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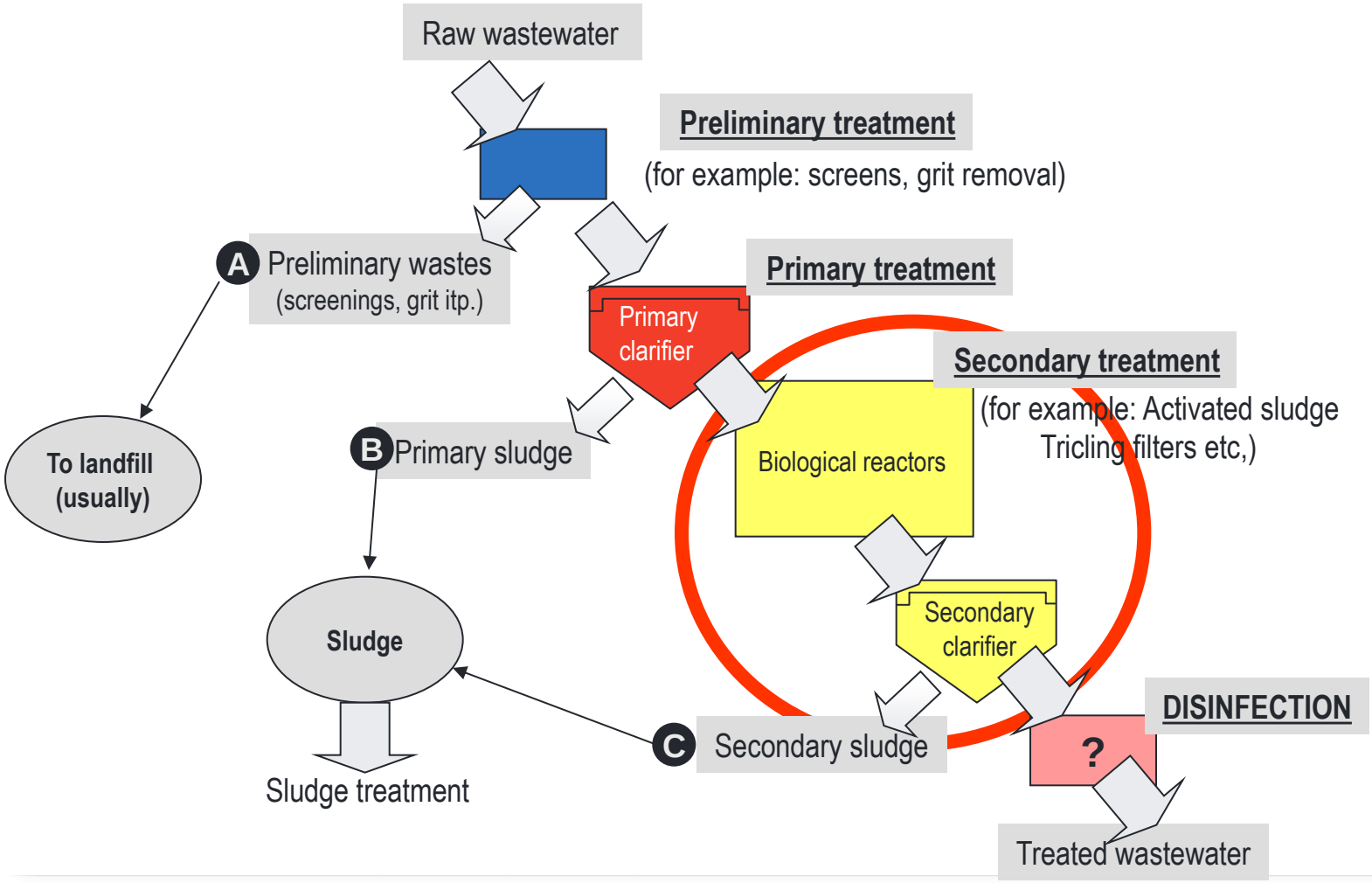
NITRIFICATION

