Course « Water and wastewater treatment », Fall 2020
Part II « Wastewater treatment » by Prof. Holliger

Homework 2

Homework 2-1 : « BOD due to nitrification »

Nitrification consumes oxygen and has to be taken into consideration in WWTPs where a low ammonium effluent concentration has to be achieved.

a) Calculate the nitrogenous oxygen demand NOD for normal, concentrated and diluted wastewaters (see lecture slides) by neglecting biomass production by nitrifyers and compare it to BOD_5 of these wastewaters.

b) How would this oxygen demand change if one takes into consideration biomass production by nitrifyers with ammonium as nitrogen source ?

Homework 2-2 : « Nitrification in a specific WWTP »

For the design of nitrifying activated sludge plants, a security factor can be taken into account that is defined as:

$SF = \mu \cdot \theta_X$

with SF = security factor
μ = growth rate of nitrifyers
θ_X = solids retention time / sludge age

If SF is < 1.0, it is very probable that the plant does not nitrify because nitrifyers will be washed out..

A WWTP was designed to nitrify at 15°C with an oxygen concentration of 2 g m^{-3} and a sludge age of 5 days. The pH of the wastewater is between 7.0 – 7.5.

Does this WWTP nitrify according the security factor concept at 15°C ?

Hints: 1. Use the information on growth rates and constants presented on lecture slides.

2. The norm for N-NH_4 is 2 g m^{-3} and the aeration tank is designed as a completely stirred tank reactor.

Homework 2-3 : « Biomass production due to aerobic and denitrifying heterotrophs and nitrifyers »

An average wastewater has a COD concentration of 340 g_{O2} m^{-3}, a BOD_5 concentration of 170 g_{O2} m^{-3}, and a TKN concentration of 30 g_N m^{-3}. The aerobic heterotrophs have a growth yield of 0.5 g_X g^{-1} organic matter, the nitrifyers produce biomass according the equation given on a lecture slide, and denitrifyers according the equation on another slide with the assumption that enough nitrate is available to oxidize all organic matter. Compare the biomasses produced by either aerobic and denitrifying heterotrophs and by the nitrifyers ?

Homework 2-4 : « Alkalinity change due to denitrification »

Alkalinity is measured by conventional titration with acid to an end pH of 4.5. The higher the value is the greater the buffering capacity. Normally municipal wastewaters with an alkalinity over 5 eqv m^{-3} (more than 5 mol of protons/acid is needed per m^3 to reach pH 4.5) will not cause problems in connection with nitrification and simultaneous precipitation of phosphate.

Denitrification also influences alkalinity. If in a wastewater that has an alkalinity of 4.1 eqv m^{-3} before denitrification, 25 $g_{N\text{-}NO3}$ m^{-3} are denitrified, what will be the alkalinity TAL after the denitrification process ?

Hints: Assume that denitrification is done in a pre-denitrification process and that therefore ammonium is available as nitrogen source.

Homework 2-5 : « Oxygen savings due to denitrification »

Denitrification consumes organic matter (OM) as carbon and energy source in order to reduce nitrate to dinitrogen gas. If one would use the influent BOD_5 for denitrification, how much less oxygen has to be provided for BOD_5 removal if one has to denitrify 20 $g_{N\text{-}NO3}$ m^{-3}. Assume that there is ammonium available as nitrogen source.

Hints: - Use the empirical formula $C_{18}H_{19}O_9N$ for OM and assume a growth yield for aerobic heterotrophs of 0.5 $g_X\ g_{OM}^{-1}$.

- Establish an equation for aerobic degradation of OM like the equation for denitrifying degradation of OM to be able to determine BOD for OM degradation.