BM Respirometry

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Introduction

In any wastewater biological treatment process, the measurements only related with the nature of the water or with the physical behaviour of settling and solids in the mixed liquor, do not combine enough decisive data for a complete characterisation of the wastewater biological treatment.

Activated sludge is a living and breathing process and a lack of bioactivity information might cause serious confusion in the wastewater treatment assessment and control.

This bioactivity information is acquired by means the Respirometry technology and the measuring system for that is called Respirometer.

An appropriate Respirometer, in a very fast and practical manner, by making use of the actual genuine activated sludge, can provide the treatment plants operator the essential information to help determine the management to protect and control the biological process of the plant.

The use of the Respirometry can not only control the process on daily basis but also to get problems diagnosis and to avoid future problems.

Respirometry
General Concepts

Glossary of Terms

Activated sludge: Mixed-liquor composed by biomass and wastewater, used to treat wastewater in an aerobic reactor (aeration tank) by means an Activated Sludge Process (**ASP**) in Wastewater Treatment Plant (**WWTP**)

Aeration tank: Biological reactor of the WWTP - Also called aeration basin

Aerobic: Biological treatment where air should be present for substrate oxidation (biodegradation)

Anoxic: Biological treatment without air.

ASP conditions: pH, Temperature, Dissolved Oxygen, ... in which the ASP is actually running.

Biodegradable: Condition of substrate to be biologically oxidized and removed by means the microorganisms of the activated sludge.

Biodegradation: Oxidation of the substrate in the ASP from which is removed by.

Biomass: Microorganisms population contained in the activated sludge.

Denitrification: Part of the ASP in which Nitrate are eliminated in one anoxic zone and transformed into nitrogen gas.

DO: Dissolved oxygen in the aeration tank

F/M: Organic material (BOD) rate / Biomass ratio going in the activated sludge process (ASP) – It is one important ASP control parameter.

Inhibition: Lack of biological activity in the biomass due to any compound in wastewater or ASP bad conditions.

Mixed-liquor: Wastewater + activated sludge contained in the biological reactor of one WWTP

Nitrification: Part of the ASP in which ammonium is removed and passed into nitrate.

Operative parameters for ASP: Parameters to control the ASP (**F/M** & Sludge Age: **MCRT**)

Respiration rate in activated sludge: Amount of oxygen consumed on time basis due to its own survival activity (endogenous respiration) and when the sludge is on the oxidation process of the substrate

Solid biomass: Biomass attached to a solid carrier (Biomass-carriers, Beds, Biofilm, Granular biomass,...)

Substrate: Material (biodegradable COD and Ammonium) to be removed (oxidized) by the activated sludge.

Toxicity in activated sludge (%): Sludge bioactivity elimination due to the presence of some toxicant in wastewater.

What is the Respirometry ?

It is a technology about the measurement and interpretation of the oxygen consumption (as uptake rate or accumulated) from an aerobic biochemical reaction in the activated sludge process from one wastewater treatment plant.

This oxygen consumption (respiration) comes from the microorganisms contained in the activated sludge as their survival phase (endogenous) and biological oxidation of the biodegradable materials (exogenous)

Respirometry could be seen from two aspects:

- Analysis of the own mixed-liquor without the addition of any sample
- Analysis of the effect of one specific sample in the biomass.

On what are based the Respirometry applications ?

- Sludge is more active when it respires faster (consumes oxygen)
- The more substrate to oxidize the more oxygen to consume.
- Oxygen uptake rate is proportional to sludge activity.
- The oxygen consumed by the activated sludge for organic substrate oxidation, is proportional to the eliminated biodegradable fraction of COD.
- It exist a specific oxygen uptake rate for the Nitrification process.
- The operational parameters of the biological treatment process are direct or indirectly related with the bacteria respiration.
- Under standard conditions, the reduction or absence of oxygen consumption by the bacteria may signify the presence of a toxicant that is specifically affecting the bacteria of the sludge.