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

Nitrification

Stochiometry

$NH_4^+ + 1.5\ O_2 = NO_2^- + 2\ H^+ + H_2O$ (*Nitrosomonas*)

Oxygen consumption (~3.43 *g* O_2/*g* *N-*NH_4)

$NO_2^- + 0.5\ O_2 = NO_3^-$ (*Nitrobacter*)

Oxygen consumption (~1.14 *g* O_2/*g* *N-*NO_2)

$NH_4^+ + 2.0\ O_2 = NO_3^- + 2\ H^+ + H_2O$ (*Nitrosomonas + Nitrobacter*)

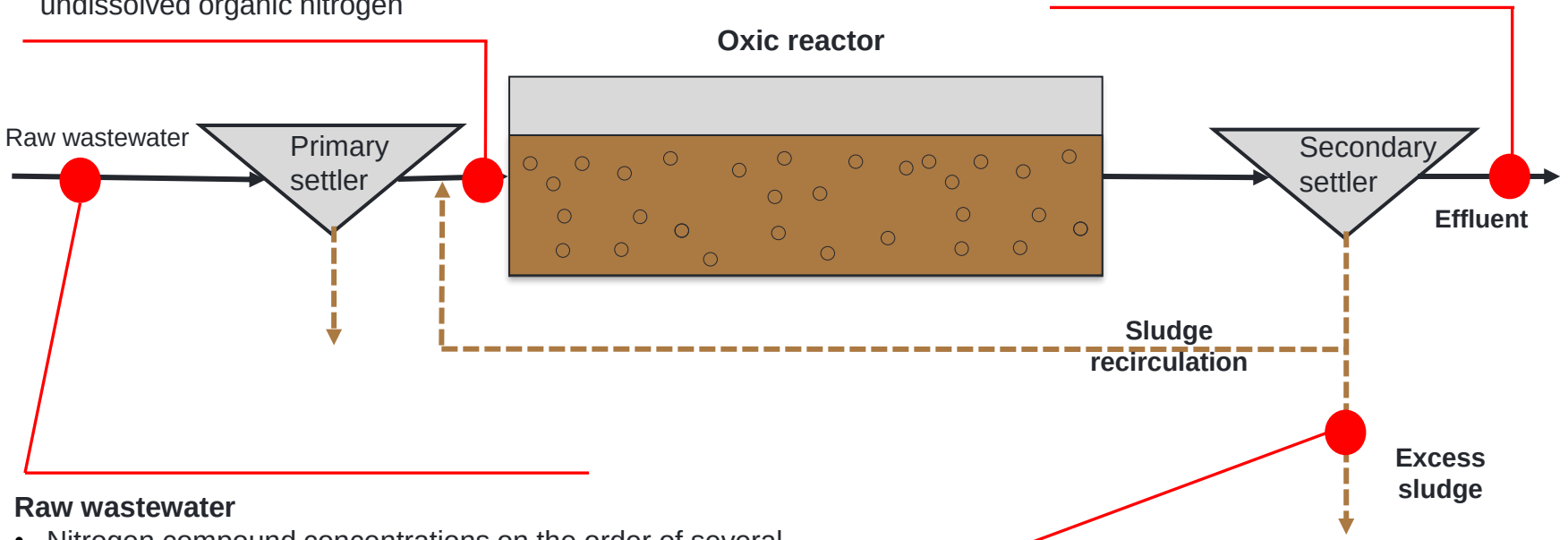
Oxygen consumption (~4.57 *g* O_2/*g* *N-*NH_4)

Nitrification

Mechanism

Mechanically treated wastewater
- A decrease in nitrogen concentration of approximately 10%
- All nitrogen compounds removed in the primary settler are undissolved organic nitrogen

Treated wastewater
- Nitrate nitrogen and residual ammonium nitrogen leave the treatment plant
- The effluent also contains small amounts of organic nitrogen (in suspended solids and in dissolved form)

