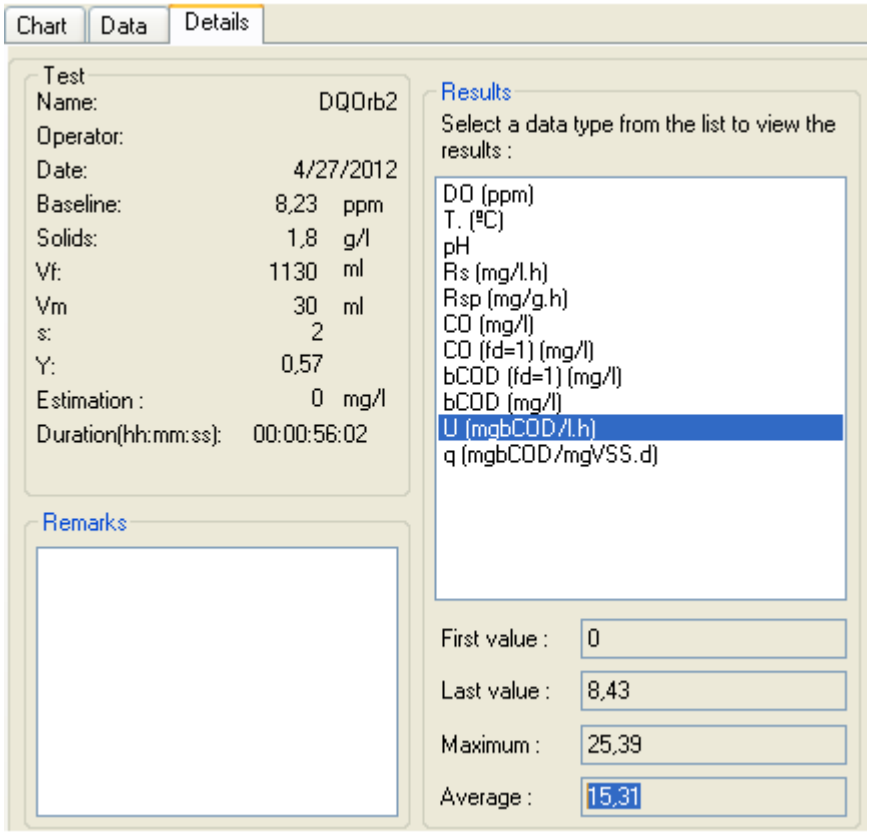
3.2.1. rbCOD removal rate (U_{rb})



U_{rb} (average) ≈ 15.31 mg DQOb/(l.h)

T_{rb} = bCOD / Ur_b = 269 / 15.31 = 17.5 h

Analysis

The time to remove the rbCOD (T_{rb}) will be good or not depending of the actual HRT (*) available for it.

(*) HRT data was not provided to SURCIS in this study

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3.3. Percentage of slowly biodegradable COD (sb) in total COD

sb = b – rb = 83 – 63 = 20 %

Analysis

The percentage of sbCOD in COD is normal.

3.4. Percentage of inert COD (i) in total COD

i = 100 – b = 100 – 83 = 17 %

Analysis

The percentage of iCOD in COD is normal (a bit high)

