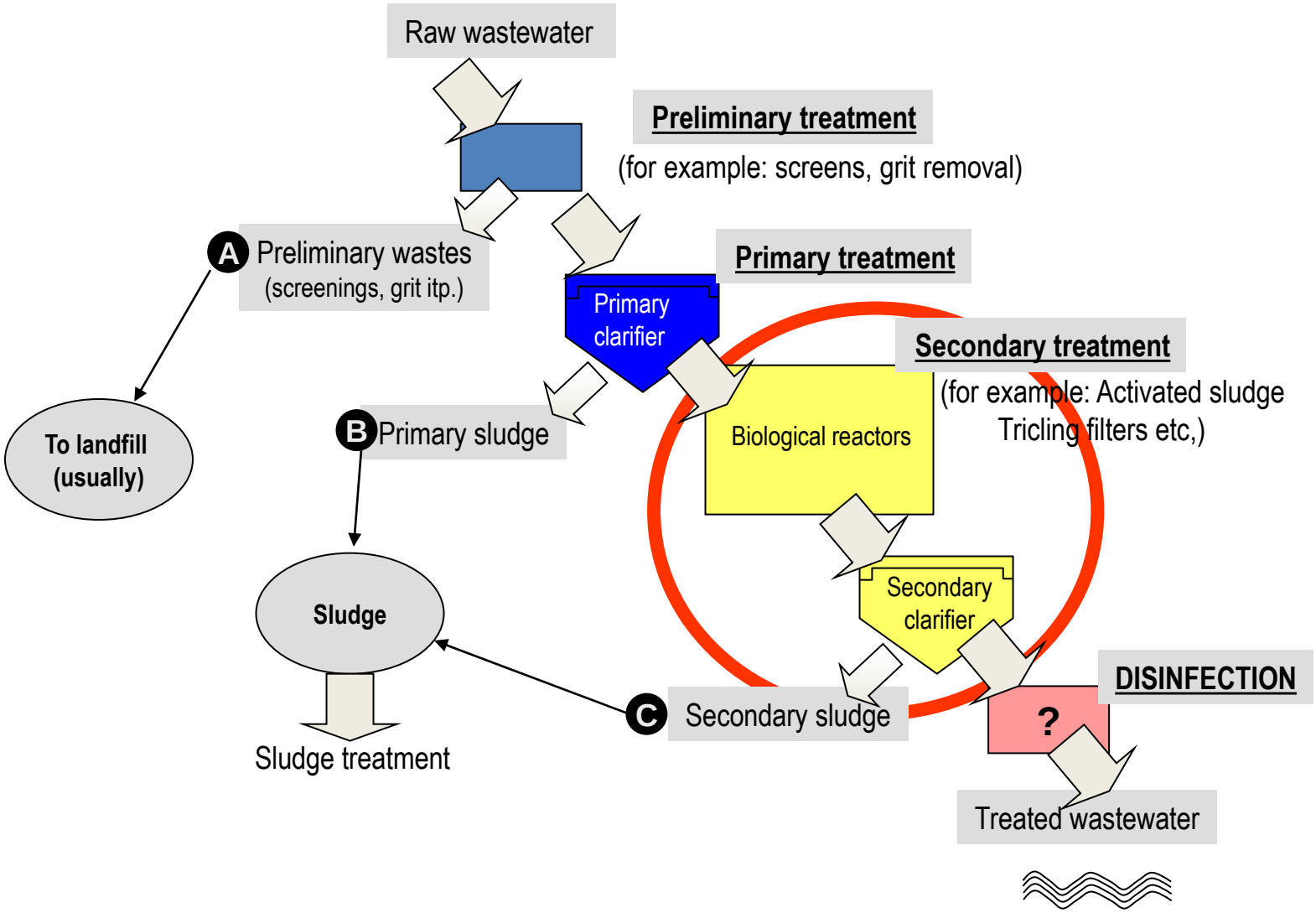
Wastewater Treatment Technology
Lecture 5

