

Course « Water and wastewater treatment », Fall 2025

Part I « Wastewater treatment »

Homework 5

Homework 5-1 : « Design of WWT plant Bern without nitrogen removal by SBRs »

The WWTP of Bern treats since several years its wastewater with so-called biofilters. The treatment of the sludge digester effluent by SBRs has been taken into account in the design of the biofilters. At present, there are 16 biofilter cells, each with a surface of 132 m^2 and a volume of 400 m^3 . The WWTP has been designed for 350'000 person equivalents and a dry weather flow rate $Q_{DW} = 1500 \text{ L s}^{-1}$. The WWTP has to respect an effluent concentration of $N_{\text{tot,eff}} = 15 \text{ mg}_N \text{ L}^{-1}$, which is equivalent to a nitrogen removal of 55% which is achieved by a pre-denitrification in the biofilter system.

- a) What would have been the consequence for the size of the secondary treatment by biofiltration if this part of the WWTP would also had to treat the nitrogen at present removed by the SBRs ?
- b) Which parameters would one have had to verify if one would have wanted to realize this treatment by the biofilters knowing that the primary clarifier removes 80% of the COD ?

In order to be able to answer to (a) one has to make the following assumptions :

- *the nitrogen load treated by the SBRs is equivalent to 43% of the nitrogen load treated at present by the biofilters.*
- *the SBRs remove 100% of this nitrogen by nitrification-denitrification, hence the effluent nitrogen concentration of the SBRs can be considered to be zero.*
- *the discharge of the SBR effluents is already included in Q_{DW} , hence the treatment of the sludge digester effluent by the biofilters would only increase the nitrogen load but not the flow rate.*

Homework 5-2 : « N mass balance in WWTP with DEMON process and aeration savings »

A WWTP based activated sludge has to remove 80% of the influent nitrogen from wastewater and therefore installed nitrification - denitrification. Waste sludge (WS) produced on-site and waste sludge from other WWTPs (40% of total treated waste sludge) are treated in an anaerobic digester. Digested sludge is dewatered by centrifugation. Half of the nitrogen contained in the fresh waste sludge is leaving the WWTP by the dewatered digested sludge (incinerated elsewhere), the rest is present mainly as ammonium in the digester effluent. Before 2008, the resulting ammonium-rich digester effluent was redirected in the biological wastewater treatment. Since 2008, the digester effluent is pretreated in a separate DEMON sequencing batch reactor (SBR), a system that combines partial nitritation of ammonium and anaerobic ammonium oxidation (analog to SHARON-Anammox). The DEMON system removes 85% of the nitrogen contained in the digester effluent. The DEMON effluent is directed to the activated sludge tanks (AT).

WWTP parameters: $Q_0 = 50'000 \text{ m}^3 \text{ d}^{-1}$; $S_{\text{BOD5},0} = 180 \text{ gO}_2 \text{ m}^{-3}$; $N_{\text{tot,eff}} = 5 \text{ gN m}^{-3}$.

- a) Nitrogen mass balance: Calculate the nitrogen loads (kgN d^{-1}) and fill in the mass balance flow scheme below. Give the details of all calculations with adequate units on the next page.
- Hint: Start load calculations by determining first the load for N-waste sludge.*
- b) Aeration savings: With the implementation of the separate DEMON treatment, calculate the annual savings in comparison to full nitrification if you consider an aeration cost of CHF 0.25 per kgO_2 .

