# Assessment over time of Biochemical Oxygen Demand using a wireless sensor

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**The RESPIROMETRIC Sensor by VELP Scientifica, associated with the Wireless DataBox™ and the RESPIROSoft™ dedicated software, allows to observe in real time the progress of the BOD analysis. The method maximizes the reliability of measurement and allows to analyze the trend of the oxygen demand by the microbial community over time.**

The Biochemical Oxygen Demand (BOD) is a widely used parameter to assess the quality status of various kinds of water, including sewage, effluents of wastewater treatment plants (WWTPs), and rivers. Knowing the biodegradable organic matter content of a water sample has several applications, including environmental, health and/or management issues, as the BOD (usually measured as $BOD_5$, i.e. BOD consumed in 5 days) is a good indicator of both the water overall quality and the efficiency of WWTPs. Its high value as an environmental indicator is related to its property of representing the phenomenon of water deoxygenation which, in turn, may cause considerable damage to the aquatic biocoenosis.

In the environmental and ecological field, but also in WWTP management, tracking the evolution of the BOD over time may subsequently present applied developments of noticeable interest. This knowledge can lead to a better understanding of the kinetics of organic matter degradation in the presence of different substrates and conditions, and allow to develop a greater capacity to protect the concerned ecosystems.

**VELP RESPIROMETRIC Sensor, a new approach for the determination of BOD**

This work was developed to evaluate the effectiveness of the RESPIROMETRIC Sensor system (Fig. 1), manufactured by VELP Scientifica, for respirometric tests and for the measurement of BOD trend over time. The system is composed by the sensor, which is put directly on the bottle containing the sample; by the Wireless DataBox™, that automatically receives data sent by the sensor and transfers them into a computer; and by the dedicated software RESPIROSoft™.

***Fig. 1***

The sensor measures, within a closed atmosphere, the progressive decrease of the internal pressure and provides a measure of the oxygen consumed by the microorganisms directly in mg/L. The measurement is available for four different scales - 90, 250, 600 and 999 mg $O_2$/L.

The detected data are sent wireless to DataBox at regular intervals, which may be set by the user (from 30 min. to 24 hours). The remote data transmission ensures a high reliability, since there is no need to open the door of the incubator, thus eliminating the risk of substantial variations in the internal temperature. The RESPIROSoft software allows the operator to monitor and record the analysis progress, and produces reports of the experiment (including a graphical representation).

## Results

The experiment was conducted on samples of wastewater, with known COD and $BOD_5$/COD ratio to assess the measurement scale among those available for the sensor. The tested samples were prepared by mixing different amounts of sewage, industrial wastewater, and freshwater. In this way it was possible to perform the tests (with three replicates) on samples belonging to the 90, 600 and 999 mg/L scales, respectively labeled as "type 1", "type 2" and "type 3" wastewater. The variation over time was recorded at 12 hours intervals for 28 days, assuming $BOD_{28}$ = Total BOD.

Standard deviation among replicates (Table 1) is very small, demonstrating that the RESPIROMETRIC system minimizes external interference.

The results show that the trend of the BOD in time does not deviate from the theoretical value expected from wastewater with significant presence of domestic sewage (Tchobanoglous et al, 2003), for which the BOD5 is about 70% of the total BOD, while the BOD20 reaches 99% of the total BOD (see the example of the “type 3” wastewater in Fig. 2).
Actually, the plateau level was reached after 18 days in all the tested cases.

The most significant difference was observed in the “type 2” wastewater, for which the BOD5 was found to be 62.5% of the total BOD. The explanation for this divergence is evident with the analysis of the BOD over time, made possible by the record made with the RESPIROMETRIC system.

As shown in Fig. 3, starting from day 15 an increase of the slope of the BOD curve was observed, with a “step” trend between days 15 and 18. After that, the increase of BOD practically stopped, having reached the expected value.

