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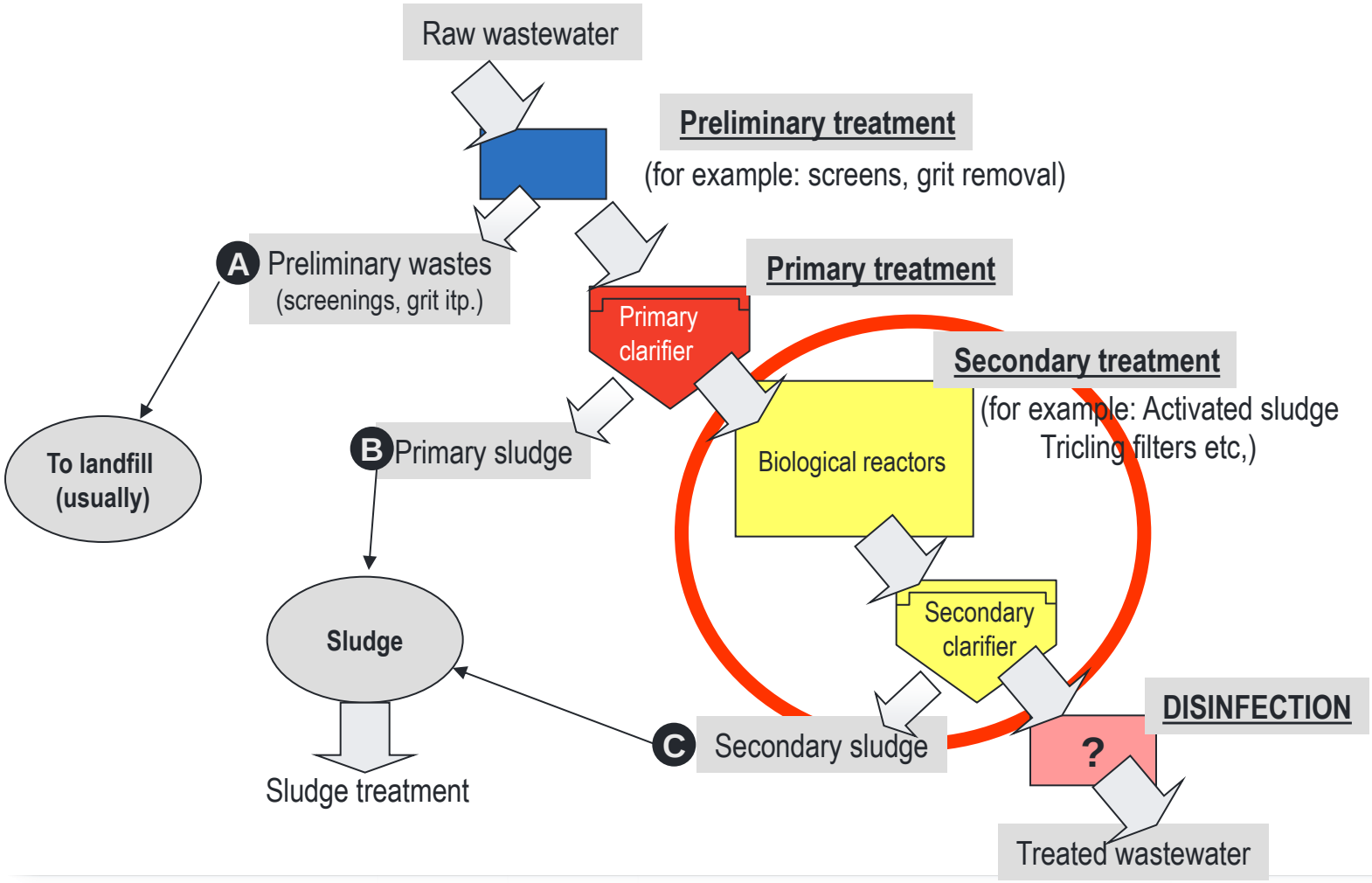
DENITRIFICATION – TECHNOLOGICAL ASPECTS

Wastewater Treatment Technology- course
Faculty of Environmental Engineering, Wroclaw University of Science and Technology