In general, what are the benefits that we can obtain from the BM Respirometry use?

- Time saving in the ASP control.
- Daily updated operational parameters.
- Problems prevention, such as bulking and foaming.
- Anticipation to the problems knowledge
- Problems solutions find out.
- Energy optimization and saving.
- Toxicity detection.
- Accurate activated sludge activity follow-up.

BM Respirometry

What is BM Respirometry ?

It is a technology designed by SURCIS that combines the traditional Respirometry with a state of the art method that permits to carry out different types of tests on fast and simple way to measure the oxygen uptake from the microorganisms of the activated sludge.

BM - Respirometry can work on different combinations:

- **Activated sludge (mixed liquor) or solid biomass**
- **Activated sludge or solid biomass + wastewater sample**
- **Activated sludge or solid biomass + standard compound**

Main automatic BM Respirometry parameters

- **OUR (mg O2/l.h): Oxygen Uptake Rate**
  It measures the oxygen uptake rate from the activated sludge within only one measurement along certain period of time.

- **SOUR (mg O2/g VSS.h): Specific OUR**
  Specific OUR related to MLVSS. SOUR = OUR / MLVSS

- **Rs (mg O2/l.h): Dynamic Respiration Rate**
  It measures the oxygen uptake rate from the mixture of the activated sludge and certain amount of wastewater sample or compound within a continuous chain of measurements.

- **Rsp (mg O2/g VSS.h): Dynamic specific respiration Rate**
  Specific Rs related to MLVSS. Rsp = Rs / MLVSS

- **bCOD (mg O2/l): Biodegradable COD**
  Biodegradable COD fraction, based on Rs measurements integration from a mixture of activated sludge and biodegradable sample.

- **rbCOD (mg O2/l): Readily biodegradable COD**
  Soluble readily biodegradable COD fraction, based on Rs measurements integration from a mixture of activated sludge and soluble biodegradable sample.

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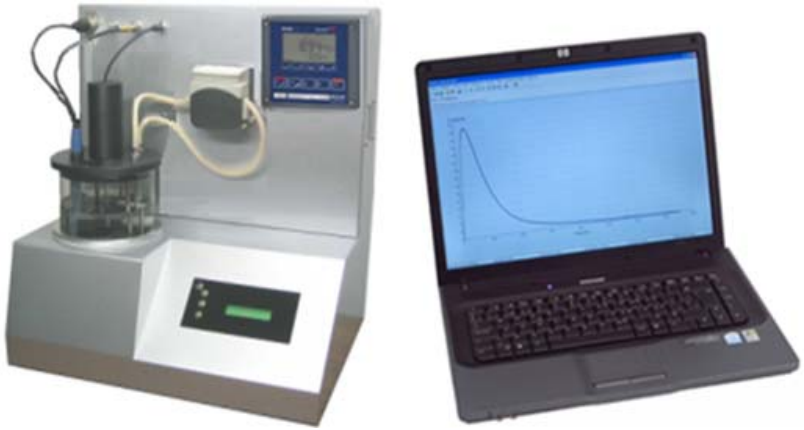
BM Respirometers from SURCIS

BM-T respirometer

BM-Advance respirometer



BM-EVO respirometer

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BM respirometers are the only ones in the market doted with three different operation modes