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4. Nitrification

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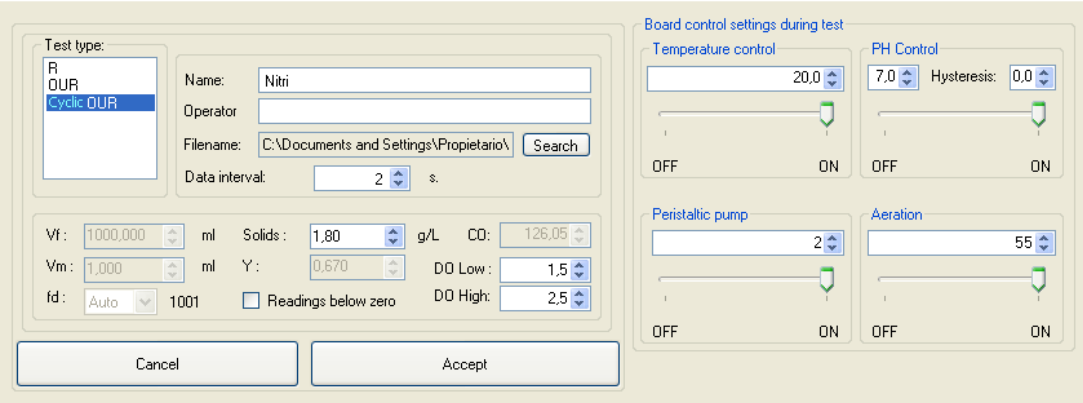
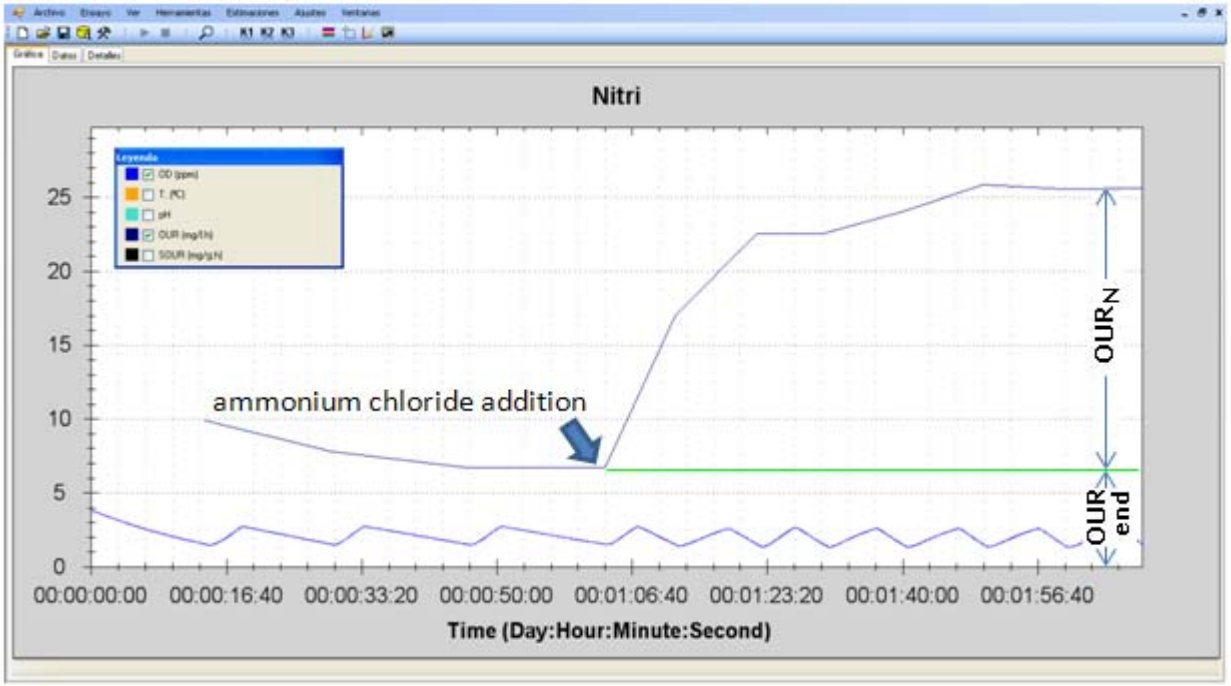
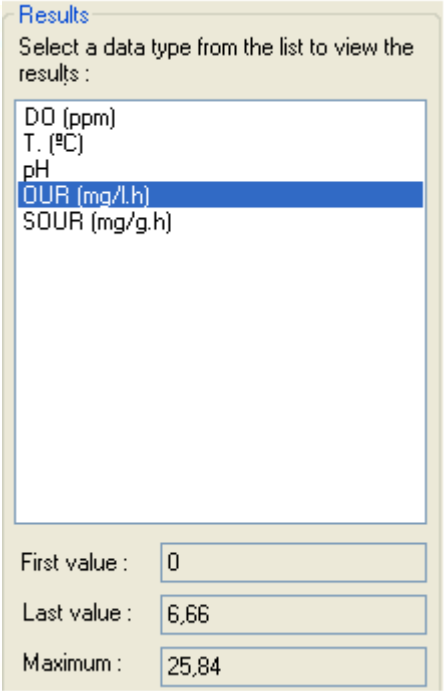
4.1. Maximum ammonium uptake rate (AUR) & Nitrification timen (T_N)

For the nitrification test we are making use of ammonium chloride with equivalent values of N-NH4 concentration, oxygen (1.5 – 2.5 ppm), temperature (20ºC) and pH (7) to the actual process in a cyclic mode respirometry test.