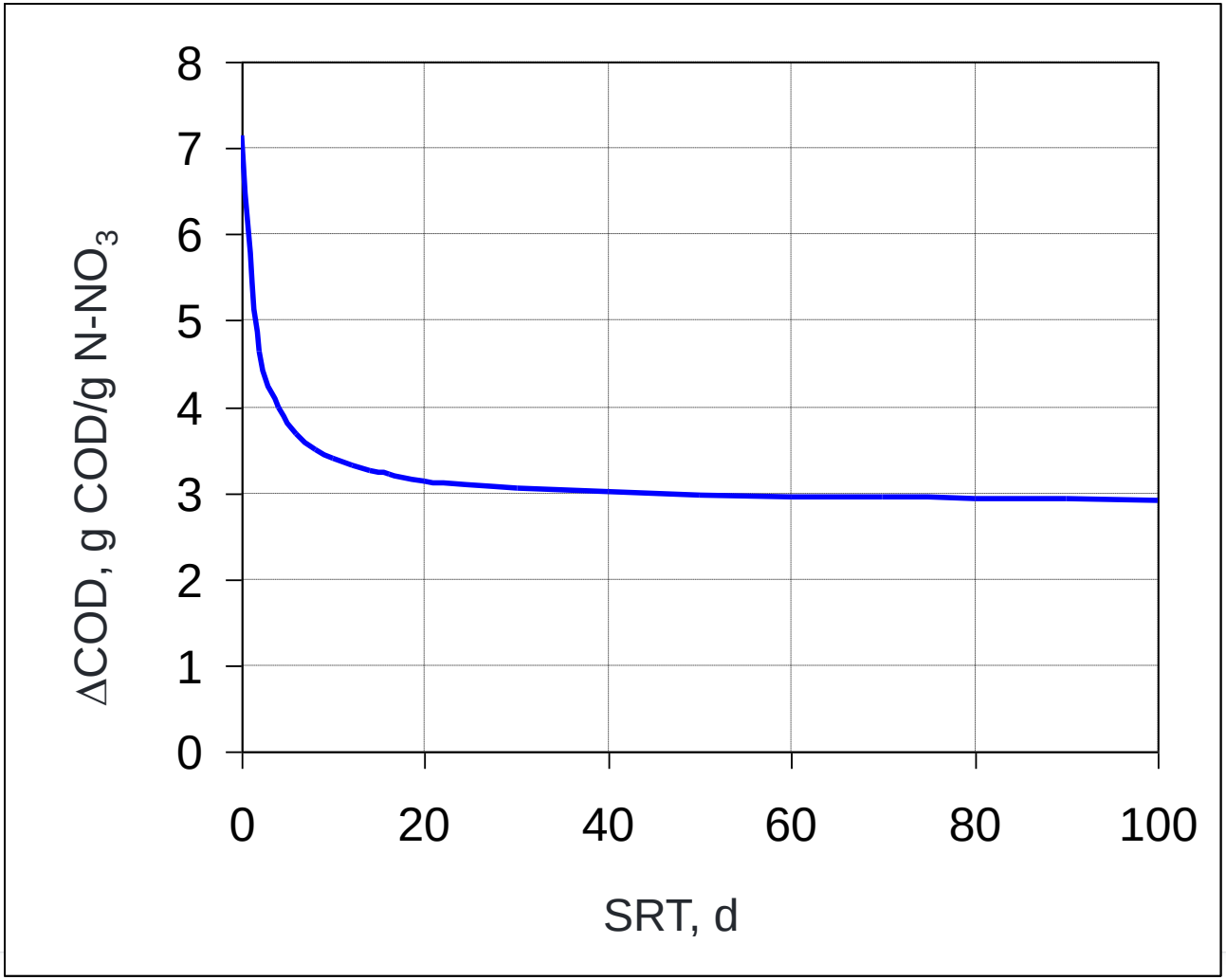
WROCŁAW, 2025

Where are we?


Raw wastewater
Preliminary treatment
(for example: screens, grit removal)
A Preliminary wastes
(screenings, grit itp.)
To landfill
(usually)
Primary treatment
Primary clarifier
B Primary sludge
Secondary treatment
(for example: Activated sludge
Tricling filters etc,)
Biological reactors
Secondary clarifier
Sludge
Sludge treatment
C Secondary sludge
DISINFECTION
?
Treated wastewater

Denitrification

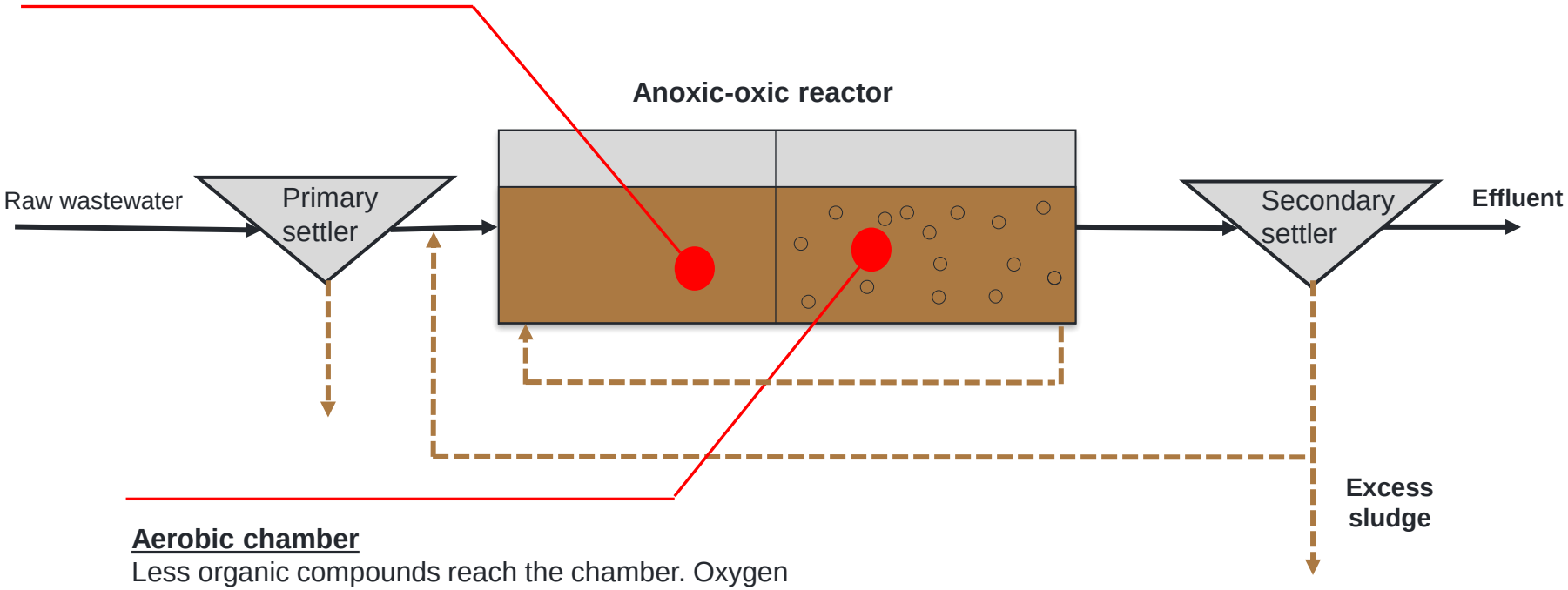
Organic carbon requirement



Denitrification

Oxygen consumption

Nitrate recirculation
Organic compounds are removed using nitrates, not oxygen.



Aerobic chamber
Less organic compounds reach the chamber. Oxygen consumption decreases.

