BM Respirometry Denitrification

SURCIS

Conditions for denitrification process

Conditions	
pH	6.5 a 8 (optimal)
BOD/TKN	2.5 to 5
Soluble biodegradable COD/N-$NO_{3.DN}$	≥ 2.83
DO	< 0.3 mg/L
Denitrification zone with enough HRT to perform the process	
Without any inhibitor nor toxic compounds	

Preparation of the aerobic R test for the determination of NUR with wastewater

Endogenous sludge

Conversion of one liter of efluent sludge from anoxic zone to endogenous phase, and add allyl thiourea (ATU) to inhibit nitrification (~3 mg ATU/g SSV)

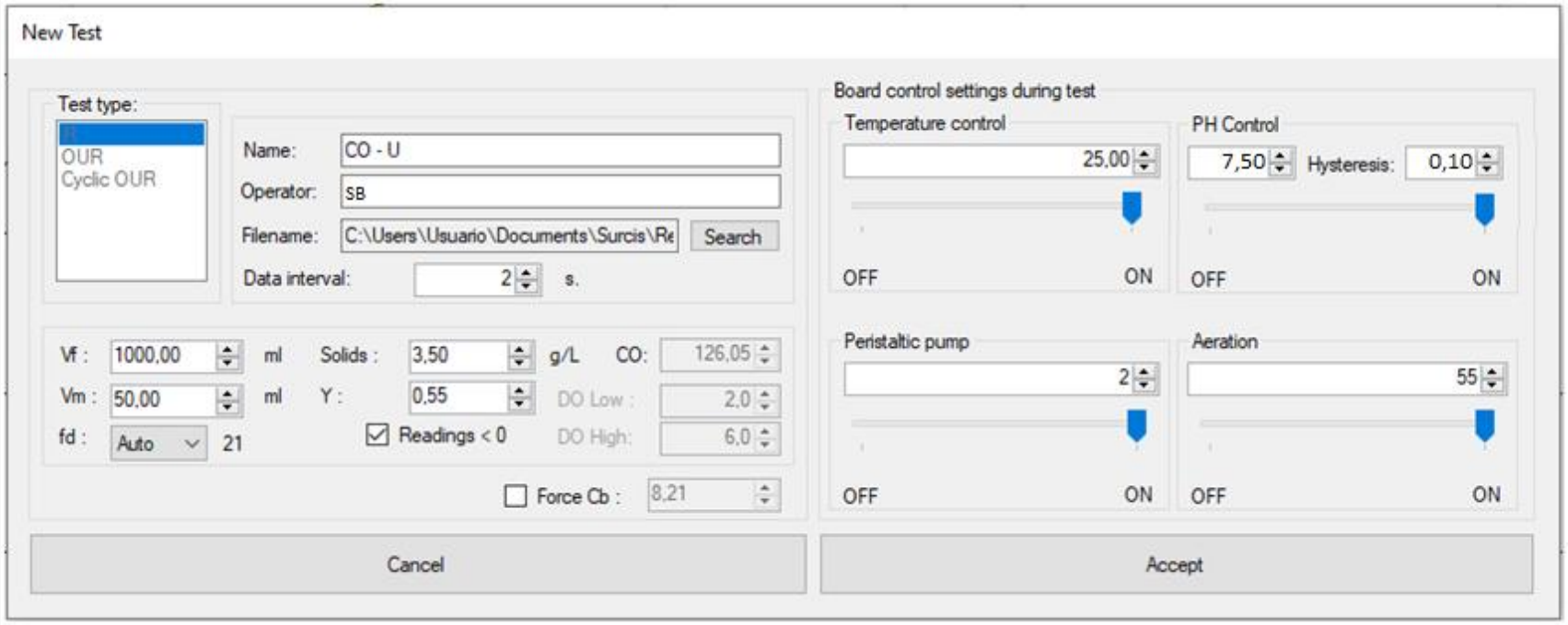
Let the ATU take effect in the stirred sludge for at least 20 minutes before the test.

Wastewater sample

Prepare a dose of 50 to 70 mL ("Vm" programmed in the test configuration) of the influent wastewater to the anoxic process of denitrification.

