Respirometry service

Study about the influence of the pH and temperature in a biological wastewater trickling filter with beds of attached biomass to small stones

SURCIS

Preliminaries

This service is carried out from the agreement reached by Surcis with an engineering company to conduct a study on the approach to analyze the influence of temperature and pH in a municipal wastewater treatment plant provided with a tricking filter process with small stones (as biomass carriers), where there is a very poor nitrification process performance.

This biological process is designed to remove organics and ammonium nitrogen. However, in winter time, the process operates under relatively low temperature (12ºC), fluctuant pH (6.5 to 7) and BOD/TN ratio of about 3. Those current conditions lead to think that they are the responsible of the lack of nitrification; but, in order to get strong arguments of confirmation, the company responsible of the plant management and maintenance wanted to get a respirometry study to analyze and assess the influence of the nitrification activity for the actual winter conditions and be compared with higher temperature (20ºC) and pH (8). On that purpose, it has ordered the present study.

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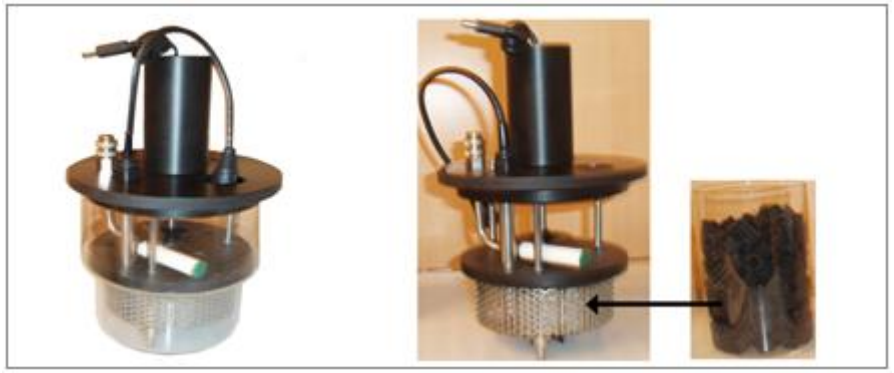
Analyzer

The respirometry system used for the present study is a BM-Advance from SURCIS, S.L. equipped by a biomass-carrier reactor for the special stone bio-films.

BM-Advance



Special biomass-carrier reactor for BM-Advance

Objective of the study

The objective of this study is to analyze the influence on the temperature and pH conditions in the nitrifying activity and ammonium uptake rate, for different combinations of 12ºC (or lower), 20ºC, not exceeding 7 and 8 of pH in the biofilm process.

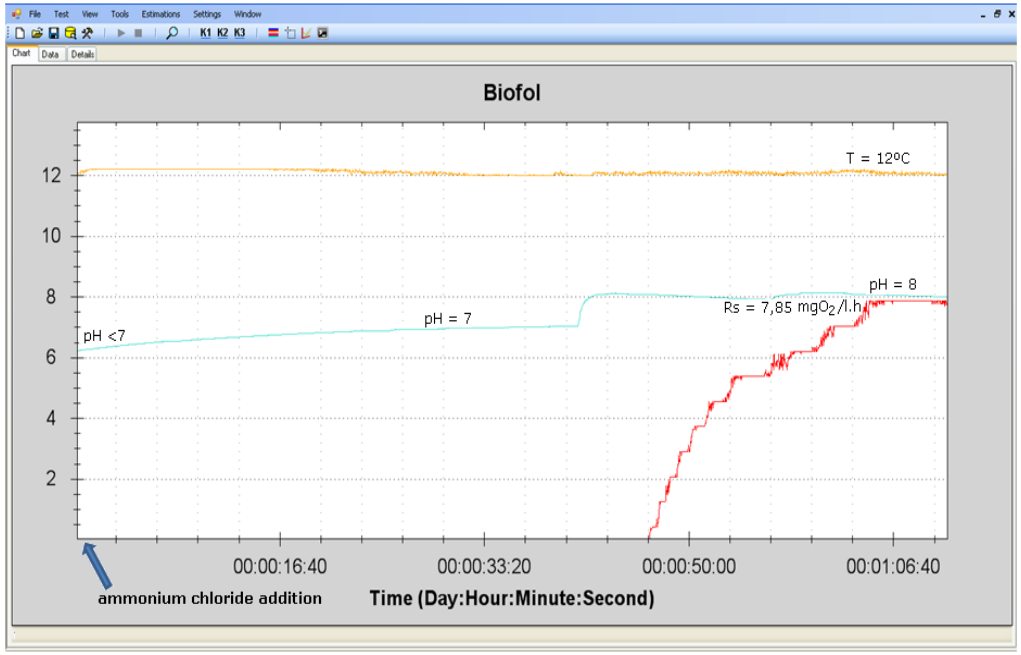
Procedure

The procedure consists in two R dynamic tests (one at 12ºC and the other at 20ºC) of respirometry where we are making use of the BM-Advance pH control system to vary this value from below 7 till 8.

