# Answers to exercises I: Introduction

## Applied wastewater engineering

### Exercise 1: Solid waste production and energy consumption of classical wastewater treatment

1) What kind of solid waste do you generate in a classical wastewater treatment plant having a primary clarifier?

*a) Screenings from screens*
*b) Grit from the grit and grease removal unit*
*c) Primary sludge from the primary clarifiers*
*d) Secondary sludge from the secondary clarifiers*
*e) Grease and scum from grit and grease removal unit/primary clarifier/secondary clarifier*

2) What happens during a biological treatment?

   a. Aerated sludge age (at moderate temperatures: < 15 °C): < 5 days

*a) Oxidation of organic material*
*b) Sludge production (containing C, N, P)*

   b. Aerated sludge age: 10 days

a) *Oxidation of organic material*
b) *Oxidation of ammonia to nitrate*
c) *Denitrification of nitrate to nitrogen if there is a denitrification tank*
d) *Sludge production (containing C, N, P)*

   c. Aerated sludge age > 25 days

*a) Oxidation of organic material*
*b) Oxidation of ammonia to nitrate*
*c) Denitrification of nitrate to nitrogen if there is a denitrification tank*
*d) Sludge production (containing C, N, P)*
*e) Mineralisation/oxidation of sludge/oxidation (also happening for lower sludge ages but to a much lower extent)*

3) What major off-gases are generated in the biological tank?

   a. Aerated sludge age (at moderate temperatures: < 15 °C): < 5 days

*a) $CO_2$*

b. Aerated sludge age: 10 days (no denitrification tank)

*a) $CO_2$*

c. Aerated sludge age: 10 days (with denitrification tank)

*a) $CO_2$*
b) *$N_2$ (from denitrification tank)*

### Exercise 2: Biological treatment

A wastewater treatment plant without a primary clarifier has difficulty to nitrify during the colder months of the year. Based on the data collected at the wastewater treatment plant you computed that its aerated sludge age is six days.

1) Why do they have difficulty to nitrify correctly?

*An aerated sludge age of seven days is insufficient to achieve stable nitrification during winter months (cold-water temperatures). A stable nitrification is achieved for an aerated sludge age above 8-10 days depending on the size of the wastewater treatment plant.*

2) What modifications do you suggest in order to solve the problem of nitrification? Propose two solutions knowing that your client does not want to modify the secondary clarifiers. Furthermore, you know, that the secondary clarifiers will not decant properly if the sludge concentration in the biological tank is increased.

*Possible answers (only two are asked for):*

*a) Construction of a primary clarifier: reduced COD and TSS loads entering the biological treatment → aerated sludge age increases → stable nitrification during the whole year (if sludge age increased sufficiently)*
*b) Extension of the aerated biological tanks: aerated sludge age increases → stable nitrification during the whole year (if sludge age increased sufficiently)*
*c) Addition of a coagulant (e.g. $FeCl_3$) to the wastewater before entering the primary clarifier (if it already exists) → the coagulant precipitates and coagulates smaller particles which can then be removed by primary clarification → reduced COD, BOD and TSS loads entering the biological treatment → aerated sludge age increases → stable nitrification during the whole year (if sludge age increased sufficiently)*
*d) Transformation of the biological treatment process to a more intensive process (e.g. transformation of activated sludge treatment to moving bed biofilm reactor (MBBR))*

3) For both solutions suggested, your client asks you whether the oxygen consumption of the aeration tanks will change.

*a) Construction of a primary clarifier: oxygen consumption will decrease because the primary clarifier removes more COD, BOD and TSS. This modification will reduce the energy*

*requirements of the wastewater treatment plant (aeration accounts for about 50 % of the total energy consumption). However, primary sludge will be generated and will have to be treated and evacuated.*

b) *Extension of the aerated biological tank: The oxygen consumption will remain very similar (a slight increase of oxygen consumption will occur during winter because of stable nitrification).*
c) *Addition of a coagulant (e.g. $FeCl_3$) to the wastewater before entering the primary clarifier: oxygen consumption will decrease because the primary clarifier removes more COD, BOD and TSS. This modification will reduce the energy requirements of the wastewater treatment plant (aeration accounts for about 50 % of the total energy consumption). However, additional primary sludge will be generated and will have to be treated and evacuated.*
d) *Transformation of the biological treatment process to a more intensive process: intensive processes generally require more oxygen than extensive processes.*