Course « Water and wastewater treatment », Fall 2025

Part II « Wastewater treatment »

Homework 1

Homework 1-1 : « Carbonaceous oxygen demand of bacteria and organic matter »

An approximate empirical formula for bacterial cells is $C_5H_7O_2N$, the one for organic matter $C_{18}H_{19}O_9N$. What would be the theoretical carbonaceous chemical oxygen demand (COD) for 1 g of bacterial cells or 1 g of organic matter ?

Homework 1-2 : « Wastewater parameters of an industrial wastewater »

The analysis of an industrial wastewater has given the following results :

- TOC : 150 g / m^3
- DOC : 0 g / m^3
- TKN : 35 g / m^3

According to the company, the wastewater contains exclusively organic matter with a composition of $C_{18}H_{19}O_9N$ and ammonium nitrogen.

a) What is the concentration of the volatile suspended solids (VSS) of this wastewater ?

b) What is the ammonium concentration of the wastewater ?

c) How much chemical oxygen demand (COD) contains this wastewater ?

d) After primary treatment in a clarifier, a sludge is obtained with 6% SS. What are the concentrations of TOC, DOC, and NH_4-N of this sludge ?

Homework 1-3 : « Incoherence in measured wastewater parameters »

To improve anaerobic digestion of waste sludge (primary and secondary sludge together), a company proposes to treat the effluent of the anaerobic digester by a hydrothermal treatment and to transform non-degraded organic matter (especially the particulate matter) into solubilized organic molecules. The idea is that this liquid could then be recycled into the anaerobic digestion process and the solubilized organic matter transformed into biogas. In order to do a test on laboratory-scale to investigate whether this hydrothermal treatment liquid can be digested anaerobically, a detailed analysis was carried out on different parameters:

Parameter	Unit	Average
volatile solids (VS)	[mg/L]	1457
fixed solids (IS)	[mg/L]	610
total organic carbon (TOC)	[mg C/L]	2016
total inorganic carbon (TIC)	[mg C/L]	1301
chemical oxygen demand (COD)	[mg O2/L]	7480
Kjehldahl nitrogen (TKN)	[mg N-TKN/L]	1865
ammonium nitrogen (N-NH4)	[mg N-NH4/L]	2320

When having a closer look at these values, it is quite obvious that there is incoherence in this data. Identify the incoherence in the data by comparing the different parameters and by making some back-of-the-envelope calculations, and explain why the data is incoherent.

Remark: If you need the chemical composition of the solubilized organic matter in the hydrothermal treatment liquid, you can use $C_{18}H_{19}O_9N$ which has a COD of 1.42 g_{O2} g_{OM}^{-1}.

Homework 1-4 : « Return sludge – waste sludge »

An activated sludge WWTP treats the wastewater of Q_0 = 17'500 m^3 d^{-1} and the sludge production ($X_{produced}$) is 135 g_{TSS} $m^{-3}{}_{WW}$. The activated sludge concentration (X_{AT}) in the aeration tank is maintained at 3.5 $\mathbf{k}g_{TSS}$ m^{-3}. One pumps 17'000 m^3 d^{-1} sludge, return and waste sludge combined. The effluent of the secondary clarifier contains 15 g_{TSS} m^{-3}.

a) How much sludge in m^3 does one has to remove from the total sludge volume pumped per day as waste sludge assuming that $Q_{effluent} = Q_{0, inflow}$?

b) Comparing the amount of sludge circulated each day with the amount of sludge produced each day, how many times larger is the circulated amount?

HINT: For a) assume that $Q_{Recycle}$ is about equal to $Q_{Recycle}+Q_{Waste}$ since Q_{Waste} is very small.