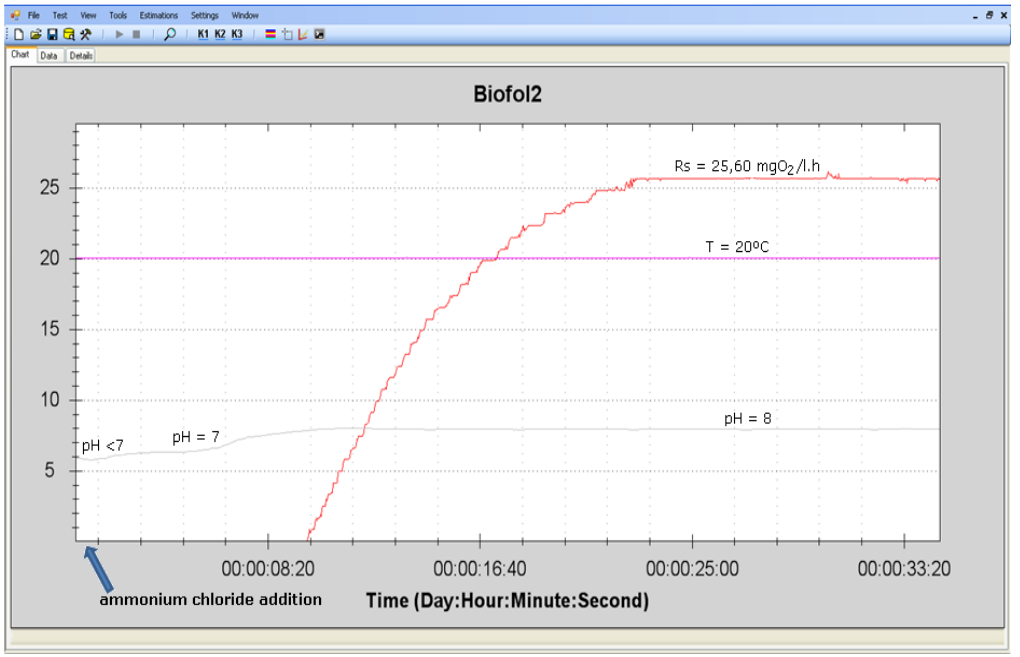
On each test we add a dose of ammonium chloride equivalent to the maximum process ammonium concentration (48 mg N-NH_4/l.h) in the process, and as test is performing we vary the pH from <7, 7 and 8 values.

During the test, the BM-advance respirometry system is automatically calculating the corresponding dynamic respiration rate (Rs) for each pH until reaching its maximum level, and from there we calculate the corresponding ammonium uptake rate (AUR) by means the following mathematical formula:

AUR (mg N-NH_4/l.h) = Rs / 4.57 4.57: mg O_2 that 1 mg of N-NH_4 needs to be converted into N-NO_3