Nitrification

WWTP overall scheme



Nitrification

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

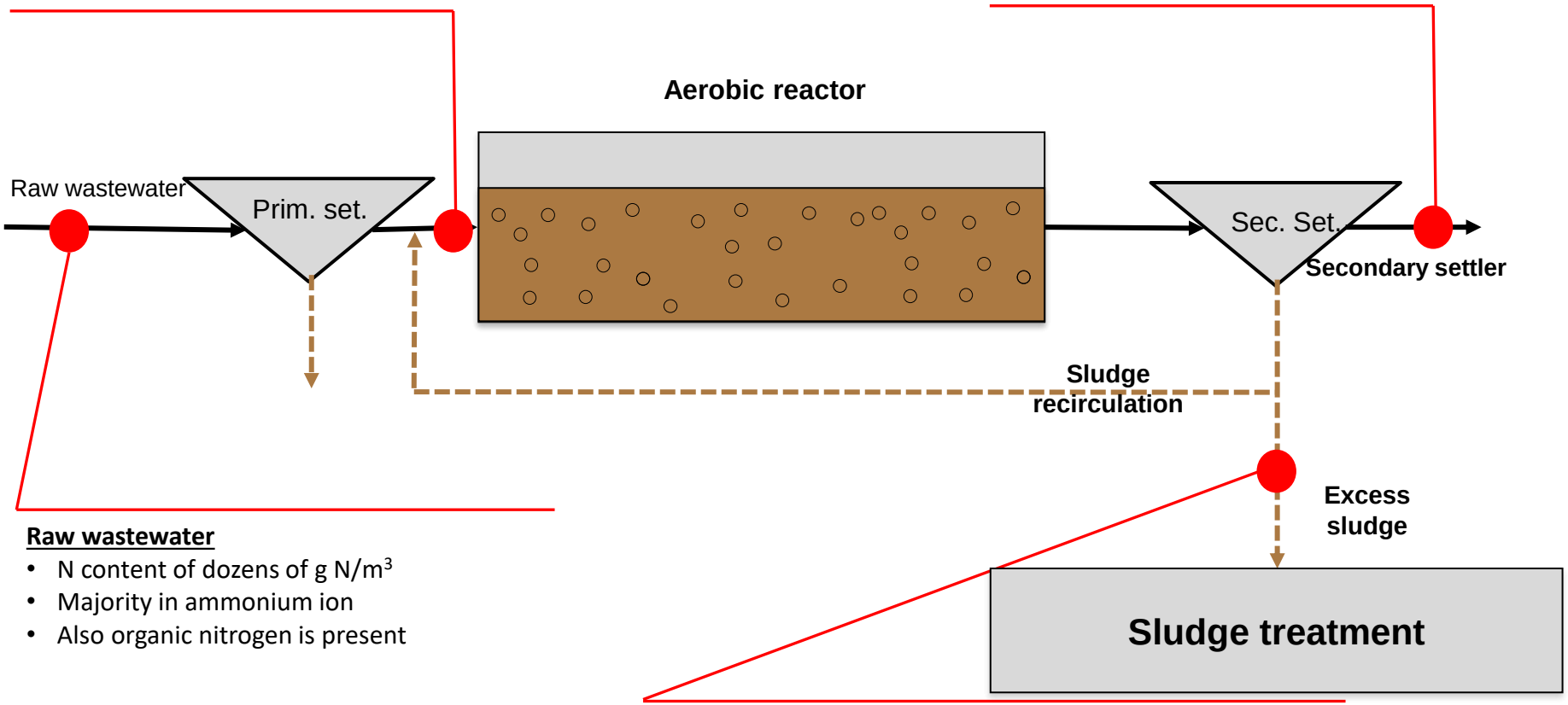
Oxygen consumption (~4.57 *g* O_2/*g* *N*-NH_4)

Mechanically treated wastewater

- N lower by ca. 10%
- All what is removed in primary settler is nitrogen in suspended solids