Static mode

For fast assessments

Cyclic mode

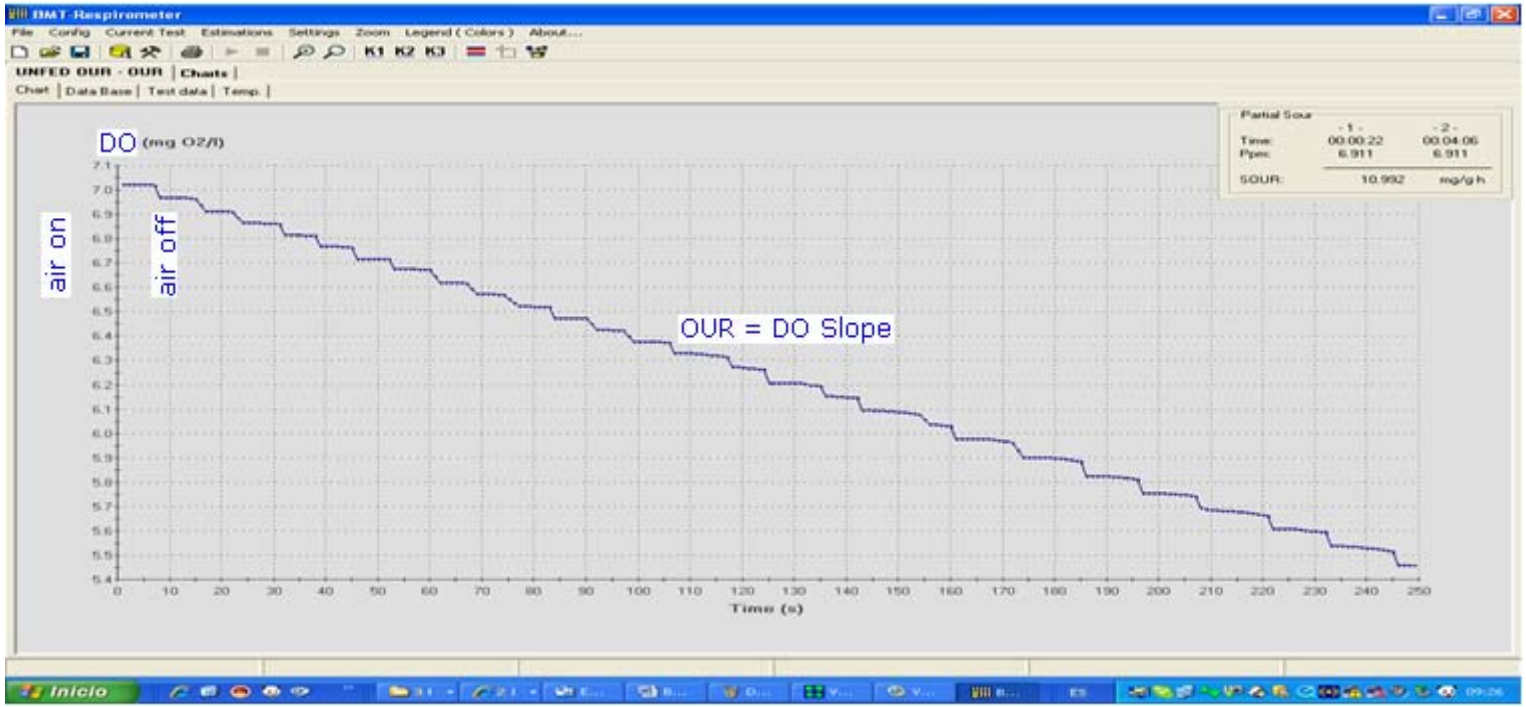
For ASP reproduction

Dynamic mode

For wastewater in activated sludge analysis

Static Mode

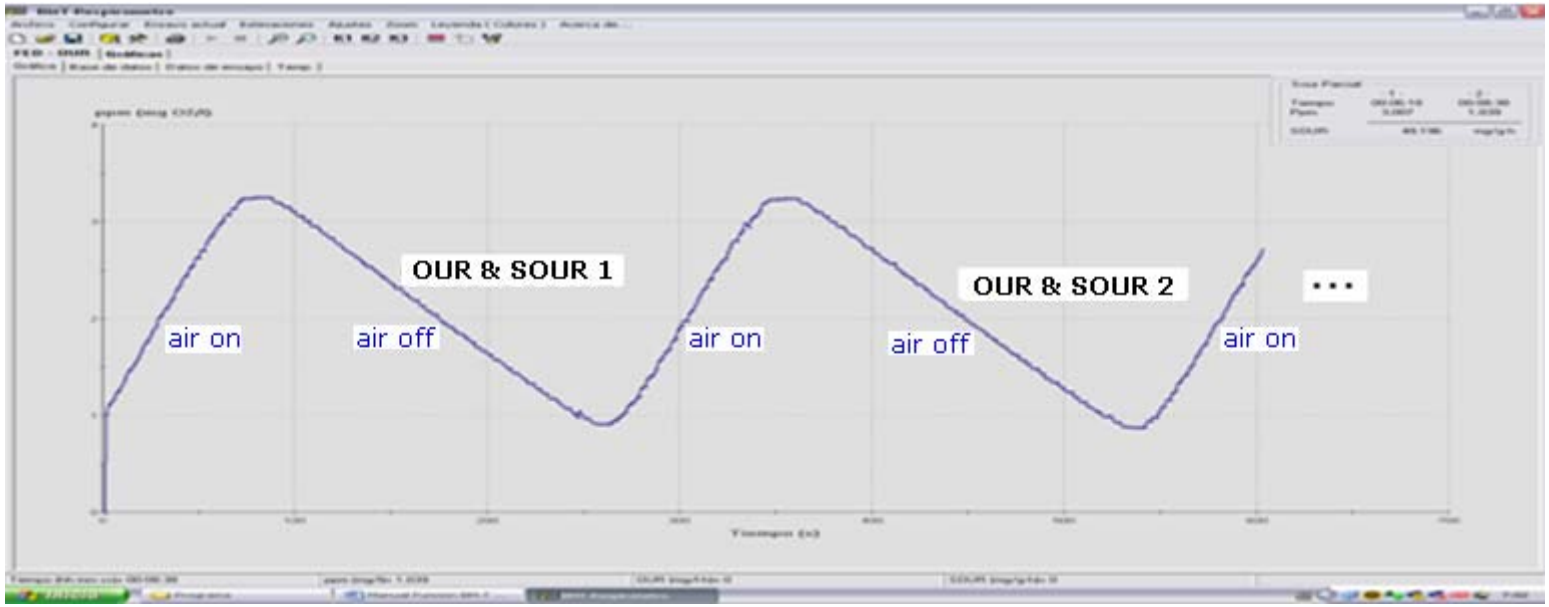
Measurement	Description
OUR (mg O2/l.h)	**Oxygen Uptake Rate** in mixed-liquor