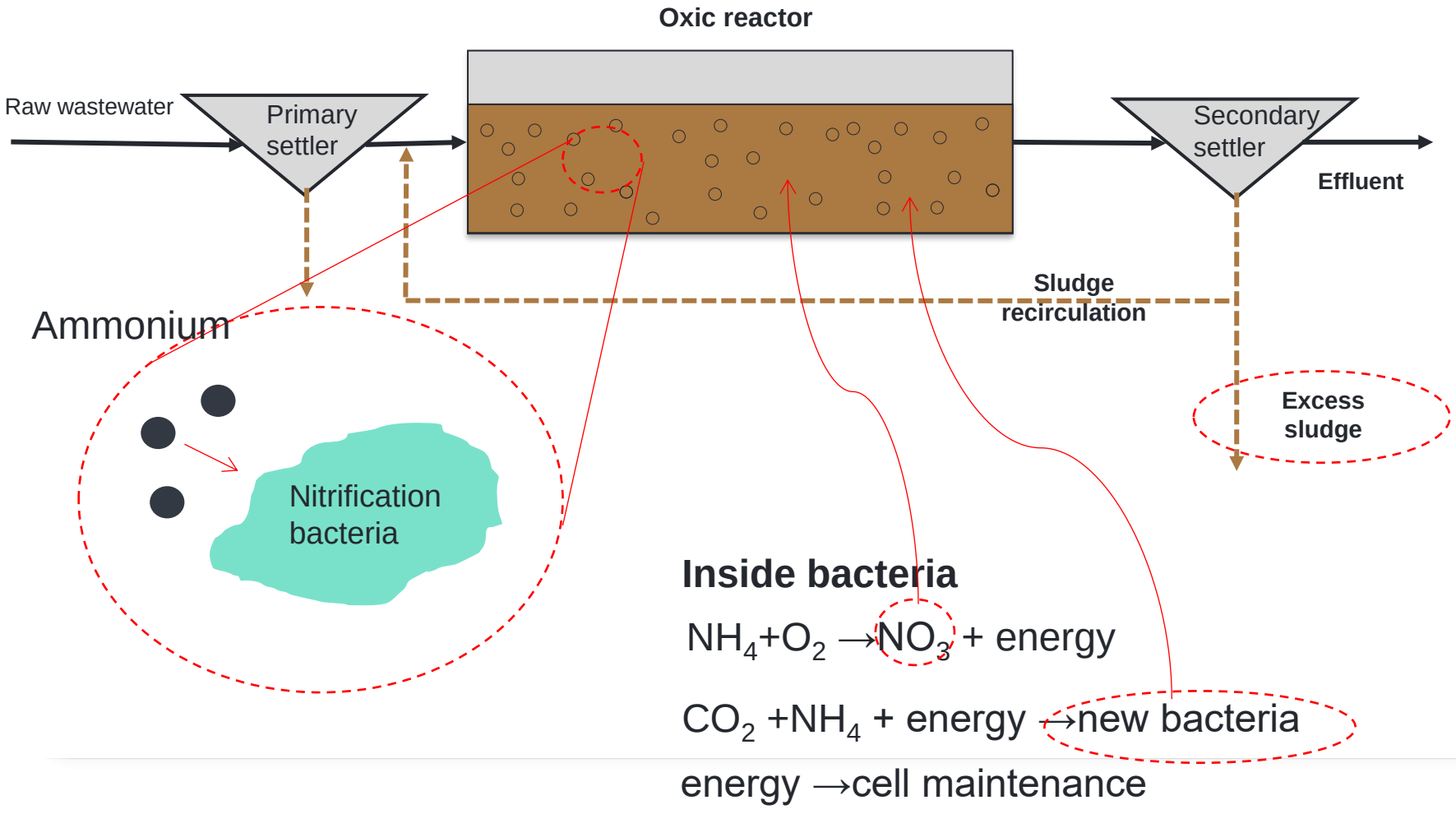


Raw wastewater
- Nitrogen compound concentrations on the order of several tens of g N/m³
- The majority is in the form of ammonium nitrogen Presence of both dissolved and particulate organic nitrogen

- **Waste activated sludge**
- All non-biodegradable undissolved organic nitrogen is found in the waste activated sludge
- It also contains a certain amount of biodegradable undissolved organic nitrogen.