Denitrification

Oxygen consumption

$$\Delta Z_{O2} = \frac{Q \cdot 2{,}9 \cdot S_{NO_3,\,D}}{1000} \; [\mathrm{kgO_2/d}]$$

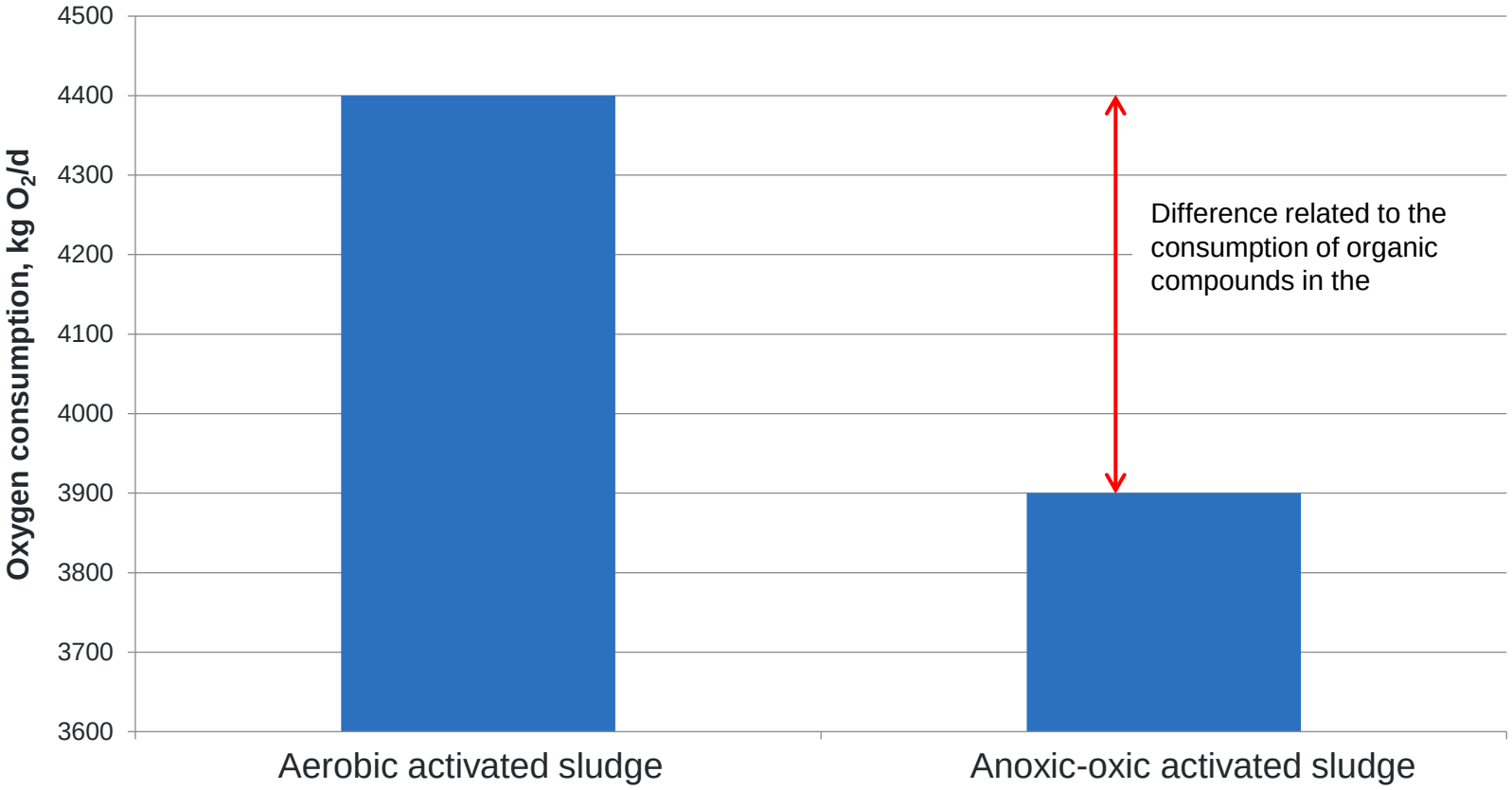
Influent flow to the biological unit [m³/d]

Unit oxygen recovery coefficient from denitrification per 1 g N-NO_3

Nitrate nitrogen concentration for denitrification [g N/m³]

