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BIOCHEMICAL OXYGEN DEMAND

BACKGROUND

Being in the wastewater treatment field requires a lot of knowledge of wastewater pollutants, environmental discharge quality requirements as well as treatment options for different target pollutants. In the domestic wastewater treatment field, the most commonly measured parameters are total suspended solids (TSS), fecal coliform, total phosphorus (TP), total nitrogen (TN) and the biochemical oxygen demand (BOD). The definition of each of these parameters is pretty clear, but the last one deserves a bit more of an explanation in order to fully grasp its significance and its impact on the environment.

WHAT IS BOD?

Although it is generally considered a pollutant, BOD is actually an indicator of the degree of pollution in an environment. The microorganisms present in an environment assimilate biodegradable organic compounds as a source of energy. The assimilation process, aided by the oxidization of the compounds, consumes available oxygen in their environment. It is this demand for oxygen required by the assimilation of these compounds that is evaluated by the BOD. The extent of this oxygen demand is impacted by, among other things, the quantity of organic matter in the wastewater (Olivier, 2017).

DIFFERENT VARIATIONS OF BOD

The biological degradation of organic materials requires multiple days and evolves over time. As a result, the duration of these tests during a sample analysis needs to always be indicated.

UBOD

Ultimate biochemical oxygen demand (UBOD) represents the demand for oxygen that would be required to oxidize all the biodegradable material in an environment.

BOD_{20}

In practice, BOD20 results produced in a laboratory represents the UBOD of natural degradation. After 20 days, all the oxidizable compounds are generally considered oxidized (Actu Environnement, 2021; Marc Olivier, 2017).

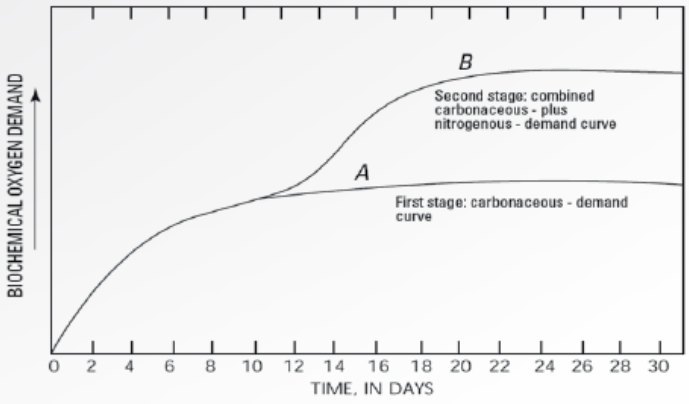
Why isn't BOD_{20} used, knowing that it represents the actual BOD? The reason is in the number of days required to evaluate the parameter. A delay of 20 days before receiving the results of a sample analysis is just too long.

BOD_5

A representative indicator was needed that required a shorter delay to analyse. Many countries chose the oxygen consumption over 5 days, which corresponds to the oxidation of the pollution that biodegrades fastest. This conventional duration comes from England, where its use was justified in 1912 by the fact that river water discharges take less than 5 days before reaching the ocean (UVED, 2013). The first authority to recommend this technique was the Royal Commission for Sewage Disposal. Following this, BOD5 quickly became a dominant parameter in wastewater treatment. In 1937, the American Public Health Association Standards Committee used it as a reference indicator. In France, it became a standard parameter in 1998 (NF EN 1899-1 and -2). Today, BOD5 is implemented around the world to monitor the majority of urban and industrial wastewater treatment factories (Magnin et col., 2015). An important fact to know is that BOD5 represents only a partial indication of the actual demand, corresponding to a range of 60 to 85% of the ultimate biochemical oxygen demand.

CBOD and NBOD

BOD is separated into two types: the carbonaceous biochemical oxygen demand (CBOD) and the second stage BOD, also referred to as the nitrogenous biochemical oxygen demand (NBOD). Despite the fact that the NBOD usually doesn't appear until after a few days of incubation, it can be desirable to eliminate the portion of BOD associated with this nitrification. By using a nitrification inhibitor during the analysis, the effluent results are indicated as CBOD instead of BOD (Rich, 2003). The lower curve represents the CBOD.



Mirza (2012)

WHY IS $CBOD_5$ PREFERRED IN THIS FIELD?

Since the objective is to establish an indication of the pollution, the BOD_5 can be misleading since it is generally inflated by the nitrification mechanism ($NBOD_5$) which occurs during the BOD_5 tests. Contrary to the carbonaceous demand, which is proportional to the concentration of the carbonaceous biodegradable components in the effluent, the nitrogenous demand appearing during the 5-day test is proportional to the number of nitrifying organisms captured in the sample being tested. As a result, the BOD_5 cannot be representative of the impact of the effluent on the environment while a large number of nitrifying microorganisms are present. A concrete example of the difference between the BOD_5 and the $CBOD_5$ is presented in Figure 1.