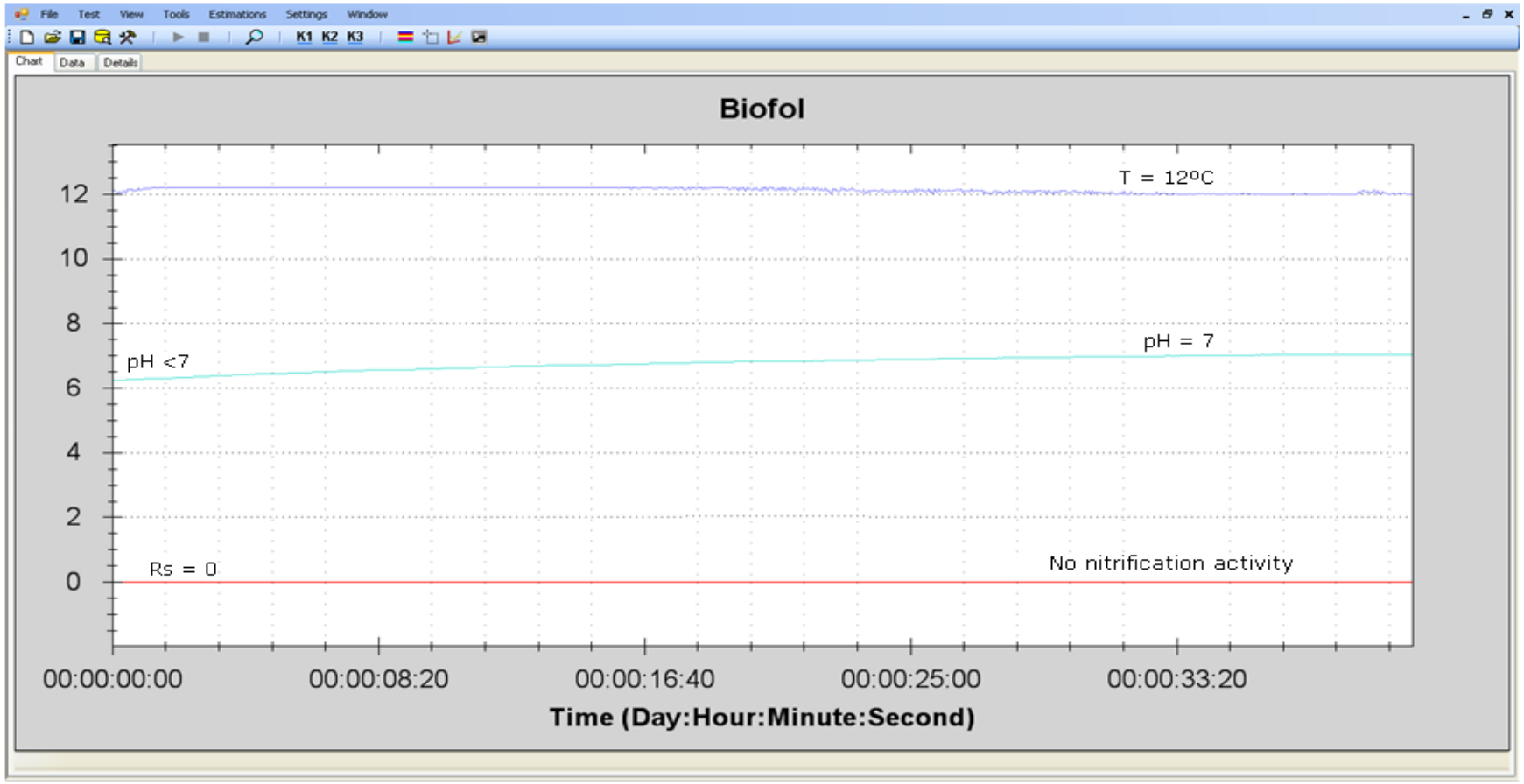


Respirogram from 12ºC test



Respirogram from 20ºC test

Ammonium uptake rate influenced by temperature of 12ºC, and pH from <7 to 7

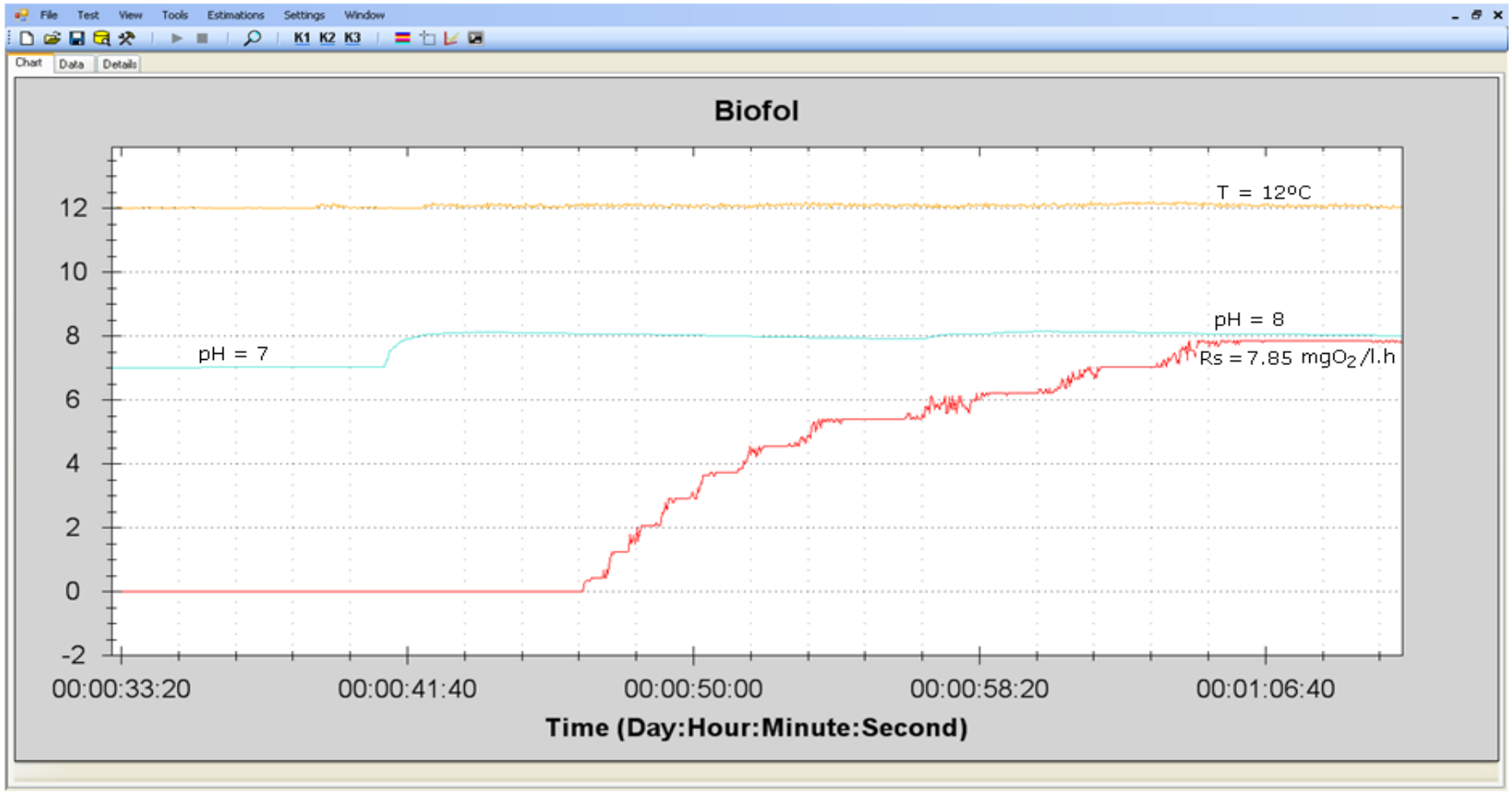


Respiration rate (Rs) Respirogram at 12ºC and pH from <7 to 7

Conclusions from the test

At the temperature of 12ºC (and below it), with pH equal or less than 7 there is not any nitrifying activity.