Denitrification

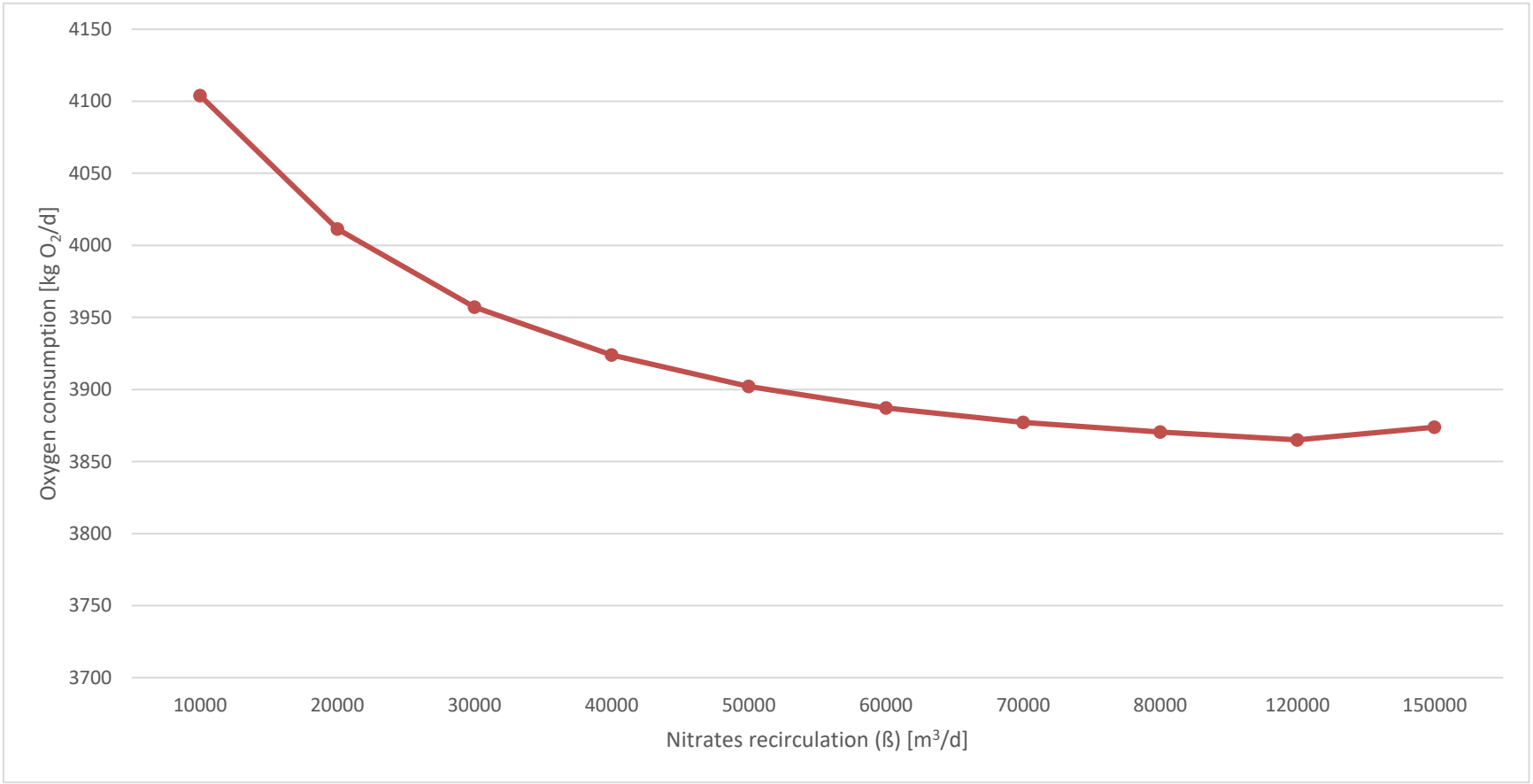
Oxygen consumption



Wastewater flow = 10 000 m³/d
Typical domestic wastewater

Denitrification

Oxygen consumption



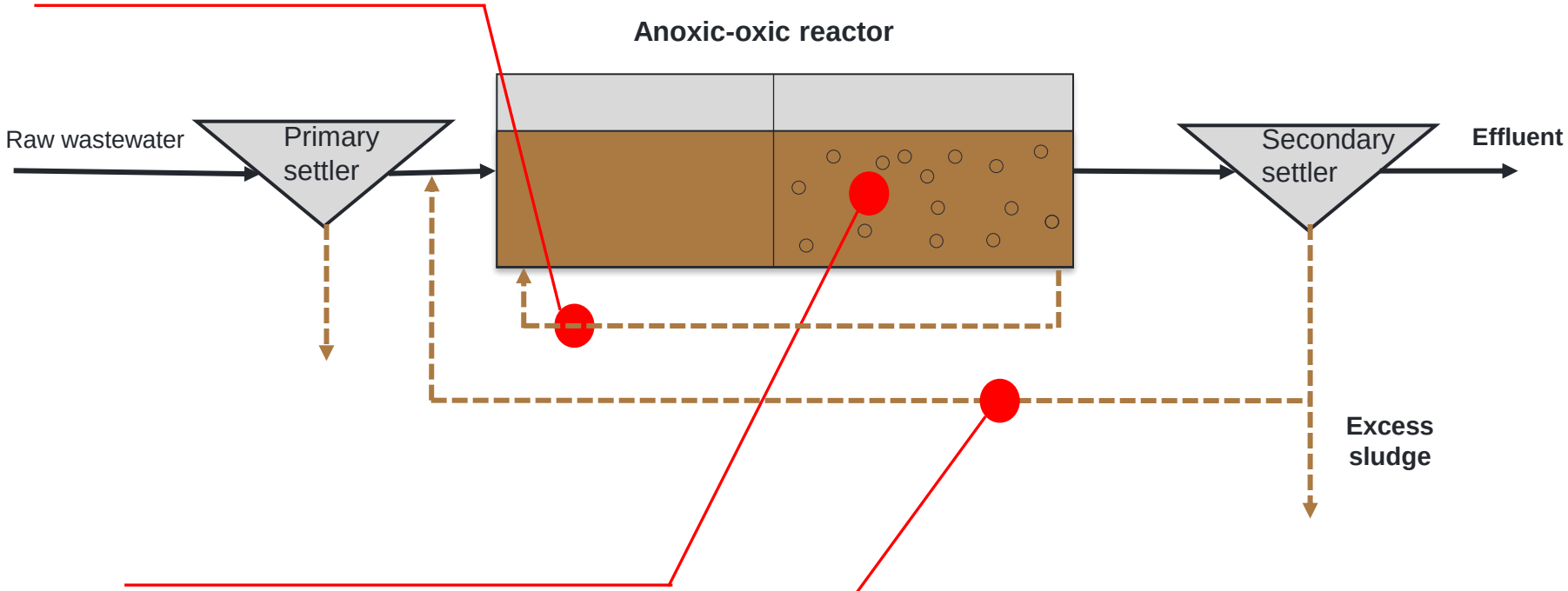
Wastewater flow = 10 000 m³/d
Dissolved oxygen concentration in reactor: S_0 = 2 g O_2/m³
Temperature in reactor: T = 14.2°C SRT = 27 d, SRT_OX = 13.5 d
Typical domestic wastewater

Denitrification

Oxygen in nitrates recirculation

Nitrate recirculation

- The oxygen present in the aerobic chamber is recirculated
- The recirculation rate usually amounts to several hundred percent of the influent flow (Q_{entry})