Also, in the domain of decentralized wastewater treatment, the $CBOD_5$ is preferred because it specifically measures the concentration of biodegradable carbonaceous matter and isn't really affected by other factors in the way that the nitrogenous portion is.

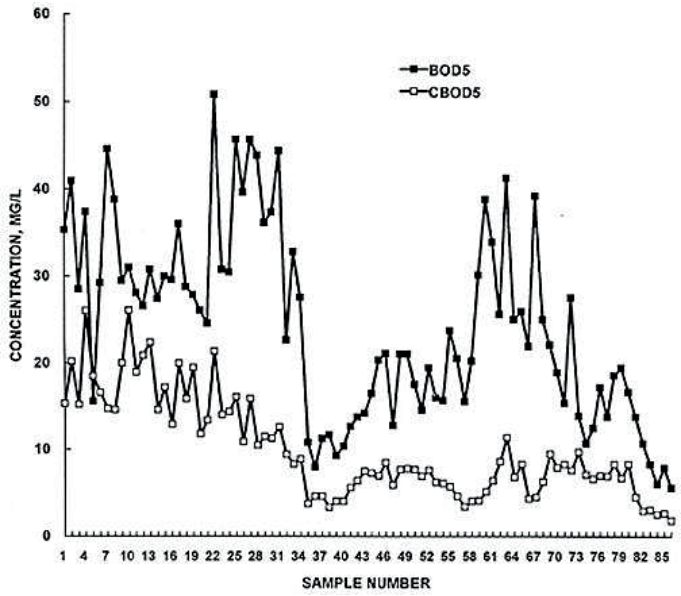


Figure 2. Comparaison entre la DBO_5C et la DBO_5 (Tiré de Rich, 2003)

BOD'S ENVIRONMENTAL IMPACT

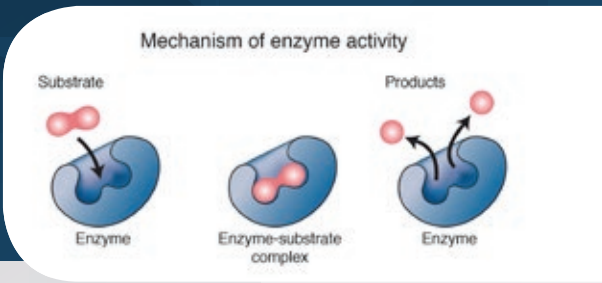
The health of a body of water is reflected by its biodiversity and its appearance, which are directly impacted by the presence of sufficient oxygen and by the balanced amount of organic nutrients. In fact, a well oxygenated body of water is an ideal environment for the proliferation of most aquatic species. The discharge of water with a high BOD concentration into a waterway can have a very negative effect on the environment. Specifically, the consummation of the oxygen present in the ecosystem for pollutant degradation and the increase of organic sediments. The depletion of oxygen as well as the accumulation of organic sediments at the bottom of a body of water are two major players associated with the eutrophication of a waterway. The proliferation of algae due to the presence of an excessive amount of phosphorus and nitrogen are not the only causes. Treating organic matter associated with the BOD in wastewater that discharges into the environment is vital to its sustainability and health.

HOW IS BOD REDUCED?

In the presence of digestible nutrients, microorganisms produce catalytic proteins, also known as enzymes. These enzymes accelerate biological reaction by breaking down molecules into smaller units (the product of the enzymatic reaction), making them more easily assimilable. This mechanism is initiated by the recognition of the substrate by the active site on the enzyme, as shown in the figure below.

Each enzyme, thanks to its active site, is specific to a certain substrate. In function of which pollutants are present in the water, a biomass producing the enzymes that are adapted for the substrates available will generally have a greater chance of establishing themselves.

Thanks to enzymatic activity, the most complex molecules are therefore better assimilated by the microorganisms. A part of the organic load will then be used in catabolism by the microorganisms (degradation of complex molecules to release energy for cellular function) so that they can be used for the anabolic pathways required for synthesis of molecules that are required for the growth and reproduction of cells.



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CONCLUSION

Even though the term "biochemical oxygen demand" is familiar, the details behind this parameter are sometimes unclear. The explanation of the concept, the different types of BOD and the reasons behind their uses are briefly skimmed through. The impact of the BOD on the environment as well as the mechanism of its treatment is also explained.

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