Ammonium uptake rate influenced by temperature of 12ºC, and pH of 8



Respiration rate (Rs) Respirogram at 12ºC and pH from <7 to 7

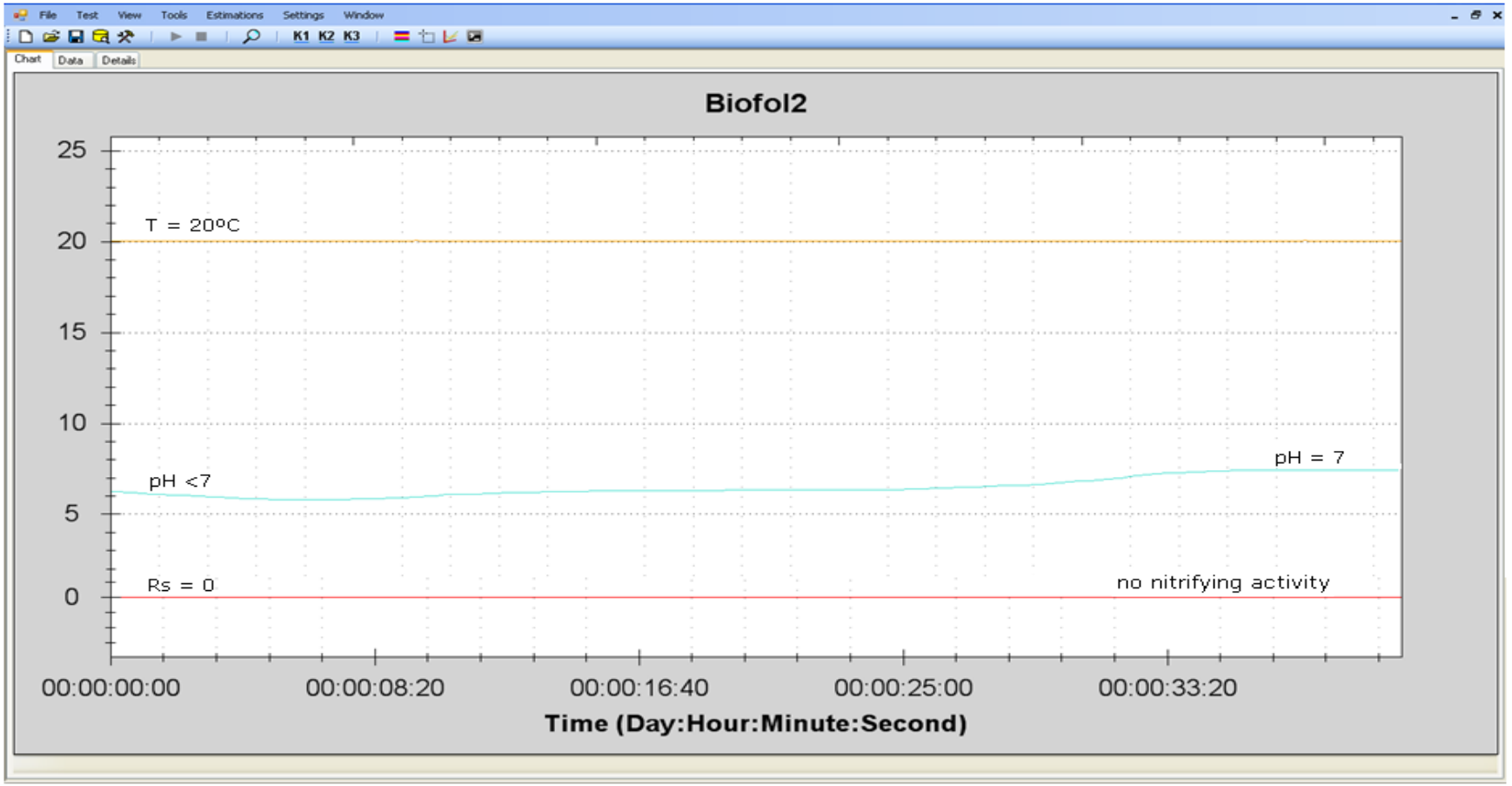
Ammonium uptake rate: AUR (mg N-NH_4/l/h) = Rs / 4,57 = 7,85 / 4,57 = 1,72 **AUR** = **1,72** mg N-NH_4/l/h

Conclusions from the test

At the temperature of 12 ºC, with a pH of 8, there is a nitrification with an ammonium uptake rate relatively low (*)

(*) The AUR value is specific to each process and its assessment depends very much to the available hydraulic retention time for nitrification.
In our experience, this time used to be above 2 mg N-NH_4/l/h