Treated wastewater

- Nitrite and remains of ammonia are present
- Low amount of organic nitrogen



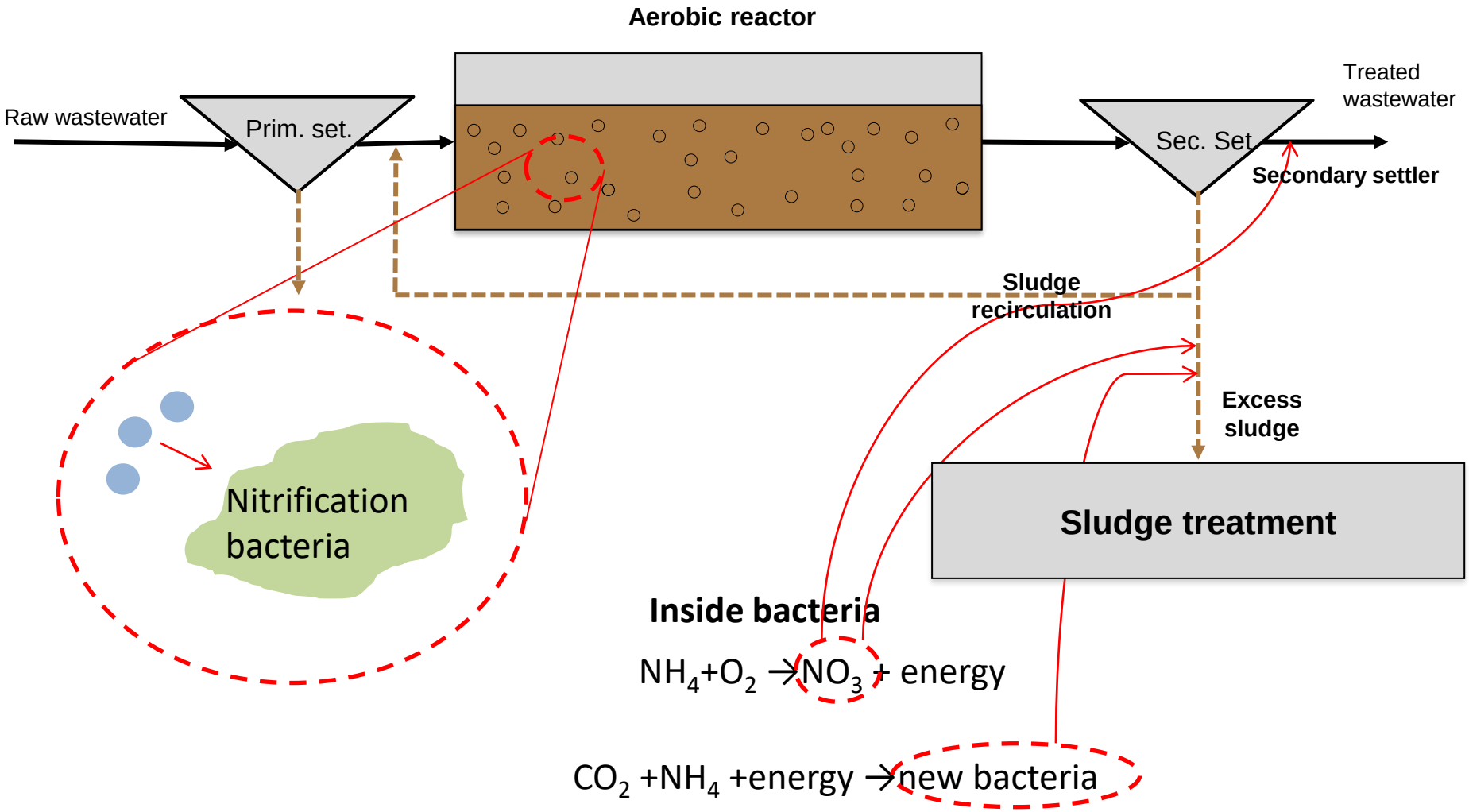
Raw wastewater

- N content of dozens of g N/m^3
- Majority in ammonium ion
- Also organic nitrogen is present