Nitrification

Mechanism



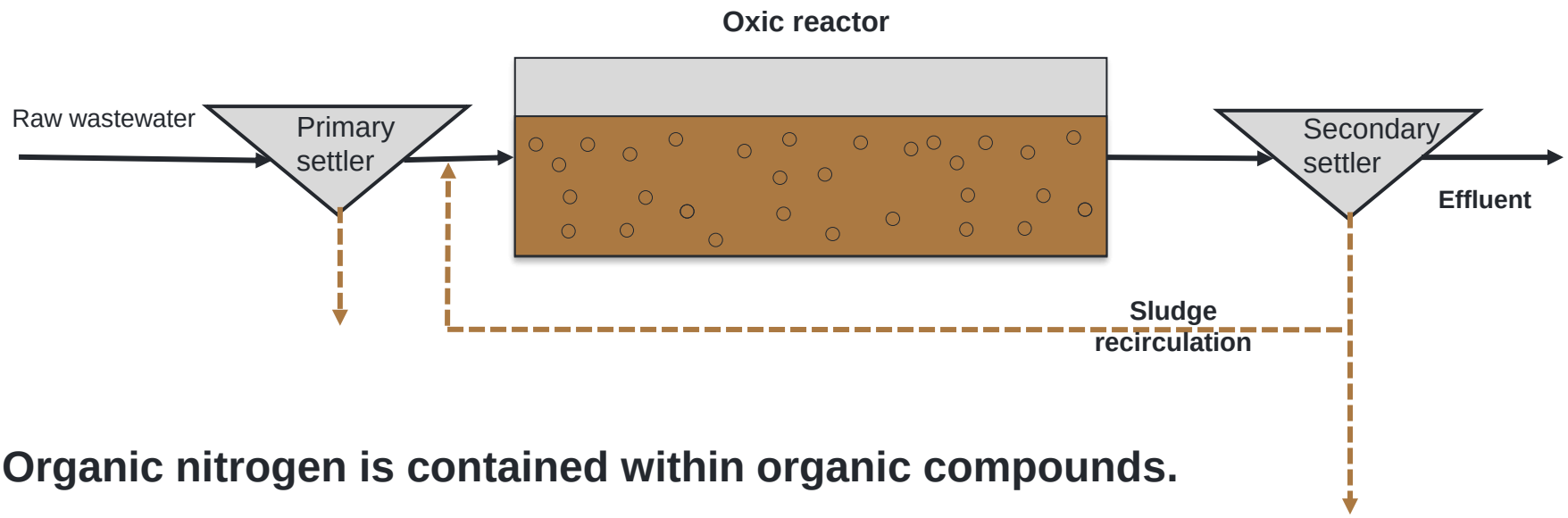
Nitrification

Mechanism

1. Ammonium nitrogen is assimilated by nitrifying bacteria primarily for oxidation, with only a negligible amount used for biomass growth.
2. The energy obtained from oxidation is used for the synthesis of organic carbon from carbon dioxide and to meet the cell’s energy demands.
3. The growth rate of nitrifiers is slow and highly dependent on temperature.