Ammonium uptake rate influenced by temperature of 20ºC, and pH <7 to 7

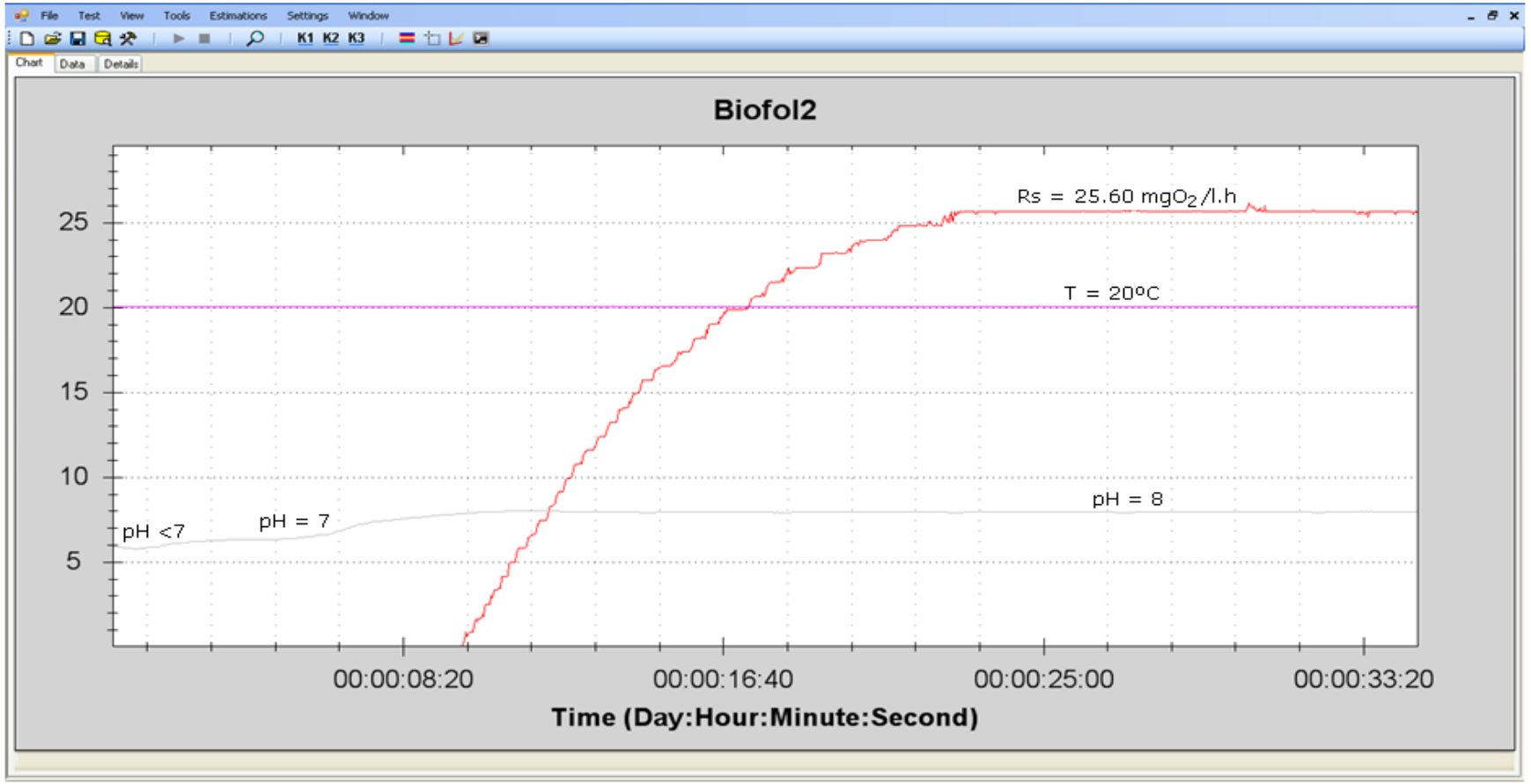


Respiration rate (Rs) Respirogram at 20ºC and pH from <7 to 7

Conclusions from the test

At the temperature of 20ºC, with pH equal or less than 7 there is not any nitrifying activity.