Aerobic chamber

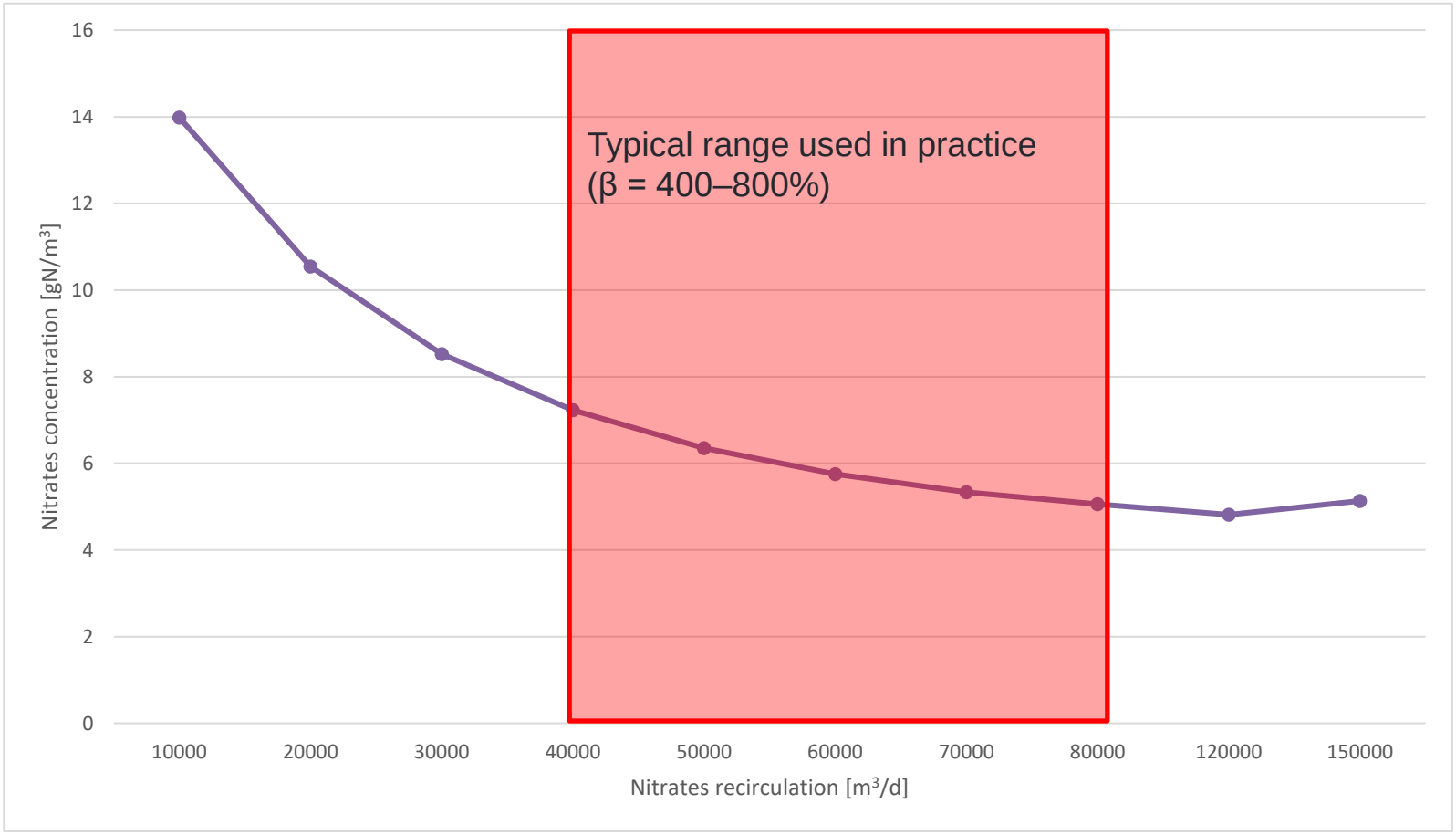
Oxygen concentration is approximately 1.5–2.0 g O_2/m^3