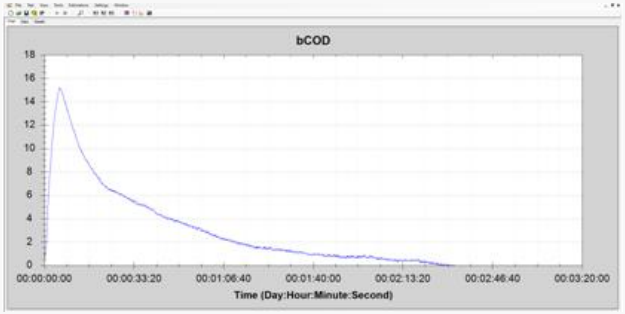
Configuration of the R test for the determination of NUR by aerobic procedure from the influent to the anoxic process

1. Conversion of one liter of efluent sludge from anoxic zone to endogenous phase.
3. Set up an R test with Y_H = 0.55 - (Muller et al., 2003)
4. Set the test to an average temperature, pH and MLVSS equivalent to that of the actual process.
5. Set Vm between 50 and 70 mL



Aerobic procedure to determine the denitrification rate determination from wastewater sample

1. Perform a complete R test for bCOD of wastewater entering the anoxic process.



2. Go to the Data tal Chart Data Details to access the table of data obtained during the R test.

Chart Data Details

Time (D:H:M:S)	DO (ppm)	T. (°C)	pH	Rs (mg/l.h)	Rsp (mg/g.h)	CO (mg/l)	bCOD (mg/l)	U (mgbCOD/l.h)	q (mgbCOD/mgVSS.d)
00:00:44:02	7,9	20	7,56	4,17	2,32	119,88	399,59	25,93	0,35
00:00:44:53	7,9	20	7,56	4,15	2,3	121,1	403,68	25,7	0,34
00:00:44:55	7,9	20	7,56	4,13	2,3	121,15	403,84	25,69	0,34

3. Find the **CO** value equal to that of oxygen for denitrification CO_{DN} , and the U and q values corresponding to the same time frame. Where CO_{DN} = 2,86 * [N-NH4]

CO (mg/l)	bCOD (mg/l)	U (mgbCOD/l.h)	q (mgbCOD/mgVSS.d)
121,15	403,84	25,69	0,34

6. Calculate the the dentrification rate :

$$\textbf{NUR}\ (\text{mg N/L.h}) = [U\ (1\text{-}Y_{HDN}) / 2.86] * K'_O / (K'_O + OD_{DN})$$

NUR: Denitrification rate (mg NO_3-N/L.h)

Y_{HD}: Yield coefficient in the anoxic zone (O_2/COD) = 0,85 * Y_H

K'_O: Inhibition coefficient due to to possible oxygen in the anoxic zone = 0.2 (mg/L) - Henze et al 1996 –

DO_{DN}: Possible Dissolved Oxygen in the anoxic zone (mg O_2 /L) – Must be below ***0.3 mg/L*** -

Test R for NUR determination by means a sodium acetate solution as standard sample

A sodium acetate solution should be used when a wastewater sample is not available or to compare NUR with the wastewater sample versus NUR with acetate for inhibition/toxicity purposes.

In any case, it is necessary that the sludge is not already affected by any toxicity, in which case another healthy saimilar sludge from another process should be used.

Procedure

1. Calculate the oxygen consumption needed for denitrification: $CO_N = 2.86 * SNO3$

   SNO_3: Nitrate concentration at the beginning of the denitrification process (mg NO_3-N/L)

2. Calculate the corresponding biodegradable COD needed for denitrification: $COD_N = CO_N / (1-Y_{HD})$

3. Prepare a sodium acetate soluction with a concentration of CODac ≈ COD_N

   1 mg/L of sodium acetate is approximately equivalent to 0.75 mg/L of COD

   Example: A COD of 300 mg/L requires a minimum solution of 300/0.75 = 400 mg/L of acetate.