Ammonium uptake rate influenced by temperature of 20ºC, and pH of 8



Respiration rate (Rs) Respirogram at 20ºC and pH from <7 to 7

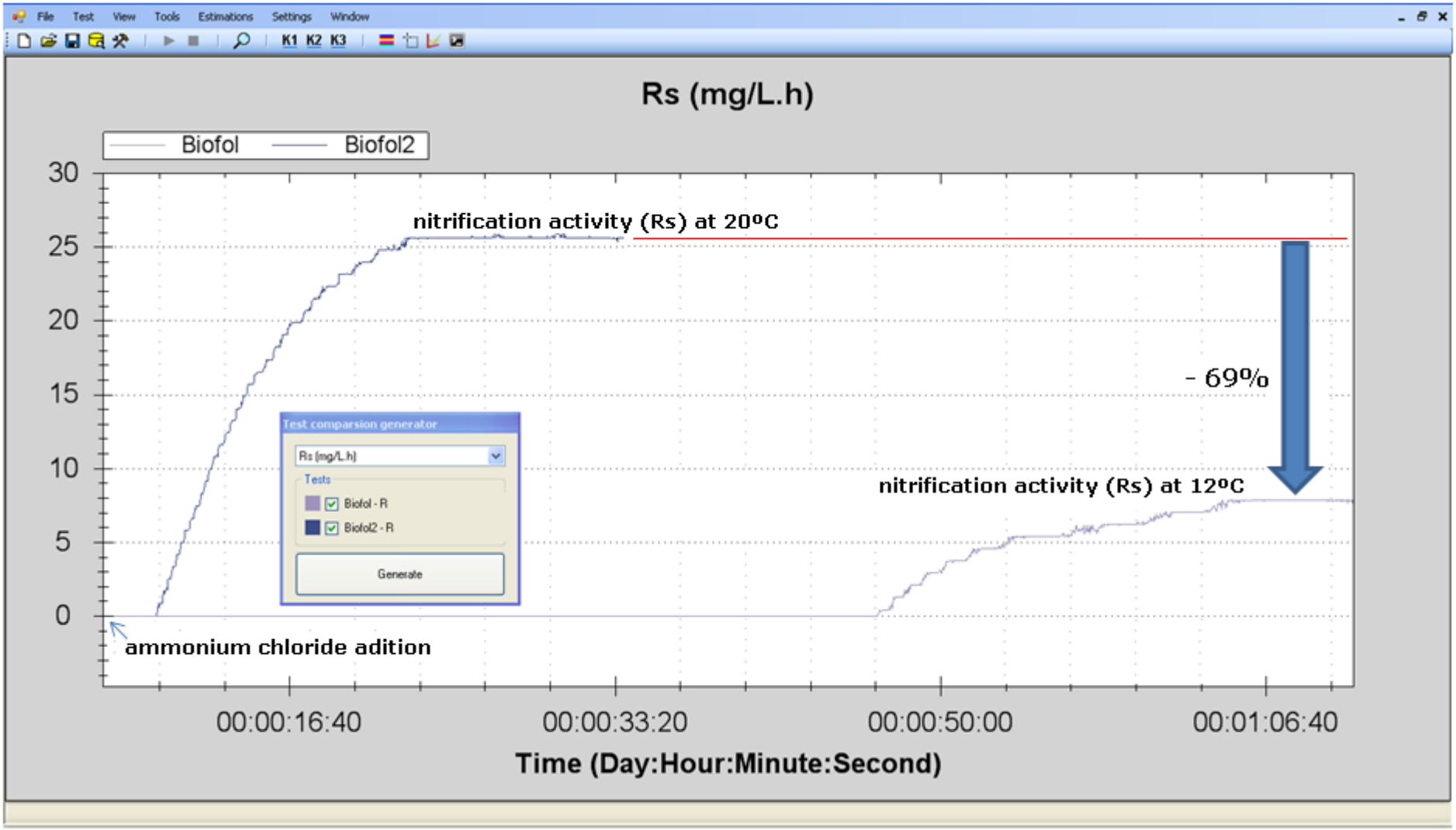
Ammonium uptake rate: AUR (mg N-NH_4/l/h) = Rs / 4,57 = 25,6 / 4,57 = 5,60 **AUR** = **5,60** mg N-NH_4/l/h

Conclusions from the test

At the temperature of 20 ºC, with a pH above 7.7 starts the nitrification and it reaches its normal activity at pH of 8 (*)

(*) The AUR value is specific to each process and its assessment depends very much to the available hydraulic retention time for nitrification.
In our experience, from >2 to 8 N-NH_4/l/h used to be a coherent normal range.

