh no all my bugs are dead! Something toxic must have come through the system!

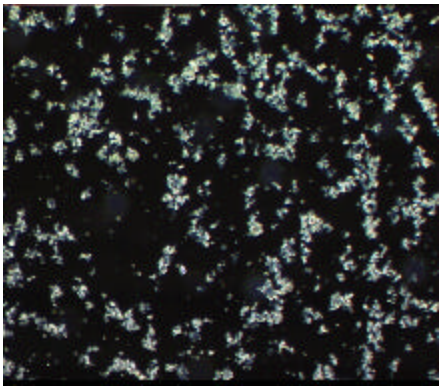
Are your bugs really dead? What exactly are you looking at to determine that your system is dead? Is there a ton of white crisp foam? If you look under the microscope are all the higher life forms dead? Is the floc blown apart and clear, diffuse and weak structures?

Crisp, white, fluffy or billowing foam
In actuality, you may not have a dead system, but you might just have gotten hit with a very high BOD loading and your system is in a young, high growth phase. 98% of the biological degradation in your system is done by the bacteria, not the higher life forms. This is a common misconception in waste treatment plants. The higher life forms, or the little critters that are moving around that you see under the microscope are, in reality, just "indicators" of how well your system is and what conditions are going on in your system.

Higher Life Forms as "Indicator Organisms" -- The higher life forms are often called collectively indicator organisms. This is because they can serve as indicators and early warning of undesirable conditions that have not yet impacted the bacterial population. Bacteria are extremely hardy and resilient creatures. They can survive and even thrive at a variety of temperatures, pH's and dissolved oxygen conditions. They are also fairly resistant to toxic compounds in that they may be inhibited, but still "alive" and capable of quick recovery. The indicator organisms are the last to show up and the first to leave. The type and abundance of protozoa are certainly an indicator of general health and stability of the system. However, higher life form "counts" alone may not be indicative of the bacterial population performance in terms of BOD degradation. For example, a slug of high pH may wipe out the higher life forms for a couple of days, but barely impact the bacteria at all. Also, most protozoa are strict aerobes and will not thrive if the dissolved oxygen levels are depressed. That being said, a significant shift in the protozoan population or the loss of higher life forms for an extended period of time should be considered cause for concern and be investigated.



The situation listed above could be an example of one of two situations, either a high BOD loading, or a large hit of surfactants. A quick and dirty test to determine which of the two it is would be to take a small sample of the water. Place it in a small jar. Shake it up. If it foams like dishwater does in your sink, you probably just got hit with a high load of surfactants and that is what is causing the foaming on your aeration basin. If it does not, another way to verify what is going on is to perform a DO uptake test. This will show if your bugs are in a high growth phase just due to a large amount of food or BOD loading



Weak dispersed floc that can cause high TSS problems

DOUR Test Procedure

Catch fresh sample in a 500ml or 1 liter bottle.
In the lab, shake sample vigorously to saturate sample with oxygen.
Fill BOD bottle with the aerated sample. Put DO probe in bottle making sure to eliminate any air bubbles. Start the magnetic stirrer.
Allow the DO readings to stabilize and record the initial reading as DO_i. Take the DO reading every minute for ten minutes. The final reading will be DO_f.

Calculate DOUR using the formula: DOUR= (DOi - DOf)/ (Tf - Ti) x 60 Units will be mg/l O_2/hr
High DOUR readings mean there is an abundance of food and the bugs are in a high growth phase
Low DOUR means there is a lower biological activity

Ok so now that I know I just got hit with a high BOD loading, what is this going to do to my plant?

There are a number of things that can happen. Usually there will be an increase in TSS or BOD in the final effluent if your system holding time is too short and unable to handle the surge. It depends upon your system and the flexibility you have to make process changes.

What can I do about it? If you have activated sludge, you can play with the WAS rates or RAS rates. Your plant will recover eventually in time. The key question is, do you have enough time?

One quick way to help you out of an upset if you do not have time or flexibility is bioaugmentation. Bioaugmentation for upset control is an excellent way to help your system recover quicker, better and less costly that having to add a ton of polymers to the clarifiers as a Band-Aid. The addition of biological products allows the plant to maintain or quickly regain acceptable performance to avoid permit violations.

Biological Product Description
Environmental Leverage products are biological products specifically formulated to be effective in

enhancing wastewater biology during upset conditions.

Through extensive research activities, the products have been developed to involve numerous strains of bacteria, which have been selected for their ability to perform under both aerobic and anaerobic conditions,

and to biodegrade organic material comprised of proteins, fats, carbohydrates and select hydrocarbons.

To assure rapid establishment in the biomass, the products are produced and blended with select biological nutrients and stimulants. The bacteria are produced under ISO 9002 certified quality conditions.

Effect
Environmental Leverage products, with their aerobic and facultative anaerobic microorganisms-establishes and maintains a biomass which by providing greater resistance to the effects of organic inhibitors present in waste waters, are able to perform more effectively than the naturally occurring biomass. Environmental Leverage products ensure that the natural mechanism for the selection of the biomass population is presented with a range of selected microorganisms. These aerobic and facultative anaerobic bacteria have been taken from their natural environment and then adapted to give optimum performance.

Guides or Publications
Or Misc. websites

http://www.toxicitylab.com/content/services/toxicity_testing_faq.php
Wastewater Toxicity Testing FAQ

http://www.epa.gov/WET/
Whole Effluent Toxicity (WET) Methods

http://cfpub.epa.gov/ecotox/
The ECOTOX (ECOTOXicology) database provides single chemical toxicity information for aquatic and terrestrial life.

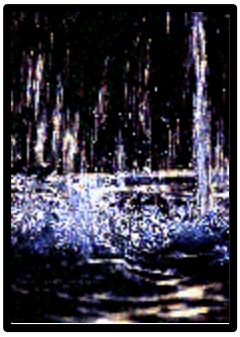
http://www.nj.gov/dep/oqa/powerpoint/DEPBasicsCourse.ppt
powerpoint on WET basics

http://www.toxicity.com/
This site contains the latest research and information on WET testing for those who must negotiate and comply with NPDES permit limits or discharge monitoring requirements for whole effluent toxicity.

http://www.dep.state.fl.us/labs/cgi-bin/sop/biosop.asp
Florida EPA site with tons of information and SOP's

http://www.setac.org/
The Society of Environmental Toxicology and Chemistry (SETAC) is a nonprofit, worldwide professional society

http://www.lagoonsonline.com/laboratory-articles/bodtest.htm
Numerous articles, SOP, methods and troubleshooting on BOD testing, nitrification, etc, excellent site and easy to find things



Many times we have suggested articles for the next months issues. Sometimes we change what we will be featuring based upon critical issues that surface during our contacts with our customers. We hope this does not inconvenience you. If you have a specific topic you are interested and do not want to wait to see if it shows up in our newsletters, call us direct. We do have over 20 gigabytes of information on file on every subject around on water and waste issues.

COMING IN THE NEXT MONTHS . . . . .

Rain, Cold Weather and Grease
Winter filaments and MLSS