SOUR (mg O2/gVSS.h)	**Specific OUR** related to MLVSS



OUR & SOUR Static Respirogram

Cyclic Mode

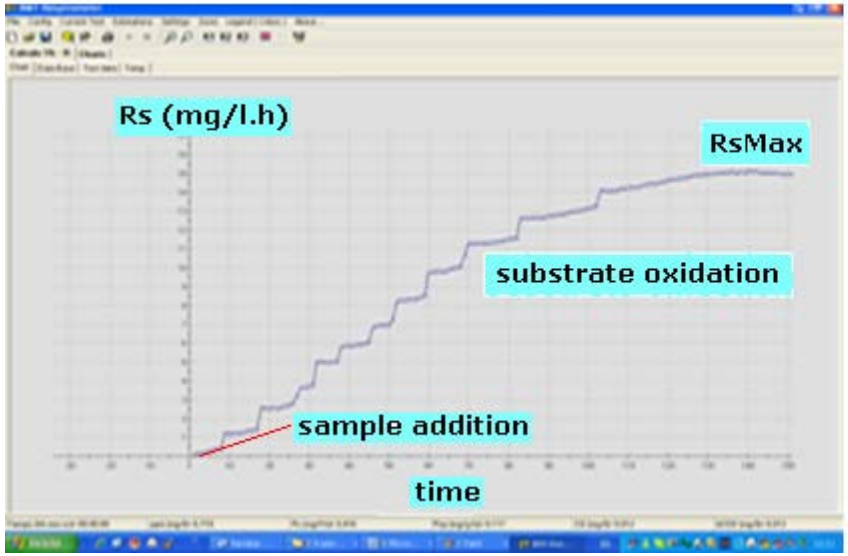
Measurement	Description
OUR (mg O2/l.h)	**Sequential** **Oxygen Uptake Rate** in equivalent mixed-liquor
SOUR (mg O2/gVSS.h)	**Sequential** **Specific OUR** in equivalent mixed-liquor