Nitrification

Biodegradable organic nitrogen



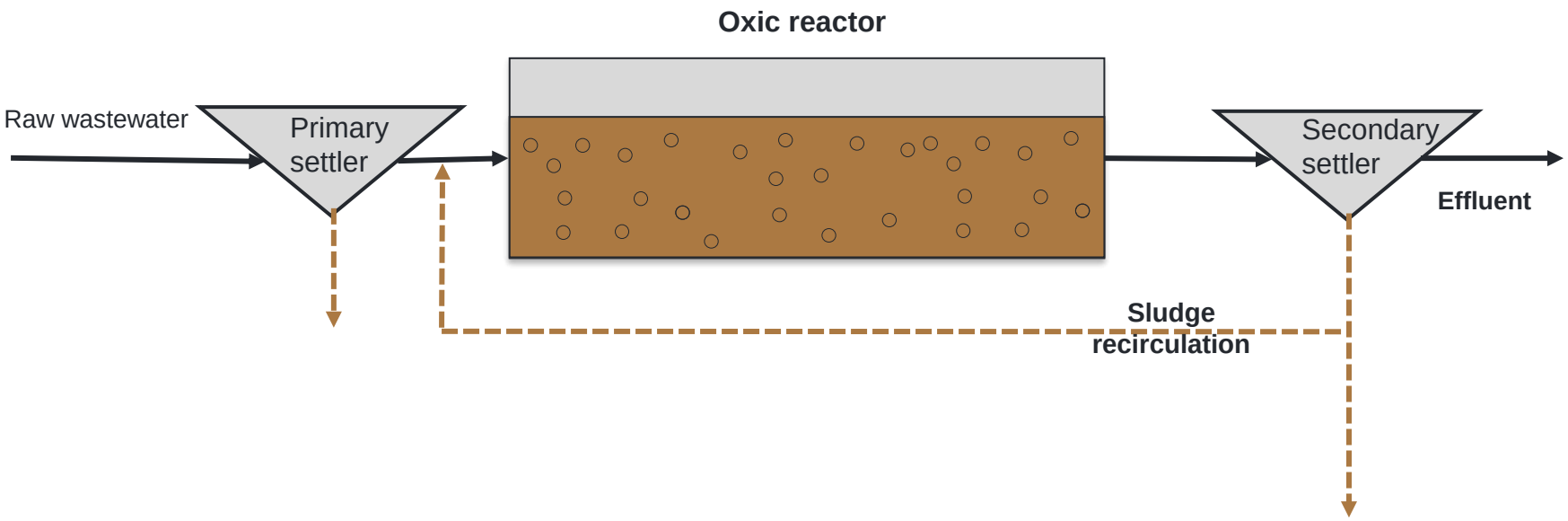
Organic nitrogen is contained within organic compounds.

When the readily biodegradable fraction is assimilated, organic nitrogen is converted to ammonium nitrogen (a process known as ammonification).

Nitrogen contained in the slowly biodegradable fraction remains unavailable until this fraction undergoes hydrolysis, followed by assimilation.