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$OUR_N = OUR - OUR_{end} = 25.84 - 6.66 = 19.18$ mg/l.h

$AUR = OUR_N / 4.57 = 19.18 / 4.57 = 4.19$ mg $N\text{-}NH_4$/(l.h)

$SAUR = 24 * AUR / VSS = 24 * 4.19 / 1.8 = 55.86$ mg $N\text{-}NH_4$/(g VSS.d)

$T_N = S_N / AUR = 60 / 4.19 = 14.32$ h

OUR_N (mg/l.h): Oxygen uptake rate due to nitrification
AUR (mg $N\text{-}NH_4$/l.h): Nitrification rate
SAUR mg $N\text{-}NH_4$/g VSS.d): Specific nitrification rate
T_N (h): Time that process needs to completely nitrify the ammonium S_N
S_N ($N\text{-}NH_4$/l): Mean concentration og ammonium nitrogen ≈ 60 mg N-NH4/l

Nitrification capacity

N_C ($N\text{-}NH_4$/l) = $AUR * TRH_N = 4.19 * TRH_N$

N_C ($N\text{-}NH_4$/l): Maximum ammonium concentration that the process is able to remove
TRH_N (h): Available hydraulic residence time for nitrification (this data was not provided to SURCIS)

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4.2. Autotrophic biomass concentration (X_A)

$F_N = Y_{A.VSS} * S_N / (Y_{H.VSS} * S_S + Y_{A.VSS} * S_N)$

S_N (mg/L): Actual eliminated ammonium-nitrogen in nitrification.
S_S (mg/L): Readily biodegradable COD (DQOrb)
$Y_A \approx 0.13$ (by default - for normal nitrification activity)

$F_N = 0.13 * 60 / (0.38 * 269 + 0.13 * 60) = 0.07$

$X_A = F_N * X_V = 0.07 * 1800 = 126$ mg/l

$X_A = 126$ mg/l

Source: Activated sludge treatment of industrial wastewater – W.W. Eckenfelder, J.L. Musterman - 1995

Analysis

We can assess the X_A value by comparing the result with a guide table of F_N values from different BOD/N ratios

BOD/N	0.5	1	2	3	4	5	6	7	8	9
F_N	0.35	0.21	0.12	0.083	0.064	0.054	0.043	0.037	0.033	0.029

Source: Metcalf & Eddy. 1995

Current BOD/N = 4 → 0.064 (table)

The 0.07 (>0.064) is coherent with the corresponding BOD/N ratio

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5. Operational parameters

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5.1. Minimum sludge age for nitrification (SRT)

SRT = 1 / [(0.13 * AUR * 24 / X_A) – b_A] = 1 / [(0.13 * 4.19 * 24 / 126) – 0.04] = 17 d

TRC_N = 17 d

Temp	Death & Decay Rate b_A ($days^{-1}$)
10°C	0.02
15°C	0.03
20°C	0.04
25°C	0.05

5.2. F / M

F/M should be calculated in full coherence with SRT.

F/M = 1 / (SRT * $Y_{H.VSS}$) = 1 / (17 * 0.38) = 0.15

F/M = 0.15

Analysis

SRT is in range but F/M is the higher limit (range: 0.01 - 0.15) for a normal nitrification. The reason of this relatively high F/M is mainly coming from the low $Y_{H.VSS}$. That means, if the process could increase the Y_H value the F/M could decrease into more normal values for nitrification.

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6. Conclusions of the study

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Conclusions

Activated sludge

The activity is normal. However the yield coefficient is slightly low, the biomass growing might be slow.
This relatively low value is also affecting the COD fractions and F/M.
Discarding the causes of a lack of nutrients, low temperature or sporadic toxicity, the cause of this low Y_H is unknown and it might be worth to carry out a specific study to find out the reasons of it - it exist some probabilities because of too low MLSS concentration for this type of process -

Wastewater sample 1

In this simple, the % of biodegradable COD (bCOD) in total COD is 45%. This value is very low compared with the habitual range and, for that reason, we can qualify its biodegradability as very low.
This relatively very low bCOD brings with it a logical very high (55 %) non-biodegradable inert COD (iCOD) in the total COD.
By other side, its bCOD removal rate gives a total removal time of 20.5 hours that, in principle, it seems to be rather high.

Wastewater sample 2

In this simple, the % of biodegradable COD (bCOD) in total COD is 83%. This value is very normal compared with the habitual range and, for that reason, we can qualify its biodegradability for this specific activated sludge as normal.
However, the % of soluble readily biodegradable COD (rbCOD) is very high; and this high percentage, depending of the process and their actual conditions, can bring the possible foaming generation and some influence in the actual available hydraulic residence time for nitrification.

Nitrification

In principle, the nitrification activity is normal.
In this study we had not the HRT available for nitrification in the process. We are however advising that, when there are not ideal conditions (DO, pH, Temperature), the high rbCOD value (wastewater sample 2) can create some lack of residence time for a complete nitrification performance.
For that reason, it will acquire special importance to get the process within the best possible conditions; and work with a SRT higher than the minimum value (17 days) here calculated.

Operational parameters

Maximum F/M and SRT are keeping some coherence. However F/M might be in the higher limit (0.15) for a normal nitrification; and this is mainly due to the low Y_H value.
In case that the high F/M could cause some problems in the nitrification performance, the advice should be to increase the MLSS concentration; thus, the F/M will be reduced.

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