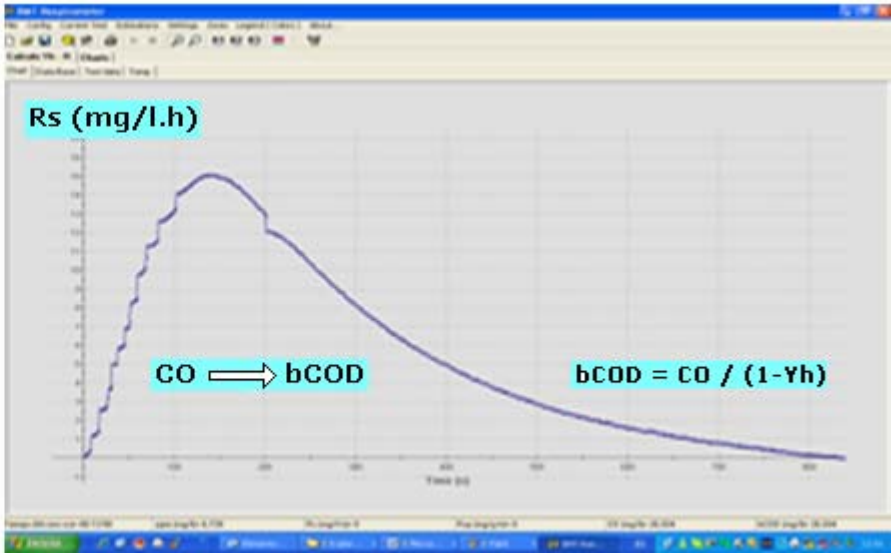
OUR & SOUR Cyclic Respirogram

Dynamic Mode

Measurement	Description
Rs (mg O2/l.h)	**Dynamic Respiration Rate** Dynamic Respiration Rate
CO (mg O2/l)	**Consumed Oxygen** BOD short term
bCOD (mg O2/l)	**Biodegradable Fractions of COD** rbCOD: readily bCOD sbCOD: slowly bCOD

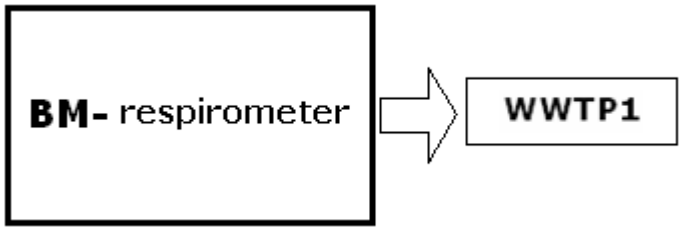
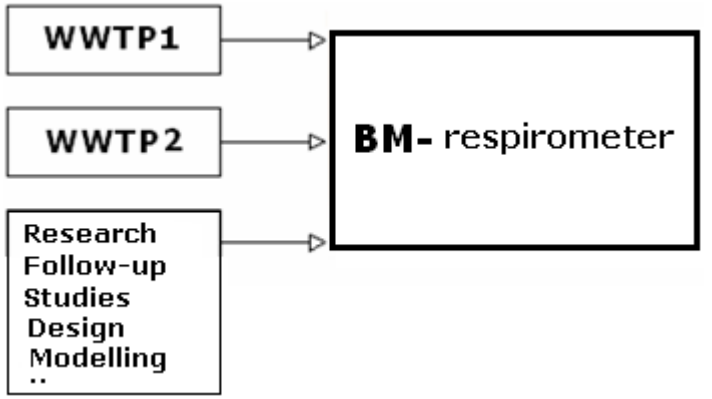
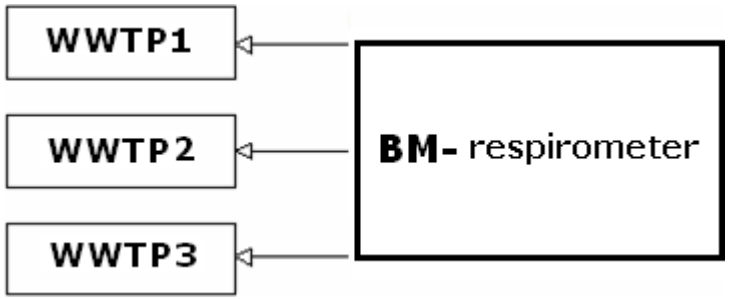


