BM RESPIROMETRY STUDY ABOUT NITRIFICATION INHIBITION AND ACTUAL AERATION CAPACITY IN AN ACTIVATED SLUDGE PROCESS

Study for municipal WWTP in Spain

This study is ordered to SURCIS as a consequence of the low process performance, practical absence of nitrification treatment.

By other side, the mixed-liquor presented some abnormal features such as weakness, dark colour and abundant white foaming.

Data for study interest

- Aeration system: fine bubble diffusers + liquid oxygen injection
- Ammonium concentration in ASP influent: 42 mg N-NH4/L
- Ammonium concentration in effluent: 39 mg N-NH4/L
- SVI: 65 mL/g
- F/M: 0.078 kg BOD/kg MLVSS*d
- Dissolved oxygen average in aeration tank: 0.02 mg/L
- Kg O_2/kWh in aeration system: 4 kg O_2/kWh
- Power installed in aeration system: 148 kW (37 kW x 4 units)
- Kg O_2/d supplied by the liquid-oxygen system: 3,030 kg O2/d

Respirometry system

This service was carried out by specialized SURCIS (Spain) personnel by means a BM-T respirometer system and some complementary reagents and instruments.

Glossary of terms

Aeration energy: Energy (kWh) utilized in the actual aeration system of the treatment plant.

AOR (Kg O_2/d): Actual oxygen requirement by ASP

ASP: Activated Sludge Process

Inhibition in activated sludge: Sludge bioactivity reduction due to some specific compounds in waste water or physical-chemical conditions.

MLVSS (mg/L): Mixed liquor volatile suspended solids concentration = biomass concentration

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

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

Points of the study

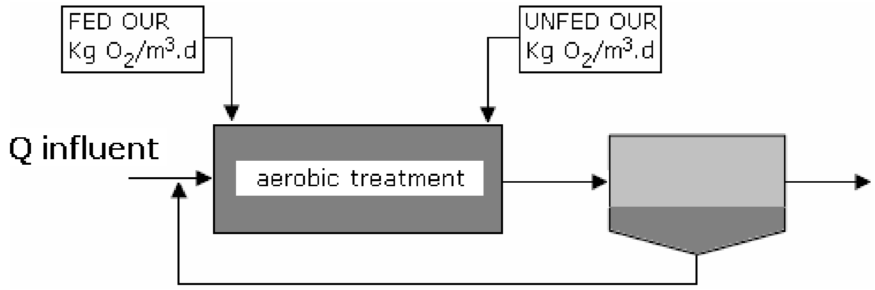
Because of the ASP symptoms in this study we have considered the following targets:

1. Determination of the actual oxygen requirements.
2. Checking of Nitrification activity.

Determination of the actual oxygen requirements (AOR)

As 1st step with the BM-T we carry out two simple respirometry tests with the BM-T: FED OUR and UNFED OUR.

By means of these tests we calculate the kg of oxygen that the ASP is consuming at the start and end of the process.



AOR calculation is carried out bay making use of the average between FED and UNFED OUR

AOR (kg O_2/d) = V * OUR average

V (m^3): aeration tank volume
OUR average = (FED OUR + UNFED OUR) / 2

The AOR we have found under loading pick (normally the plant is under loading pick regime) was the following:

AOR = 16,380 (kg O_2/d)

Oxygen transference rate of the actual aeration system (OTR_a) and liquid oxygen (OTR_{O2})

We were determining OTR from the following data:

- Kg O_2/kWh of the current aeration system = 4 Kg O_2/Kwh
- Power installed in the aeration system: 148 Kw (4 units x 37 Kw)
- Temperatura = 18º C
- DO = 0.02 mg/L
- Some others

OTR_a result was figured out from the following mathematical formula:

$$OTR\ (kg\ O_2/d) = P * (kg\ O2/Kwh) * 24 * (0{,}95Cs - Cw) * 1{,}024^{T-20} * \alpha / 9{,}3$$

P: Power (kW)
Cs: Saturación de oxígeno en agua potable a 20ºC = 9,3 ppm
Cw: Oxígeno en el proceso del agua residual = 2,1 ppm (valor medio)
α: K_{la} / K_{la} (s) = 0,5

OTR_a (kg O_2/d) = 7,744

From liquid oxygen data we already know:

OTR_{O2} (kg O_2/d) = 3,030

Total OTR is:

$OTR = OTR_a + OTR_{O2}$ = 7.744 + 3.030 = 10.774

OTR (kg O_2/d) = 10.774

AOR vs OTR comparison

In this comparison we can clearly realize that the AOR value is widely higher than OTR. That means the aerobic treatment will be in need of more than additional 5,000 kg O_2/d.