Nitrification

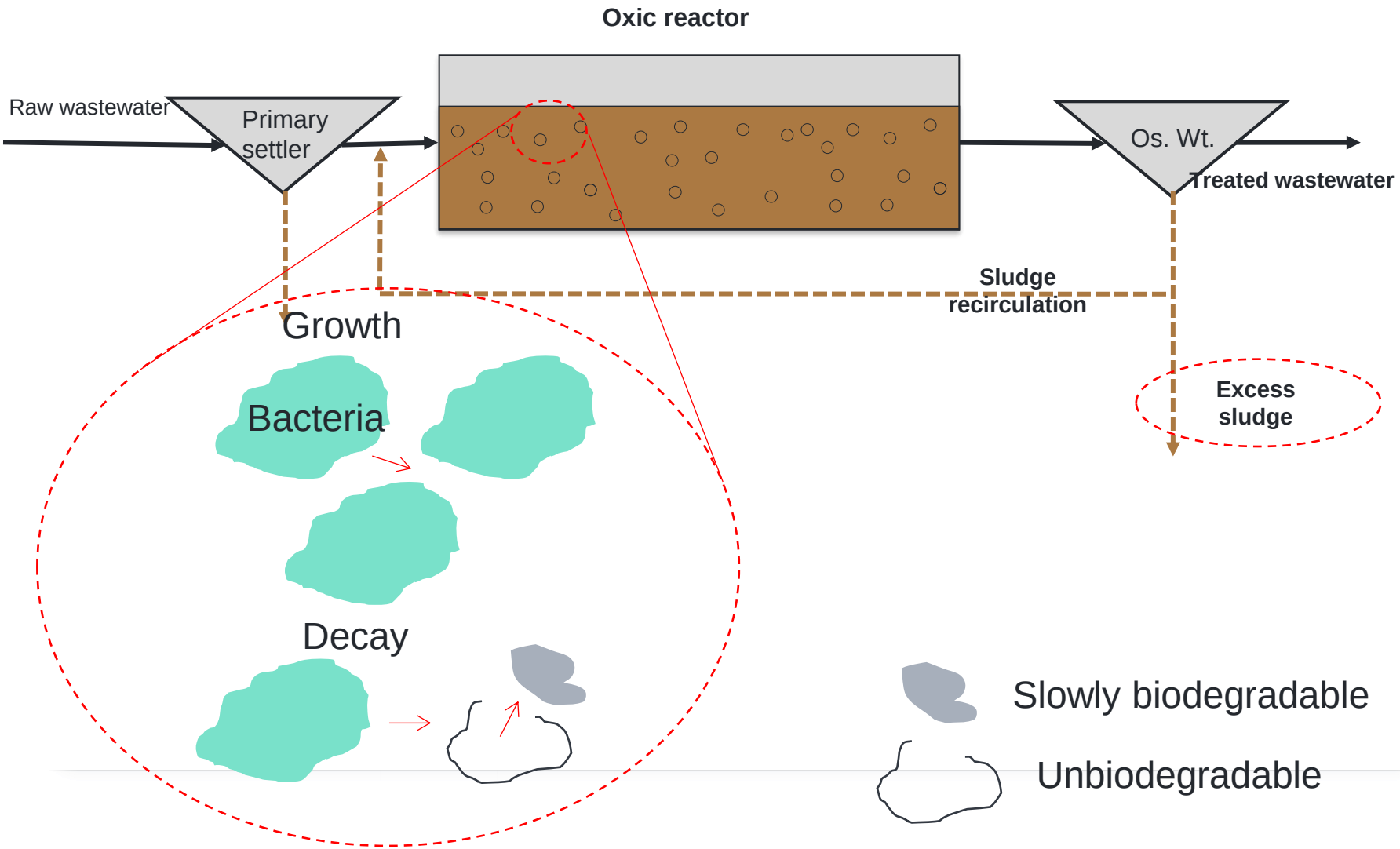
Nonbiodegradable organic nitrogen



It is removed from the treatment plant either in the waste activated sludge (when in undissolved form) or in the treated effluent (when in dissolved form).

Nitrification

Nitrifiers



Nitrification

Nitrifiers

1. The growth of nitrifying bacteria is low—several times lower than that of heterotrophic bacteria.
2. At the scale of total activated sludge mass, it is practically negligible.
3. Nitrifiers constitute only a few percent of the total activated sludge mass.

Nitrogen transformations

Alkalinity

Ammonification of organic nitrogen

$N_{org} \rightarrow NH_4^+ + OH^-$ (production of 1 val/mol ammonified N_{org})

Ammonium nitrogen assimilation

$NH_4^+ \rightarrow N_{org} + H^+$ (consumption of 1 val/mol assimilated N-NH_4)

Nitrification of ammonium nitrogen

$NH_4^+ \rightarrow NO_3^- + 2\ H^+$ (consumption of 2 val/mol oxidized N-NH_4)

Denitrification of nitrates

$NO_3^- \rightarrow 0{,}5\ N_2 + OH^-$ (production of 1 val/mol denitrified N-NO_3)

Nitrification

Maximum achievable efficiency

Under appropriate conditions:

- >95% of NH_4^+ is oxidized
- Approximately 10–15% of organic nitrogen is removed

The removal of Total N is lower than in systems with only aerobic organic matter removal.

Nitrification is not a nitrogen removal process. It is a conversion process where ammonium nitrogen is transformed into nitrate nitrogen.