Sludge recirculation

Zero oxygen concentration

Denitrification

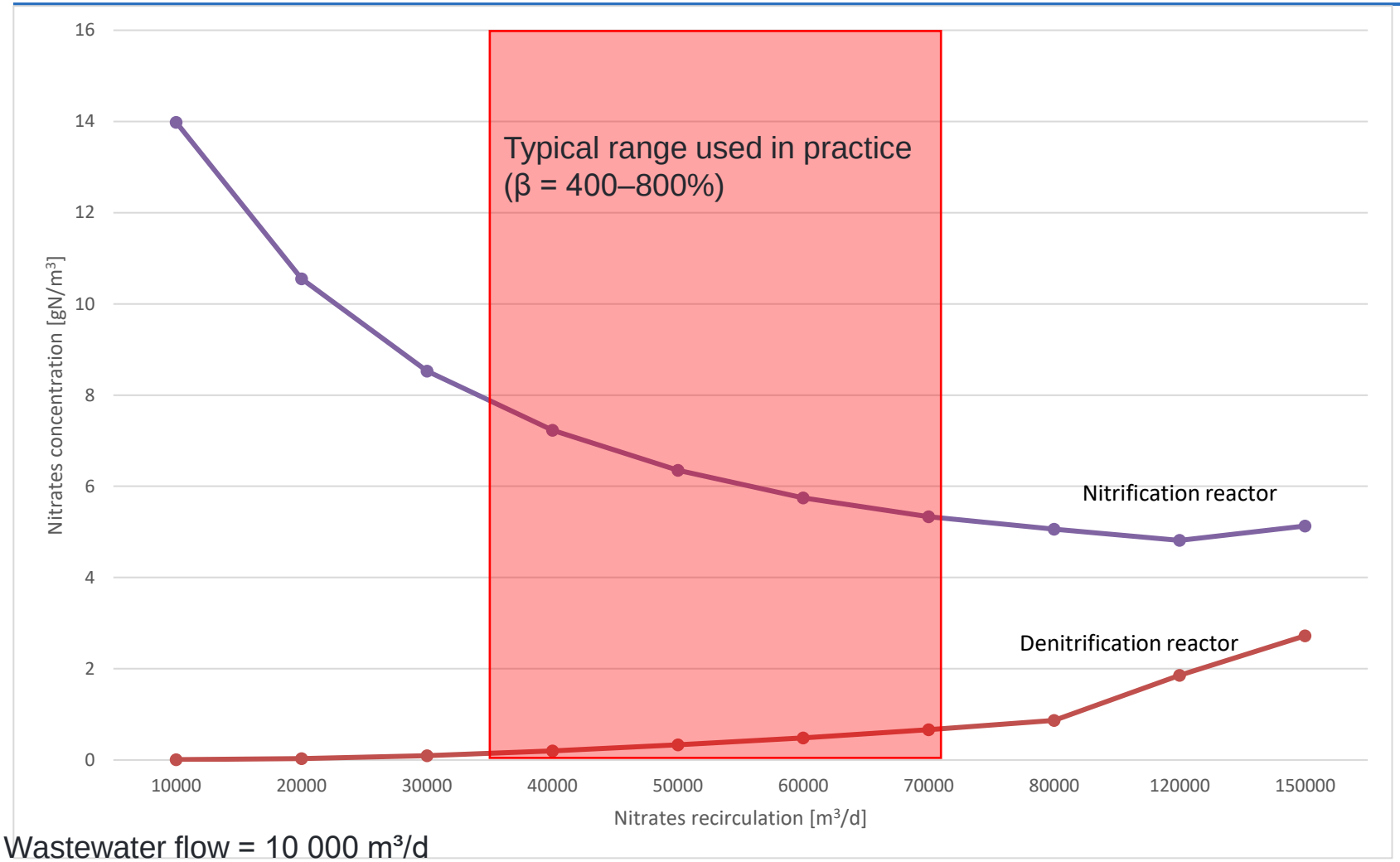
Oxygen in nitrates recirculation



Wastewater flow = 10 000 m³/d
Dissolved oxygen concentration in reactor: S_0 = 2 g O_2/m³
Temperature in reactor: T = 14.2°C SRT = 27 d, SRT_OX = 13.5 d
Typical domestic wastewater

Denitrification

Effluent quality vs nitrates recirculation



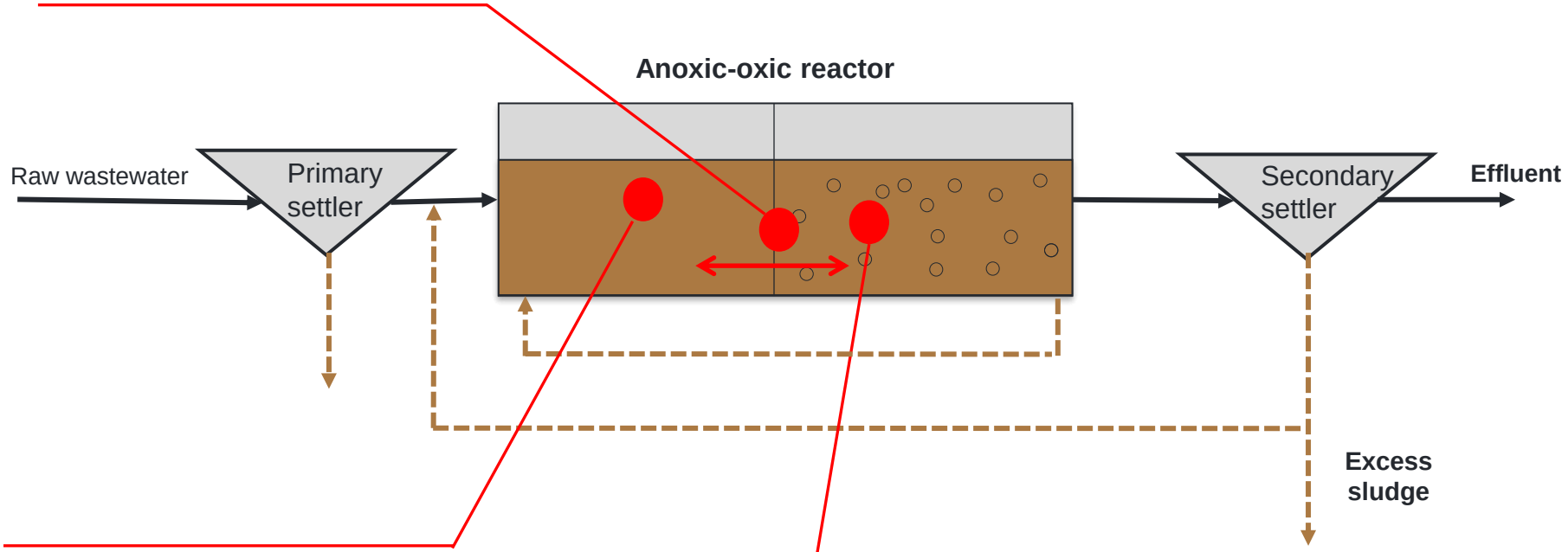
Wastewater flow = 10 000 m³/d
Dissolved oxygen concentration in reactor: S_0 = 2 g O_2/m³
Temperature in reactor: T = 14.2°C SRT = 27 d, SRT_OX = 13.5 d
Typical domestic wastewater

Denitrification

AX/OX proportion

AX/OX chamber ratio

- We change the volume of the anoxic chamber by turning the diffusers on or off
- As the AX volume increases, the OX volume decreases



