

## Course « Water and wastewater treatment », Fall 2025

### Part II « Wastewater treatment »

#### Homework 4

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##### Homework 4-1 : « Problem with biological phosphorous removal with A/O process »

An activated sludge WWTP has been designed to remove phosphorous biologically according the process A/O at temperatures as low as 10°C. The wastewater temperature fluctuates between 16-20°C and never reaches its design minimum. It is observed that the biological phosphorous removal does not really function. What could be the reason for the bad functioning of this microbiological process ?

##### Homework 4-2 : « Design of BOD-treating biological contactor »

A cheese manufacturing needs its own treatment of its wastewater and decided to install a small WWTP based on biological contactors. The wastewater contains mainly cheese whey (sugars equivalent to glucose;  $3.5 \text{ g}_{\text{sugar}} \text{ L}^{-1}$ ;  $21 \text{ m}^3 \text{ d}^{-1}$ ). You have been asked to design this small WWTP and you assume the following: the sludge biomass has the formula  $\text{C}_5\text{H}_7\text{NO}_2$ , the growth yield of the sludge is  $0.375 \text{ g}_x \text{ g}_{\text{sugar}}^{-1}$  and there is sufficient nitrogen for the production of the sludge biomass. A module of biological contactors has a surface to be colonized of  $2000 \text{ m}^2$ . How many of these modules do you need for the construction of this WWTP if only  $\text{BOD}_5$  has to be removed ?

*Hint: Since you need the  $\text{BOD}_5$  present in the wastewater, you must first estimate the BOD of glucose degradation.*

##### Homework 4-3 : « Design of denitrifying biotrickling filter-based WWTP »

A WWTP which is equipped with biotrickling filters has been designed to eliminate part of the nitrogen by pre-denitrification. You are asked to verify whether the design has been done correctly.

The parameters used for the design were the following :

$$\begin{aligned} Q_0 &= 5'000 \text{ m}^3 \text{ d}^{-1} & C_{0,\text{BOD}_5} &= 170 \text{ gO}_2 \text{ m}^{-3} \\ N_{\text{TKN},\text{inf}} &= 45 \text{ g}_N \text{ m}^{-3} & N_{\text{NO}_3,\text{eff}} &= 15 \text{ g}_N \text{ m}^{-3} & N_{\text{NH}_4,\text{eff}} &= 2 \text{ g}_N \text{ m}^{-3} \end{aligned}$$

Denitrifying filters: 2 with  $\varnothing$  of 20.5 m and 4 m high, carrier with  $140 \text{ m}^2 \text{ m}^{-3}$  surface; Recycling rate  $r = 1.30$ .

Nitrifying filters : 2 with  $\varnothing$  of 15.5 m and 4 m high, carrier with  $180 \text{ m}^2 \text{ m}^{-3}$  surface.

*Hint: to calculate organic matter needed for denitrification, you can refer to homework 2-5.*

##### Homework 4-4 : « Transform activated sludge WWTP into a “Moving bed” plant »

A WWTP that treats the wastewater of 15'000 capita has to be redesigned in order to treat wastewater of additional 10'000 capita. In addition, the WWTP is requested to completely nitrify the wastewater. One has proposed to transform the existing system into a moving bed. The existing installation has primary clarifiers and two aeration tanks of  $1'100 \text{ m}^3$ .

- Did the existing installation already nitrify the wastewater ?
- Is the existing aeration tank volume large enough in order to treat the additional wastewater with a moving bed ?

$$Q_0 = 5500 \text{ m}^3 \text{ d}^{-1} \quad C_{0,\text{BOD}_5} = 160 \text{ g}_{\text{BOD}_5} \text{ m}^{-3} \quad N_{\text{TKN},\text{inf}} = 35 \text{ g}_N \text{ m}^{-3} \quad C_{0,\text{TSS}} = 185 \text{ g}_{\text{TSS}} \text{ m}^{-3}$$