Nitrification activity comparison (pH = 8) between of 20ºC vs. 12ºC temperatures

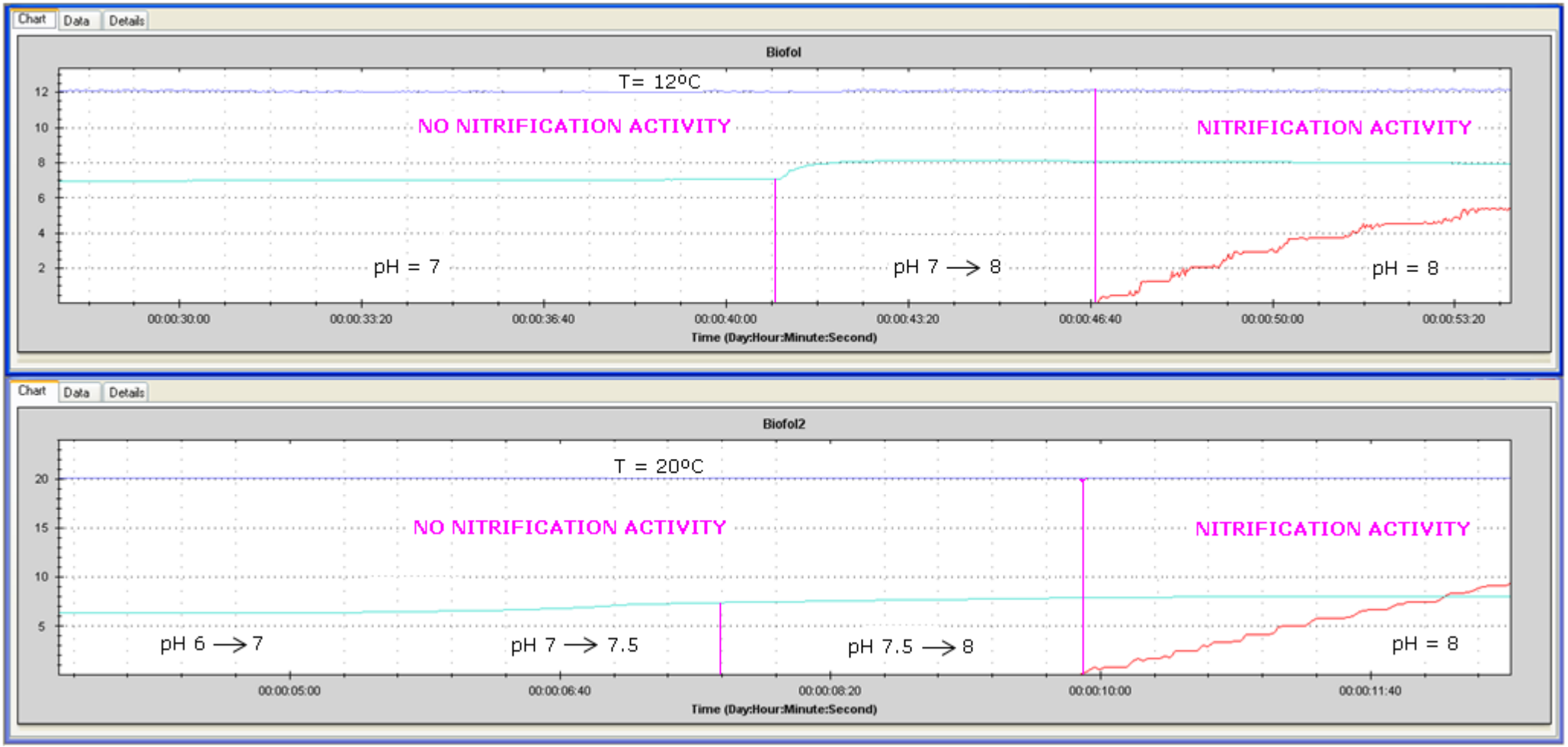


At pH of 8, when we decrease the temperature from 20 to 12 ºC, the nitrification activity experiments an important drop of about - 69%. This fact affects directly on the value of the necessary hydraulic retention time for the nitrification process for a sufficient performance.

Analysis on the effect of pH changes in the different temperatures

Although the target of the present study is not to go into a research on that level, the explanation of why there is not nitrification at pH of 7 and 20ºC (nor at pH of 7 and 12ºC) could lie on the fact that, on the current limitative operation conditions (relatively high F/M, relatively low temperature and pH) on which the process is working, the biofilm in the stones is formed by successive layers in which it prevails the heterotrophic (responsible of organics removal) versus the autotrophic biomass (responsible of ammonium removal) on a significant presence that could limit the normal activity of the autotrophic biomass for pH values ≤ 7.

Some limitative condition could be also observed in the respirograms when, as pH level is automatically raising until reaching the value of 8, the nitrification does not starts immediately by taking certain delay time to stabilize the 8 level and then starting the nitrification activity.



Final conclusions

Under the pH range from <7 to 7, there is not any nitrification activity for the temperature of 20ºC and 12ºC (or below it)

With a pH of 8 and temperature of 20ºC, there is a normal nitrification activity.
Under those conditions, the maximum ammonium uptake rate is 25.6 mg $N\text{-}NH_4$/l/h.

With the pH of 8 and temperature of 12ºC, there is a nitrification activity but relatively low.
On those conditions, the maximum ammonium uptake rate is 7.85 mg $N\text{-}NH_4$/l/h, which represents a decline of 17.75 mg $N\text{-}NH_4$/l/h or approximately a 69 % of decrease over the activity recorded with pH of 8 and 20ºC of temperature.

Because of the current condition of no stable pH (normally low), low temperature (12º) and relatively high F/M, it is very possible that the biofilm in the stones is formed by successive layers in which it prevails the heterotrophic (responsible of organics removal) versus the autotrophic biomass (responsible of ammonium removal) on a significant presence that could limit the normal activity of the autotrophic biomass for pH values ≤ 7.

SURCIS, S.L.

Date: February, 2012