Then, now we are in conditions to confirm that there is an important

Oxygen deficiency

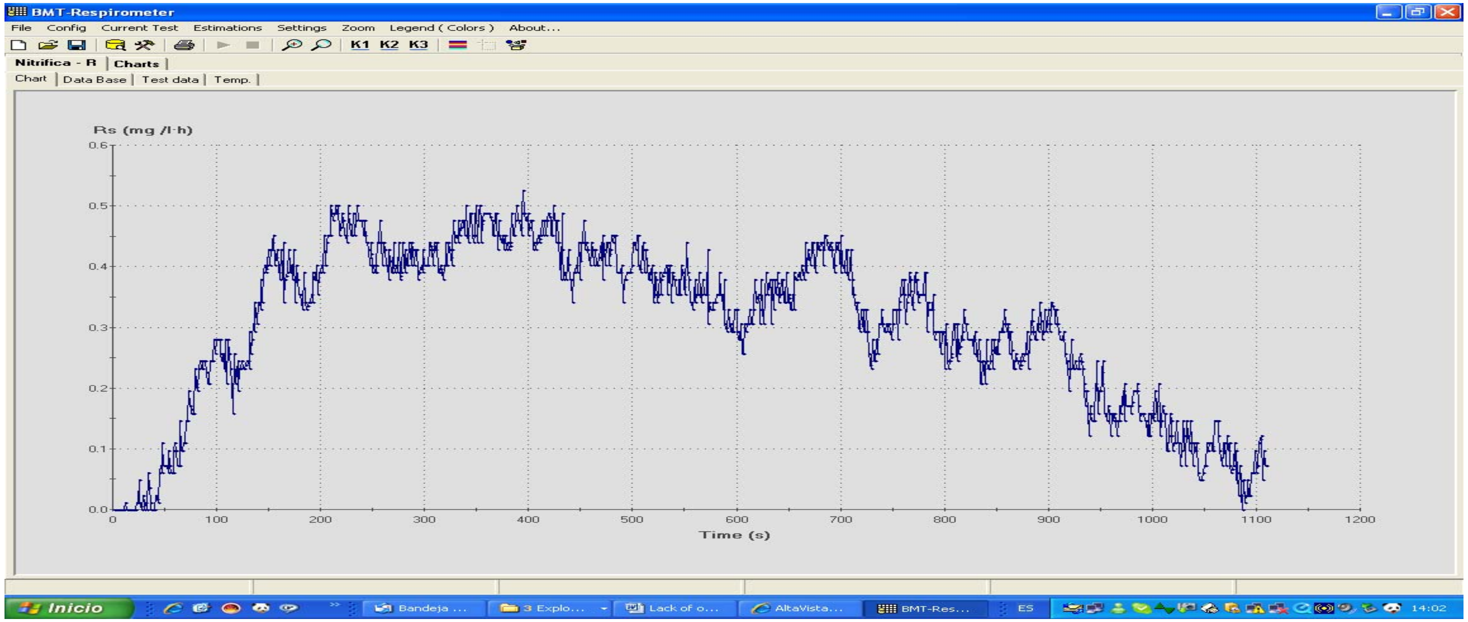
The fact that the average DO was 0.2 mg/L, the weakness contexture, dark colour and abundant white foaming are also evident signs of an oxygen deficiency that now was already assessed by the respirometry study.

Lack of oxygen = 6.380 – 10,774 ≈ 5,600 kg O2 / día

Nitrification inhibition confirmation

This confirmation is carried out by means a dynamic R respirometry test, by means endogenous activated sludge and a small amount of sodium chloride equivalent to the actual ammonium concentration in the ASP.

The test begins and once it is the base-line determined it is added the ammonium chloride to the activated sludge on the approach to observe the reaction of the nitrifier biomass to the substrate.