Effect of the wastewater in the Activated Sludge



bCOD

Main working modes in BM Respirometers

As fixed installation in the WWTP lab	BM is installed in the laboratory and exclusively used for one WWTP.	
As fixed installation in a centralized lab	BM is installed in a centralized lab in order to give variable service, by analysis of different wastewater samples and sludge that are regularly coming for different purposes.	
As easy portable for several WWTPs (only BM-T model)	BM-T analyzer is used as easily portable to give service to several plants, by going up from one to the other.	

BM Respirometry represents one step forward in the biological municipal & industrial wastewater treatment

for

- **Process management**
- **Design**
- **Research**

BM Respirometry for process management

- Operative parameters and conditions
- COD fractioning
- Nitrification - Denitrification
- Inhibition
- Energy opimization

Operative parameters and conditions

Through BM Respirometry we can get the correct operative parameters to maintain the activated sludge process (ASP) under determined levels that will avoid the plant operator get unpleasant and unexpected problems (thin biomass, bulking, foaming, ...)

Operative parameters

- **Food / Microorganism ratio (F/M - Loading rate)**
- **Sludge age (MCRT – SRT)**

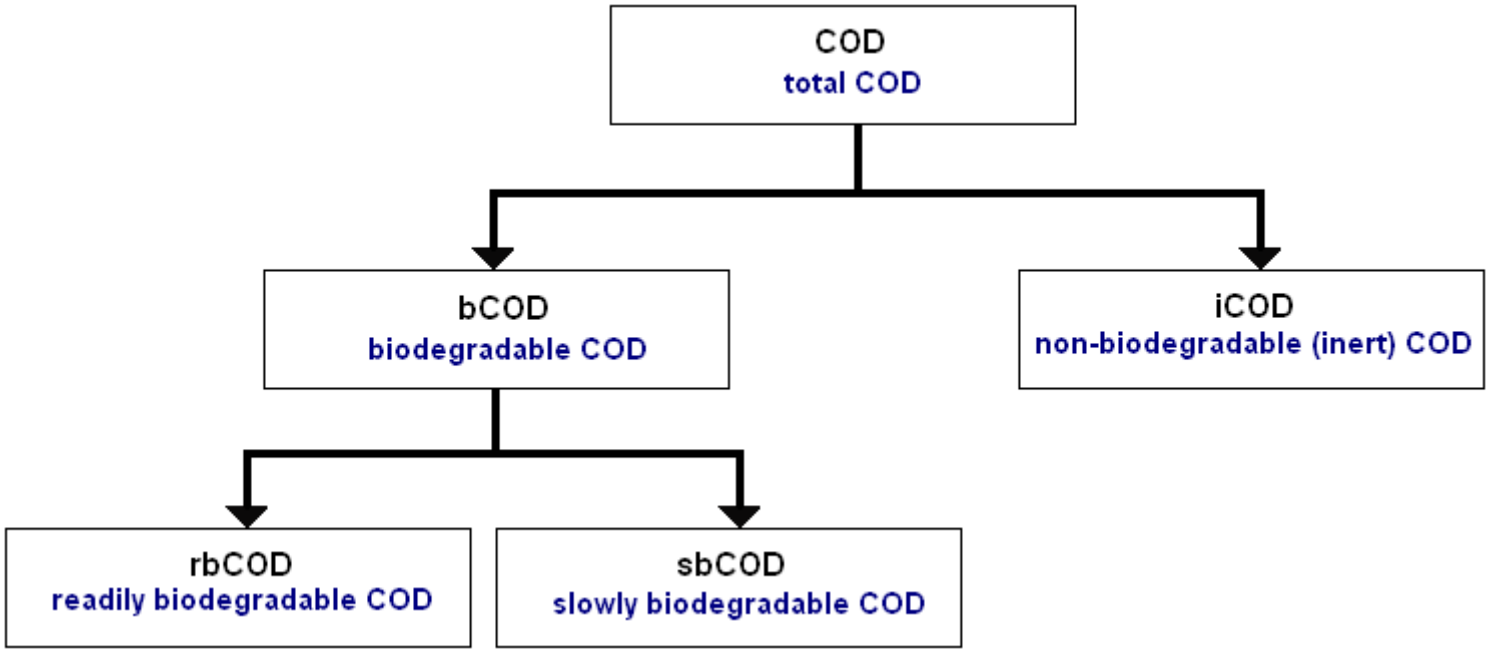
Conditions

- **Dissolved oxygen level**
- **pH**
- **Conductivity**
- **...**

COD fractioning

By means a couple of Respirometry tests we can determine the different fractions in which COD is divided.

This fractioning is very important because here we can determine the % of very slowly biodegradable COD (sbCOD) or the % fraction that the biological treatment cannot remove because it is not biodegradable (iCOD)



Nitrification – Denitrification

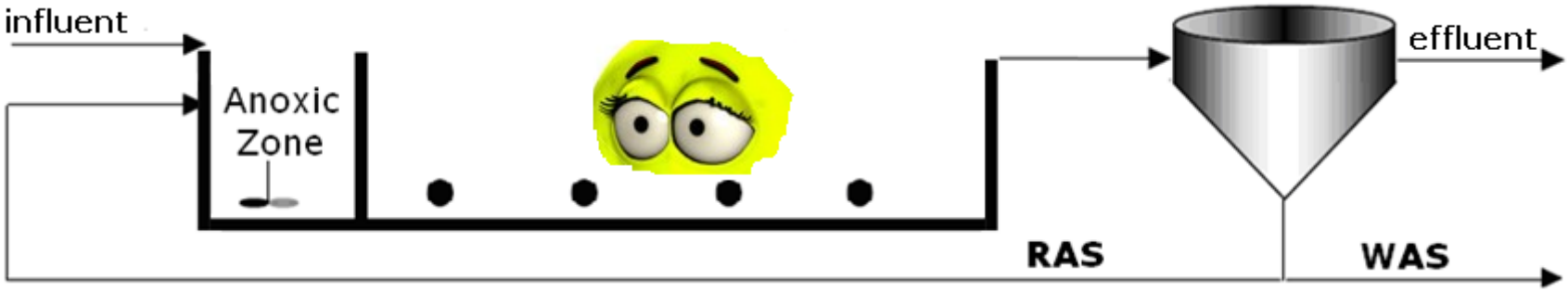
Ammonium removal (Nitrification) and then Nitrate, under the frame of best performance and energy saving, constitutes a key point in the activated sludge process; and the BM Respirometry has demonstrated to be the best tool for it.

The key factors are

1. **Optimal conditions of pH, temperature and oxygen**
2. **Minimum sludge age**
3. **Available time for Nitrification and Denitrification**
4. **Biomass activity**
5. **Actual process capacity**

Inhibition

The BM Respirometry can detect and assess any inhibition due to compounds in the wastewater or bad process conditions.