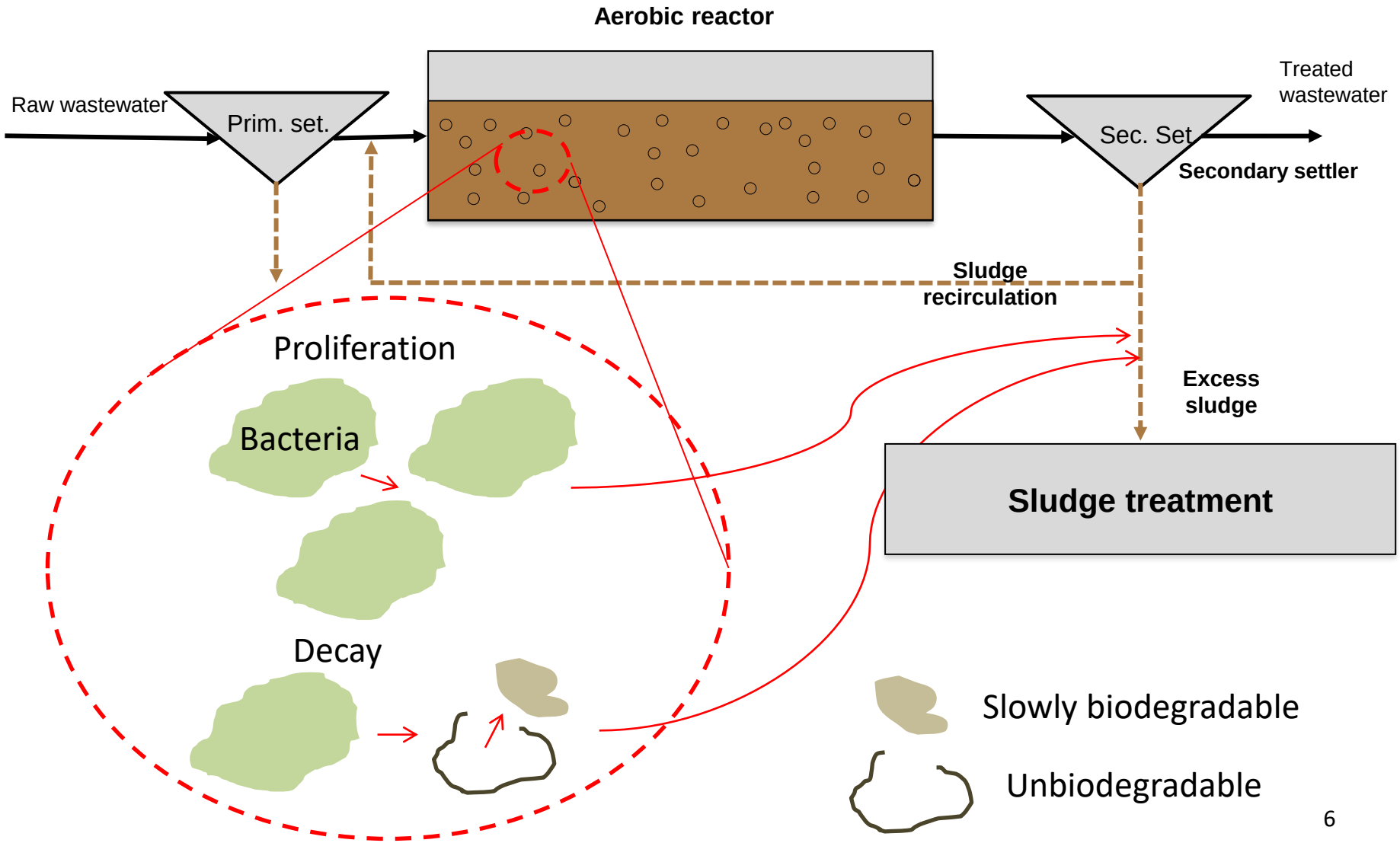
Excess sludge

- All unbiodegradable organic nitrogen in suspended solids is removed via this stream
- Also biodegradable organic nitrogen is present in some amounts

Ammonium ion



Nitrifiers


Aerobic reactor
Raw wastewater
Prim. set.
Sec. Set
Treated wastewater
Secondary settler
Sludge recirculation
Excess sludge
Sludge treatment
Proliferation
Bacteria
Decay
Slowly biodegradable
Unbiodegradable

Nitrification versus alkalinity

Amonification

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

Assimilation

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

Nitrification

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

Denitrification

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

Basic data

SRT> 6 d (in aerobic only)

pH – 7.0 – 8.0

T >8°C

O_2 > 1.5 gO_2/m^3

Nitrification is the most sensitive proces conducted in activated sludge reactors

Effectiveness of nitrogen compounds removal

In good conditions:

>95% NH_4

ca.10-15 % N_{tot}

Lower N_{tot} removal than in pure carbon removal process

Nitrification is not the nitrogen removal process

Questions

1. What transformations does nitrogen contained in easily biodegradable and slowly biodegradable compounds undergo?
2. What is the process of ammonium nitrogen removal in nitrification?
3. What are the substrates of the nitrification process?
4. Where does the CO2 used by nitrifiers come from?
5. Why do nitrifying bacteria grow slower than heterotrophs?
6. Why is the minimum sediment age for nitrifiers higher than for heterotrophs?