Anoxic chamber size

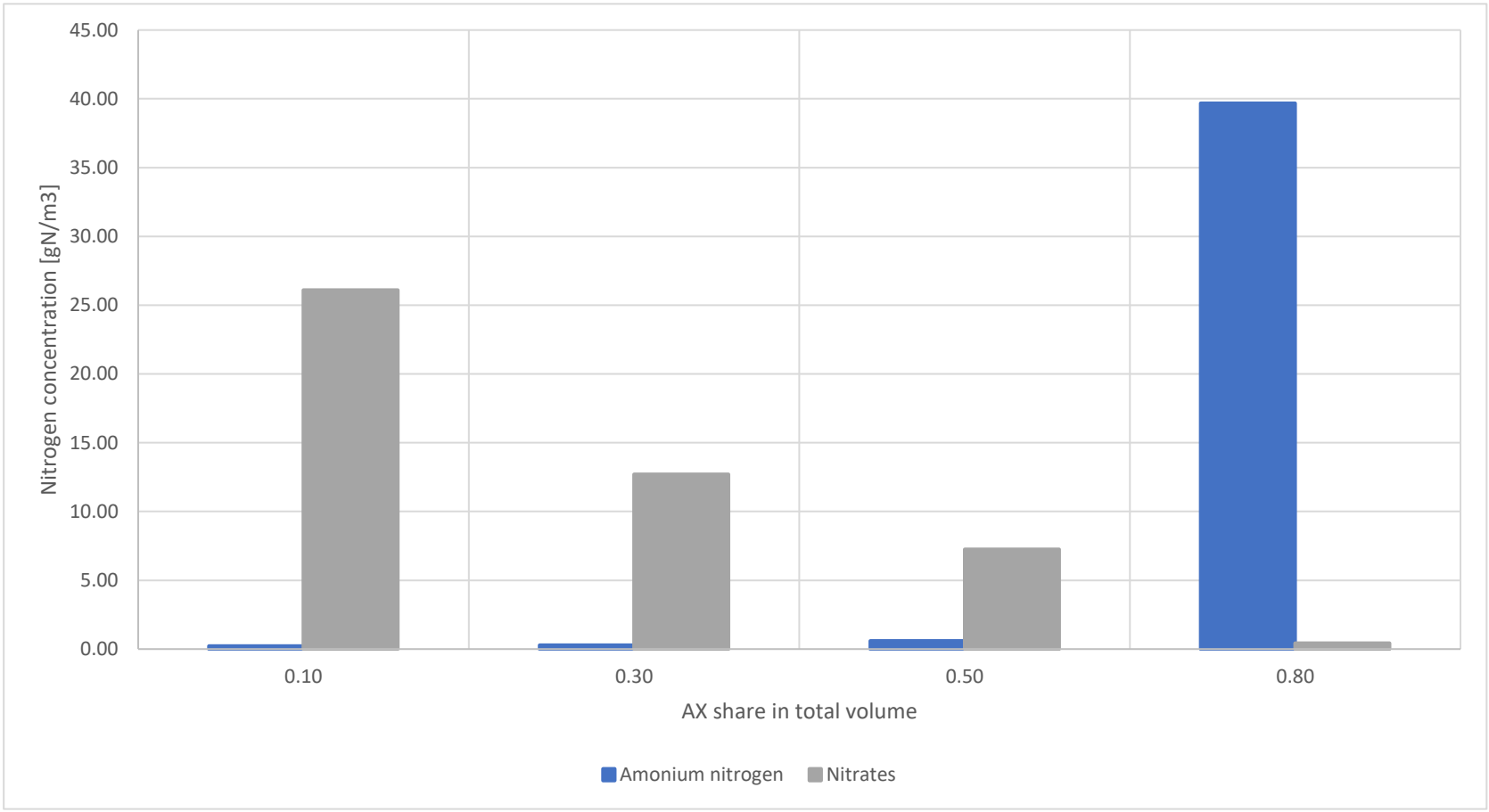
When we change the AX/OX ratio, we change the retention time in the anoxic chamber. This affects denitrification.

Aerobic sludge age

When we change the AX/OX ratio, the aerobic sludge age changes. This affects the nitrification process.

Denitrification

AX/OX proportion



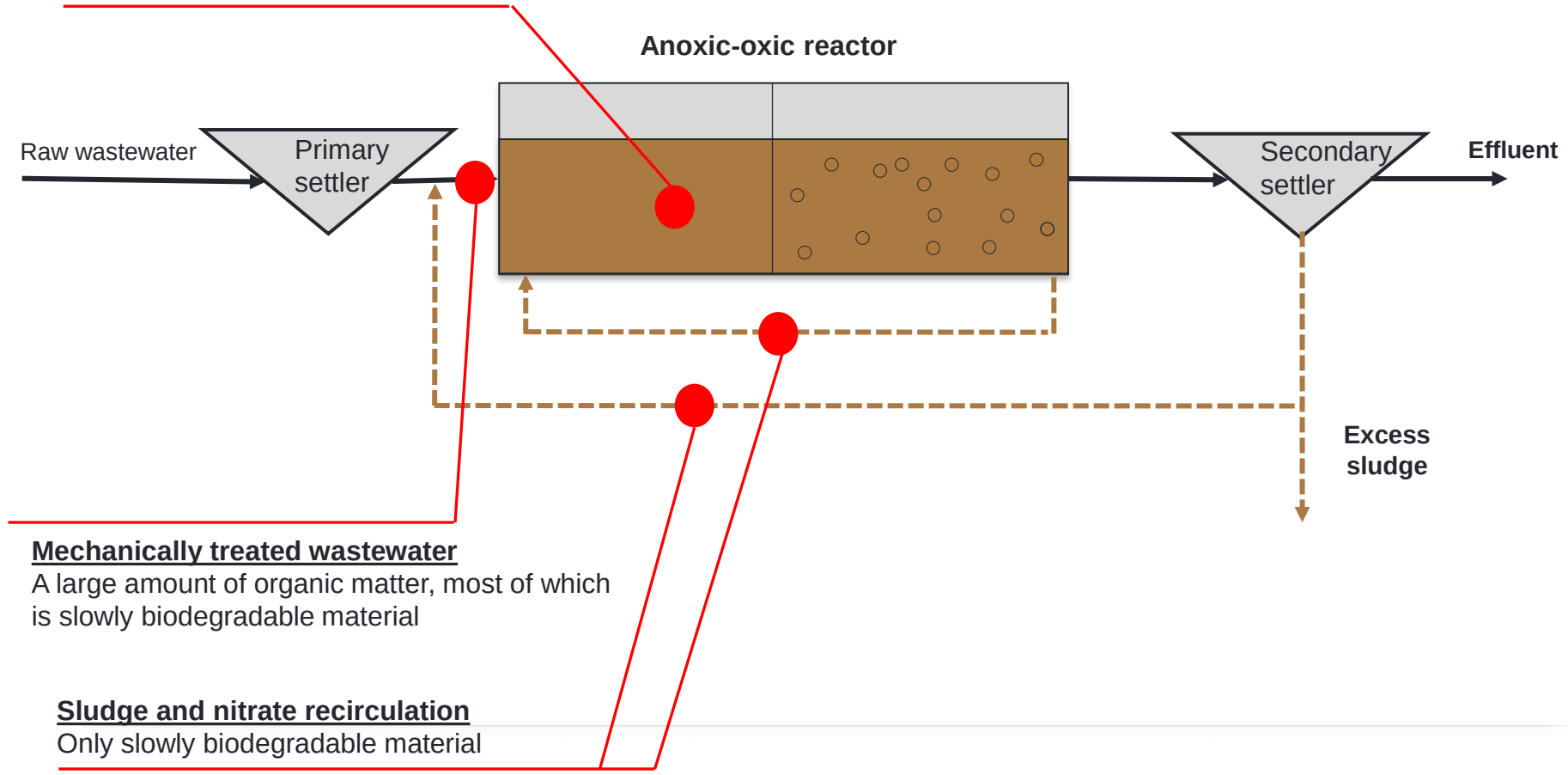
Wastewater flow = 10 000 m³/d
Dissolved oxygen concentration in reactor: S_0 = 2 g O_2/m³
Temperature in reacor: T = 13°C, SRT = 35 d, Nitrate recirculation = 400%
Typical domestic wastewater