4. Perform an R test similar to the bCOD for wastewater test.

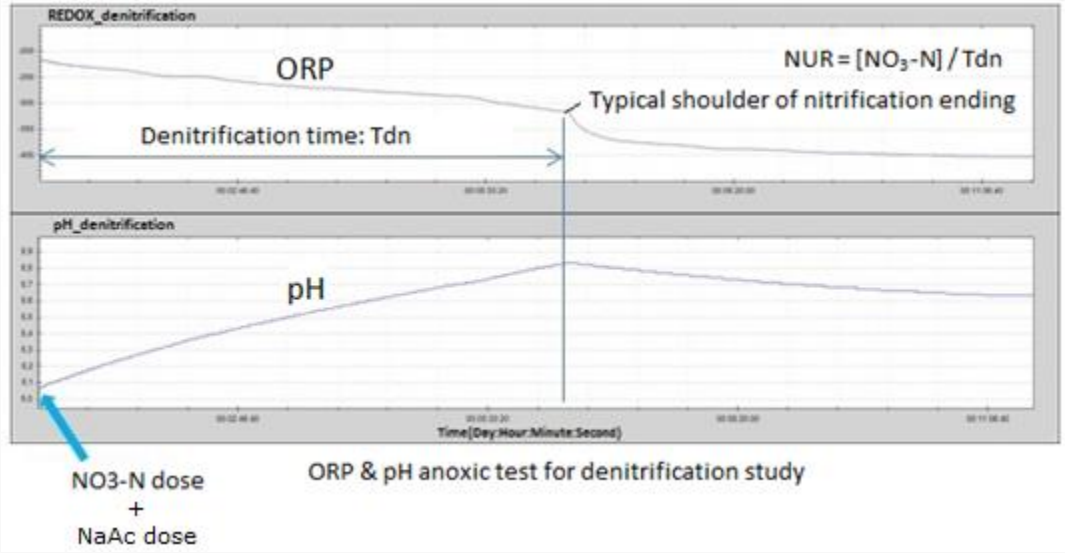
5. Click on the graph CO the point corresponding to the value de CO (calculated in 1) and get the value U for the same time frame: CO → U

6. Calculate NUR:

$$\textbf{NUR}\ (\text{mg } NO_3\text{-N/L/h}) = [U\ (1-Y_{HD}) / 2{,}86] * K'_O / (K'_O + OD_{DN})$$

NUR determination under equivalent anoxic conditions by means de ORP and/or pH slope assessment

In the models **BM-Advance Pro** (ORP and pH) and **BM-Advance** (pH) the BM respirometry offers the option to perform anoxic tests to assess the denitrification activity and to determine the denitrification rate (NUR) under that condition.



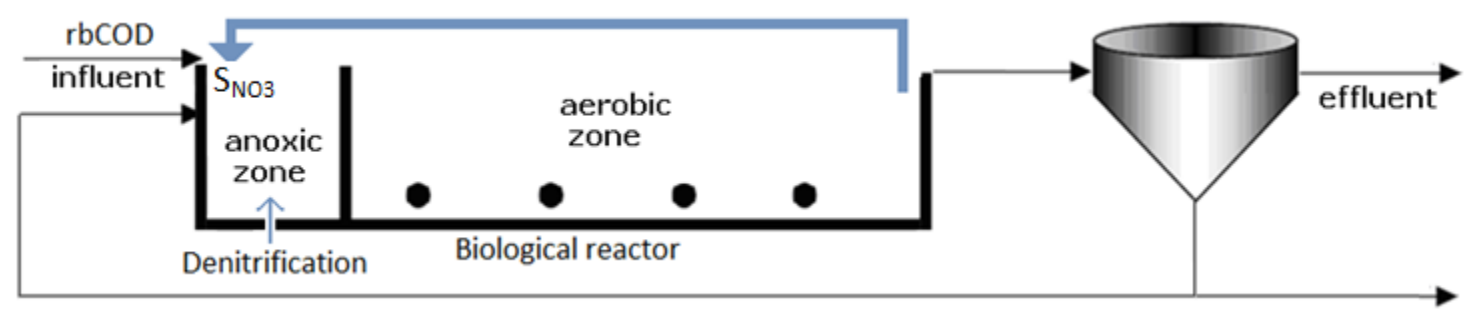
For that purpose a R test can be performed under anoxic condition (switching off the aeration) and adding at the start of the test equivalent doses of rbCOD (sodium acetate) and Nitrate (potassium nitrate)