Nitryfikacja

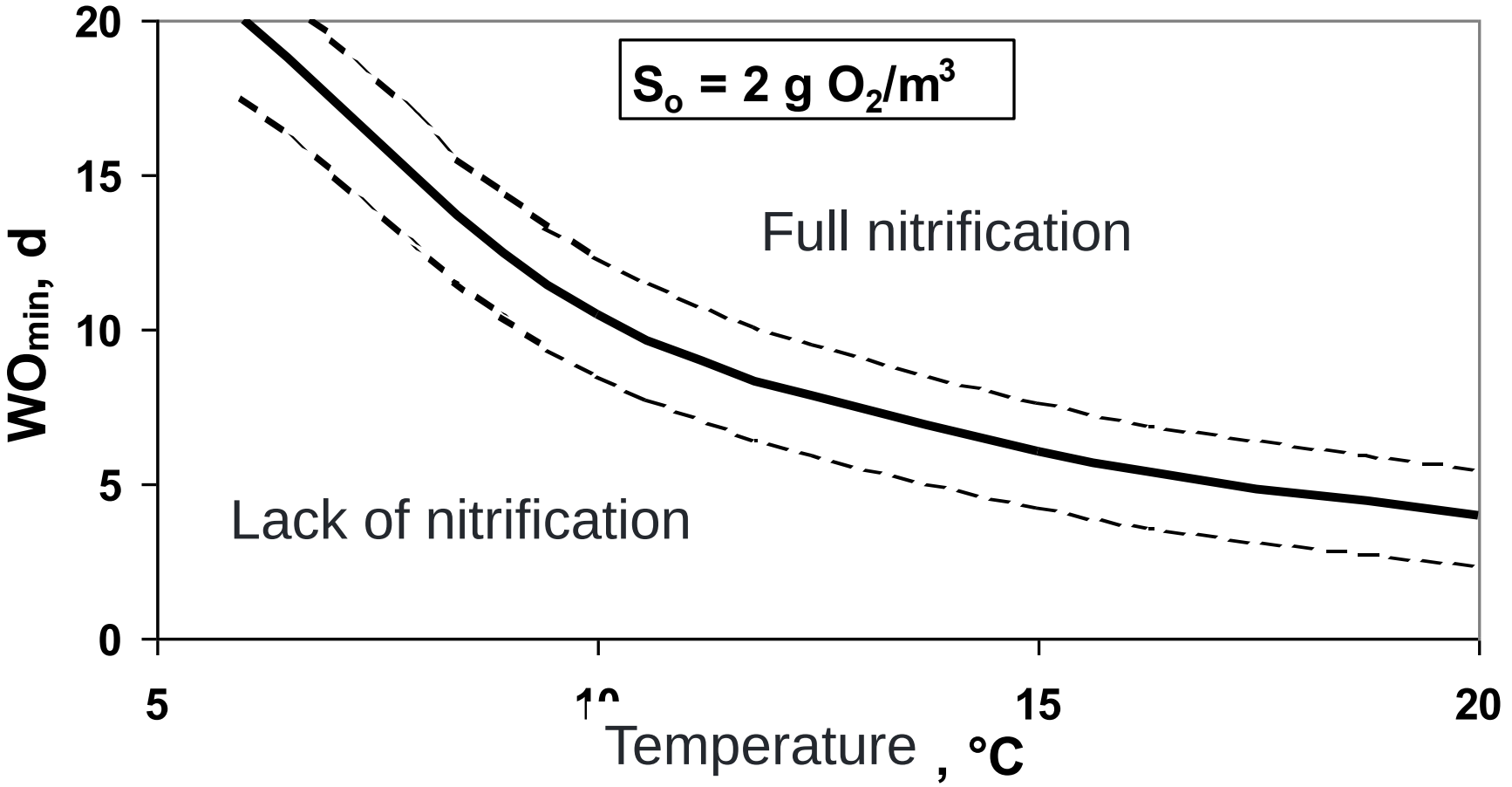
Parametry technologiczne

Sludge age > 6 days (in a system with only an aerobic zone) – parameter dependent on temperature
Hydraulic retention time – several hours
pH – 7.0 to 8.0
Temperature > 8°C
Dissolved oxygen in the aeration tank > 1.5 g O_2/m^3

Nitrification is the most demanding biological process carried out at a wastewater treatment plant.