Denitrification

Readily biodegradable and slowly biodegradable organic carbon

AX chamber

- First, bacteria oxidize organic compounds using oxygen
- When the readily biodegradable compounds are depleted, the denitrification rate is limited by the hydrolysis rate

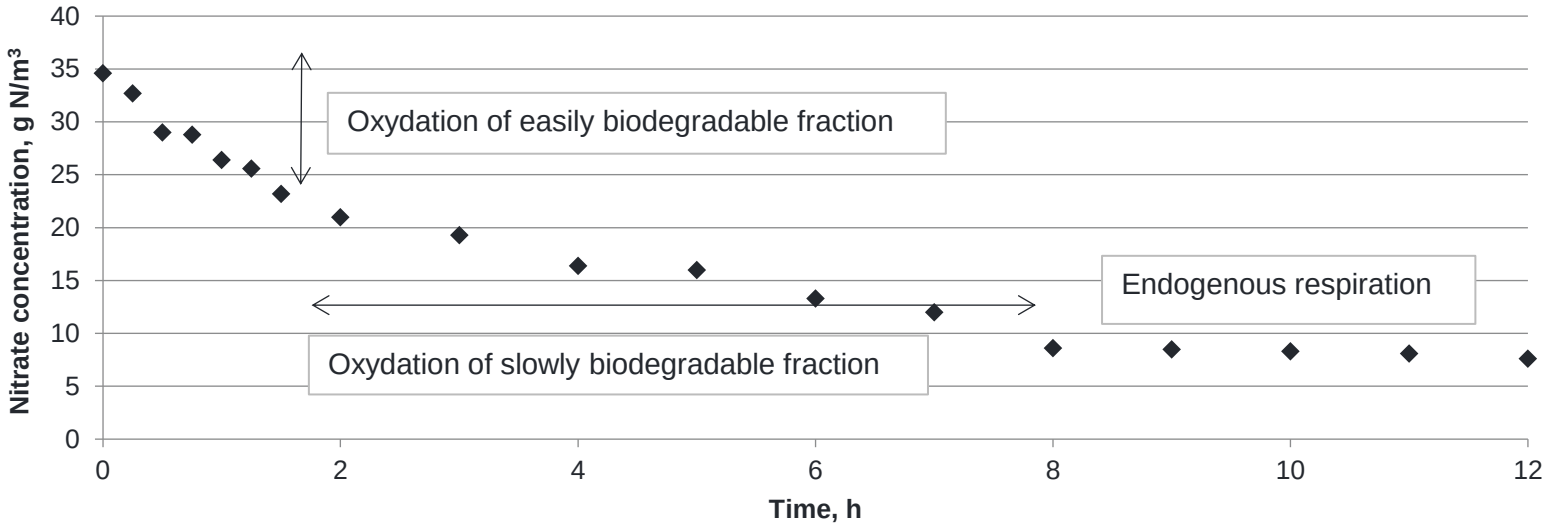


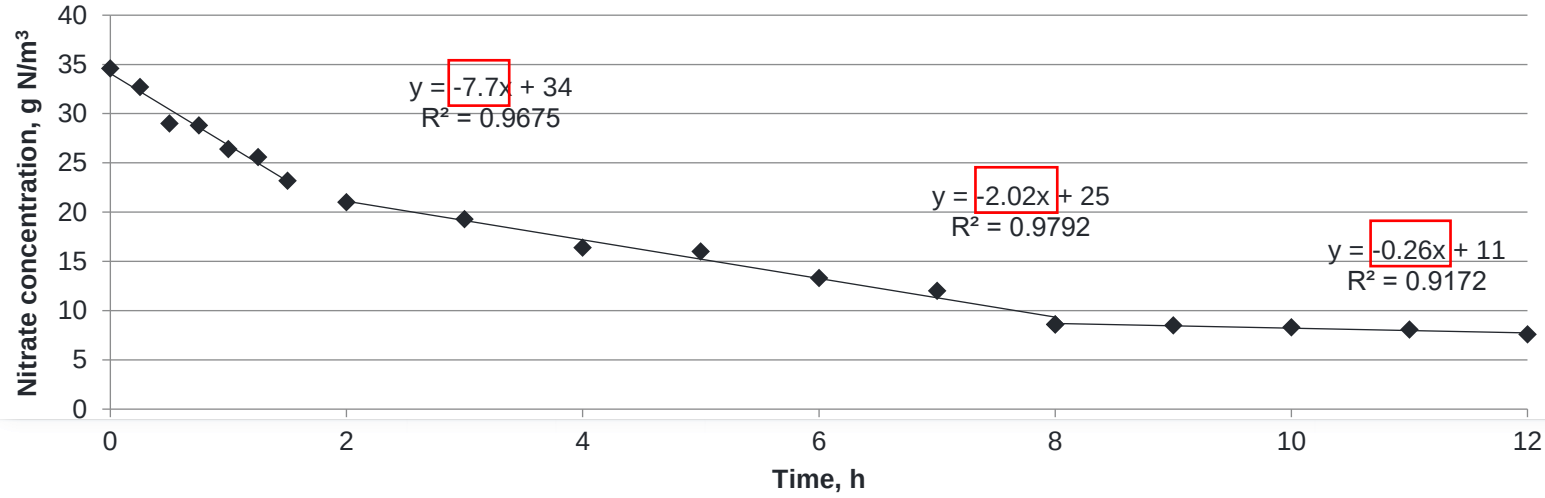
Mechanically treated wastewater
A large amount of organic matter, most of which is slowly biodegradable material

Sludge and nitrate recirculation
Only slowly biodegradable material

Denitrification

Readily biodegradable and slowly biodegradable organic carbon





Control questions

1. How does the implementation of denitrification affect oxygen consumption?
2. What is the impact of the nitrate recirculation rate on the nitrate removal process?
3. How does changing the volume of the AX chamber affect the efficiency of nitrification and denitrification?
4. Denitrification rate versus the availability of readily and slowly biodegradable substrates?