Normally, this type of increase in the BOD value is related to the oxidation of nitrogen compounds (in particular ammonia) produced by the hydrolysis of proteins. This process is caused by autotrophic ammonia oxidizing bacteria which represent a small fraction (<10%) of the total bacterial population which is strongly dominated by heterotrophic bacteria. However, the oxygen demand for the oxidation of ammonia usually starts from the sixth day, and hardly at all after the tenth, from the beginning of the degradation reactions. In the examined case, the autotrophic bacteria fraction could have been very poor and needing longer time to develop and become active.
However, it is more likely that the sample contained recalcitrant compounds (from the industrial wastewater), whose decomposition started only when the easily degradable fraction of organic matter had been depleted, according to the ecological concept of trade-off (Sibley & Calow, 1986).
In fact, the BOD curve was not so far from the plateau level before the second stage increase. Both possibilities have environmental and/or management implications, and the analysis of the BOD over time allowed to identify the possible criticality.

| Wastewater | Type 1 (BOD < 90 mg/L) | Type 2 (BOD < 600 mg/L) | Type 3 (BOD < 999 mg/L) |
|---|---|---|---|
| **$BOD_5$ (mg/L)** | 56 ± 4 | 261 ± 3 | 616 ± 3 |
| **$BOD_5/BOD_{28}$** | 0,700 | 0,625 | 0,745 |
| **$BOD_{20}$ (mg/L)** | 79 ± 4 | 411 ± 2 | 824 ± 3 |
| **$BOD_{20}/BOD_{28}$** | 0,975 | 0,984 | 0,996 |
| **$BOD_{28}$** | 81 ± 3 | 418 ± 7 | 827 ± 6 |

***Table 1***
*BOD value (mean ± standard deviation) at 5, 20 and 28 days for the various wastewater, and ratio between measured and total (=$BOD_{28}$) BOD*

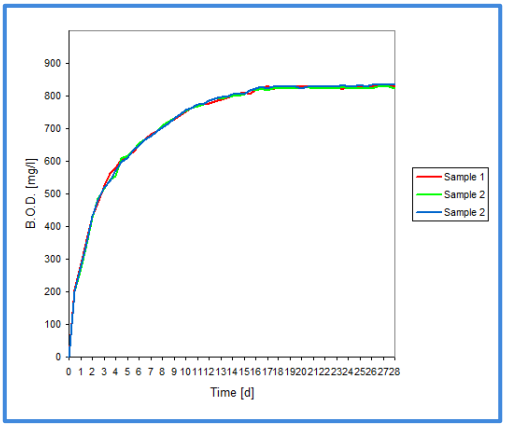


***Fig. 2***

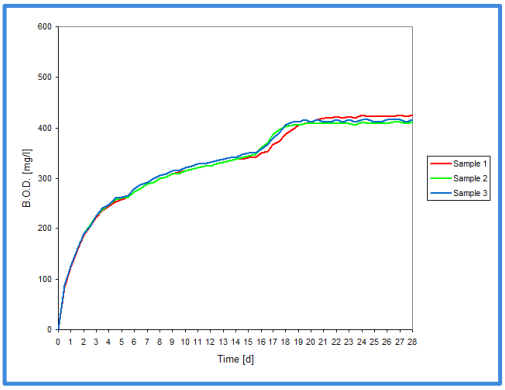


***Fig. 3***

## Conclusion

The RESPIROMETRIC system, used to analyze the biochemical oxygen demand in samples made of different kinds of wastewater, has allowed to obtain reliable measurements thanks to its ability to transmit the data, through the wireless receiver, to a dedicated software RESPIROSoft, thus minimizing interference in the analysis.
The RESPIROMETRIC system ability to archive and process BOD values over time has also enabled to evaluate the regularity of the consumption of oxygen by the biological communities. In this way, an anomaly in one of the analyzed wastewaters was detected.
The ability of evaluating the consistency (or any discrepancy) of the oxygen consumption curves with theoretical models has practical use in environmental analysis and management issues.

## Literature


Sibley, R., and P. Calow. 1986. Physiological ecology of animals. Blackwell, Oxford, U.K.

Tchobanoglous, G., F.L. Burton, and H.D. Stensel. 2003. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse, McGraw Hill, New York, USA.




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