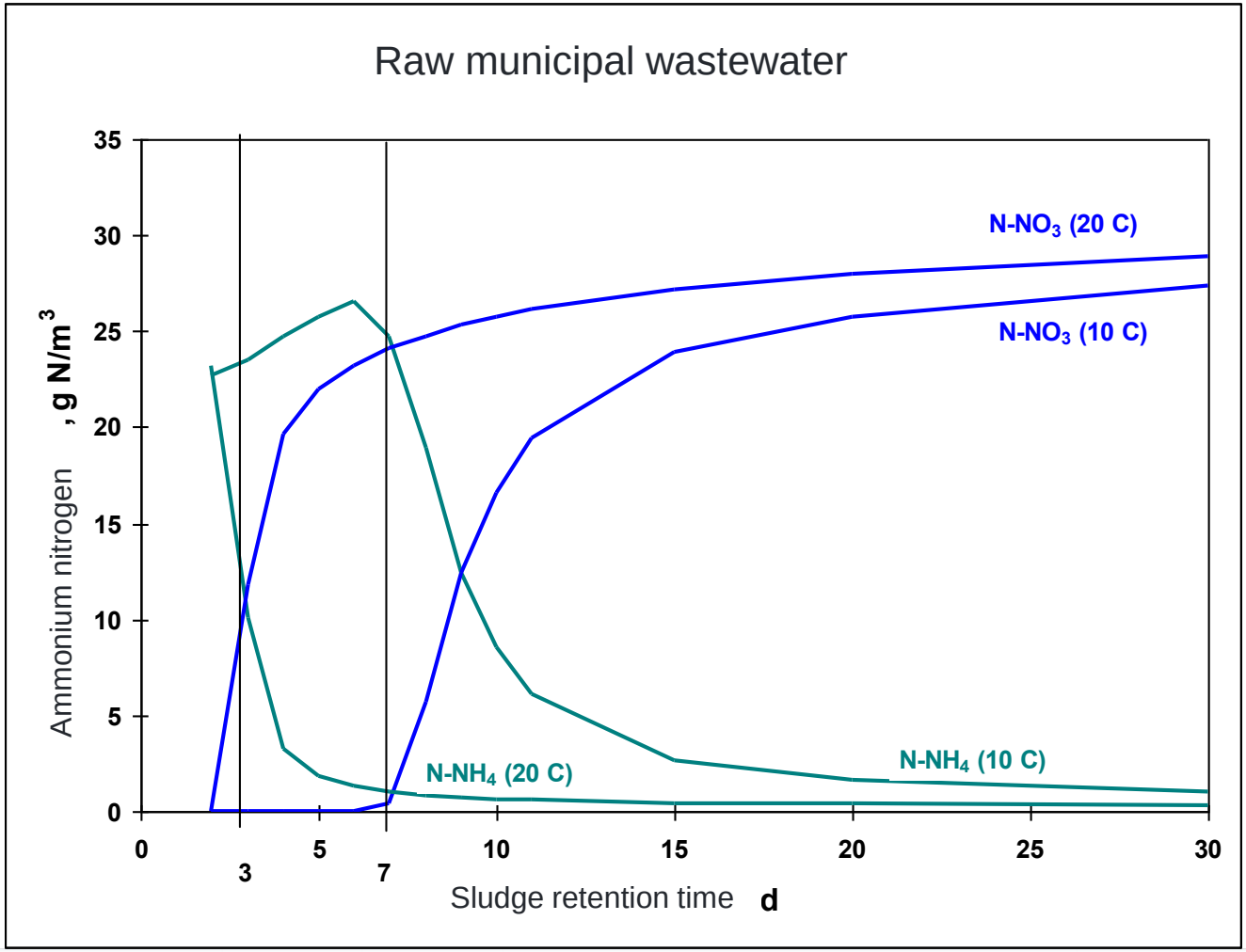
Nitrification

Sludge retention time



Nitrification

Sludge retention time



Control questions

1. What transformations does nitrogen contained in readily and slowly biodegradable compounds undergo?
2. How does the removal of ammonium nitrogen occur during nitrification?
3. What are the substrates of the nitrification process?
4. Where does the CO_2 used by nitrifiers come from?
5. Why do nitrifying bacteria grow more slowly than heterotrophs?
6. Why is the minimum sludge age for nitrifiers higher than for heterotrophs?