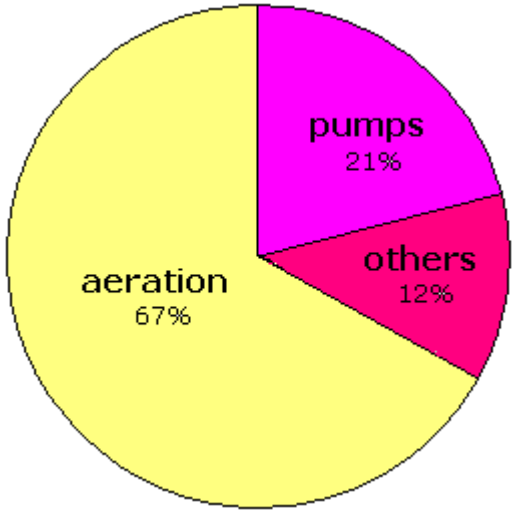


- Inhibition already present in the Activated Sludge Process

- Inhibition detection from wastewater or compound

Energy optimization

The electrical energy for the biological reactor aeration in a wastewater treatment plant, may be more than 60% of the total energy utilized in the plant, for that reason the energy optimization represents one of the most important applications that BM Respirometry can perform.



The application is based on the determination of the total oxygen required per day to run the process and its actual efficiency.

BM Respirometry for design

By means several BM Respirometry tests we can determine the essential modelling parmeters for any activated sludge process

- **Kinetic parameters for biological COD removal**
- **Kinetic parameters for Nitrification**

BM Respirometry for research

BM Respirometers include important requirements that any biological wastewater treatment research can require:

Open system
That means you can change the test configuration at any time.

Different working modes
BM Respirometers are doted with 3 different modes to operate:
Static, Cyclic and Dynamic

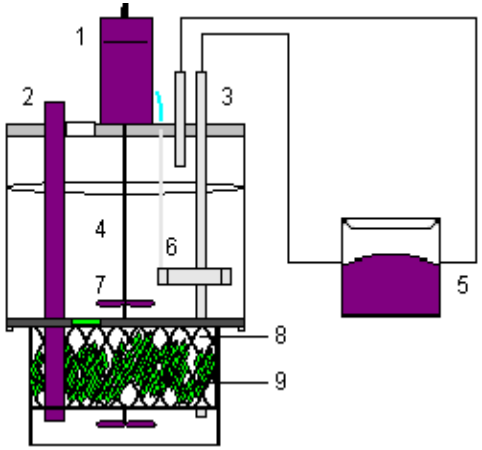
Flexible
You can add samples at any time and analyze what happen on numerical and graphical mode.

Fast
You can add very small amounts of sample to be analyzed.

Powerful software
Where you get a wide fan of combinations, calculations and different kind of graphics (Respirograms)

Option for biomass carriers

The BM-Respirometers can be easily adapted to solid biomass carriers, and run any Respirometry test by means the simple installation of a special cage in the reactor vessel where the carriers are contained.



Some important applications that BM Respirometry can carry out

Energy optimization and saving

Determination of the actual oxygen needs in the biological reactor, so as the minimum oxygen levels at which the activated sludge process could run without any detriment of the wastewater treatment quality.

COD fractioning

From COD fractioning we can analyze the actual biodegradable condition of the organic matter, the COD elimination capacity in the process and the amount of non-degradable COD (inert) contained in the effluent.

Nitrification capacity

To determine the actual capacity of ammonium removal in the actual nitrification process condition.

Effect of Dissolved Oxygen, Temperature and pH

The BM respirometers are specially designed to study the effect of physic-chemical conditions that could affect the process and to calculate the minimum and optimal level for it.

Specific toxicity referred to the biological process

To detect one process already affected by toxicity or the toxic degree from wastewater or compound in the activated sludge. We can also experiment different limitative physic-chemical conditions and flow for possible inhibition levels.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