In the BM-T respirometer an extremely low respiration rate signal was generated that could be considered as practically nothing and for that reason we can confirm that in the ASP there is an absence of nitrification.

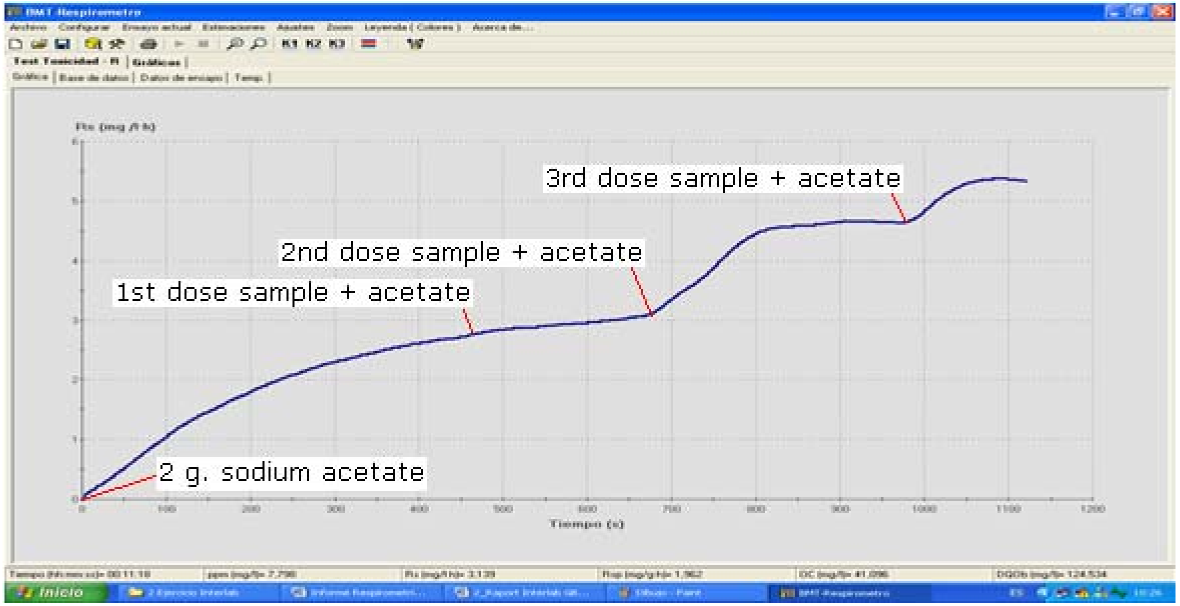
It is also evident that that the cause for that nitrification absence leans on the permanent oxygen deficiency that had provoked a clear inhibition effect.

Therefore, our diagnostic was:

Nitrification inhibition due to a permanent oxygen deficiency

Toxicity test for the biomass responsible (autotrophic) of the biodegradable COD removal

In order to confirm that the inhibition effect was not extended to the autotrophic biomass, in the BM-T we carry out a respirometry toxicity test by means of a dynamic R test. For this test we follow the method based on a progressive addition of sample, in order to go progressively increasing the sample concentration in the sludge.



As a 1st step, to the sludge, once base-line is determined, we add a high dose of sodium acetate in order to create a continuous maximum respiration rate plateau which will serve as our reference level for toxicity detection and assessment.

Once we had reached the plateau, after waiting a representative time, we were adding for three times some equivalent sample volumes to the sludge.

In case of toxicity, after adding each dose of sample, normally the respiration rates values would start to go below the maximum reference respiration rate (plateau). However in any of the times we have added the sample we could observe any toxicity symptom; and therefore we confirm:

There is not any toxicity in the biomass (heterotrophic) responsible of biodegradable COD removal.

Benefits obtained from the results of the BM-T respirometry study

1. From the respirometry study, the plant knew exactly the amount of additional that the ASP was in need to get a solution of the problem about oxygen deficiency. By means of this data the plant could extend its aeration system.

2. It was confirmed that the nitrification inhibition was provoked by the oxygen deficiency and not for any external toxicant.

3. With the extension of its aeration system, the company responsible of the plant maintenance the plant has let be economically penalized and has been able to renew its maintenance contract with the corresponding regional Water Agency..

4. The maintenance company as well has recovered its image in face to the market and Water Agency.

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