The assessment of the ORP and/or pH slopes for the denitrfication time until the nitrate is consumed will be the base to directly assess the denitrification bacteria activity and calculate the corresponding NUR

rbCOD required for denitrification

When the anoxic denitrification process takes place just before the aerobic treatment, a possible critical situation could arise when there is very little rbCOD in the influent and it is completely removed in that zone. Thus, there would be no rbCOD left for the aerobic zone and only the slowly biodegradable COD (rbCOD) would be in the aerobic zone. Then, under that condition and due to of a possible lack of direct food, it may result in low biomass heterotrophic growth, weak flocculation and poor process performance.

For this reason, in many cases, it is important to exceed the minimum rbCOD required for a given nitrate concentration.



<u>rbCOD required for denitrification</u>

$$\mathbf{rbCOD_{DN}} \geq 2{,}86 * S_{NO3} / (1 - Y_{HD})$$

Where

$rbCOD_{DN}$ Minimum readily biodegradable COD required for denitrification (mg/L)

Y_{HD}: Heterotrophic yield coefficient in the anoxic zone (mg O_2/mg COD) ≈ 0,55 (usual default value for the

S_{NO3}: Nitrate to denitrify (mg NO_3-N/L)

If the required rbCOD is not met, it may be necessary to resort to the use of an external source of of readily biodegradable COD (normally methanol)

Specific denitrification rate

$$\textbf{SDNR} = 24 * NUR / X_V$$

SDNR: Specific denitrification rate (mg N-NO_3 / mg VSS.d)

Guide table

Estimated Specific Denitrification Rates

Temp ° C	Estimated SDNR	Temp ° C	Estimated SDNR
10	0.035	18	0.076
12	0.042	20	0.091
14	0.052	22	0.110
16	0.063	24	0.132

Source: Long Island Sound Training – Nitrogen Removal - 2003 (EPA)

Possible reasons for which the actual specific denitrification rate could be less than the reference table value

1. The process is not operating under one or more correct conditions range.

2. The concentration of the readily biodegradable COD is too low (soluble organic cabonaceous matter)

3. Anoxic zone is not gathering the anoxic condition (oxygen < 0.3 ppm)

4. The hidraulc retention time in the denitrification zone is too short (it has not enough volume)

5. Presence of inhibitor or toxic compounds in the wastewater.

6. Others

Calculation of methanol loading for a determined denitrification efficiency

Just in case the denitrifiction process has not enough rbCOD for its normal development, another readily biodegradable compound should be added. Most comun compound is the methanol

PROCEDURE

1. **Calculation of the S_{NO3} and rbCOD present in the influent**
   - Calculation of the nitrate concentration to denitrify (S_{NO3})
   - Calculation of the rbCOD in the influent by mean a R test with filtered wastewater sample.

2. **Calculation of the methanol loading for maximum denitrification**
   - Methanol loading (m^3/d) = 2.86 * Nitrate loading - rbCOD loading

     Nitrate loading (kg S_{NO3}/d) = Q (m^3/d) * S_{NO3} (kg NO_3-N)/m^3

     rbCOD loading (kg COD/d) = = Q (m^3/d) * rbCOD (kg COD/m^3)
   - Methanol loading (L/d) = 1000 * Methanol loading (m^3/d)

     1 liter methanol = 1.2 Kg rbCOD
   - Methanol loading (kg/d) = Methanol loading (L/d) / 1.2

3. **Calculation of the methanol loading for a determined denitrification efficiency (E)**
   - E = 1 - S_{NO3e} / S_{NO3}

     E: denitrification efficiency

     S_{NO3e} : Nitrate expected in the effluent (mg NO_3-N/L)
   - Methanol loading' = E x Methanol loading

     Methanol loading': Methanol loading for E efficiency (liter/day)

In any case, the metahnol must be progressively acclimated to the sludge before applying the calculated methanol loading

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