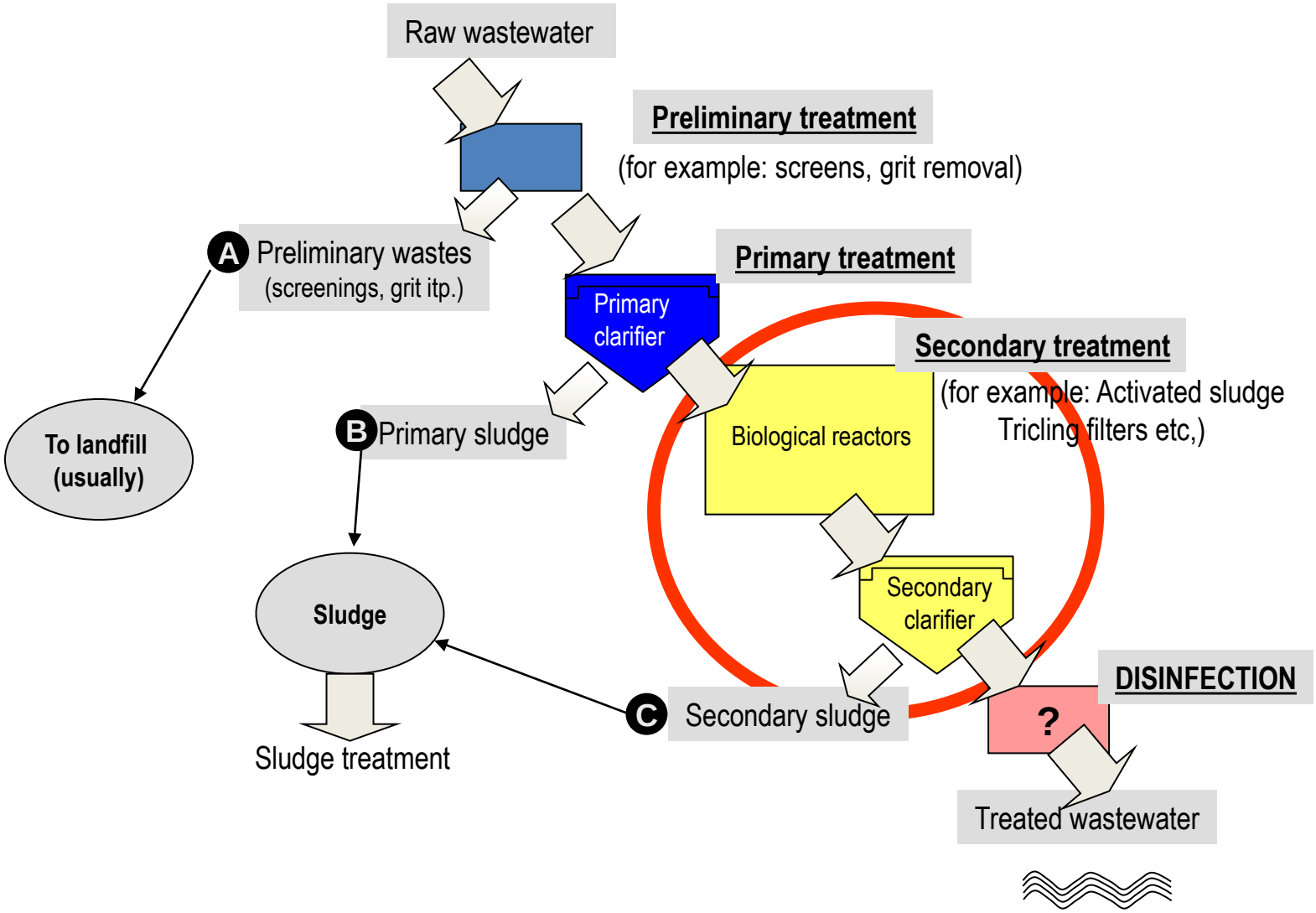
Wastewater Treatment Technology
Lecture 6

Denitrification

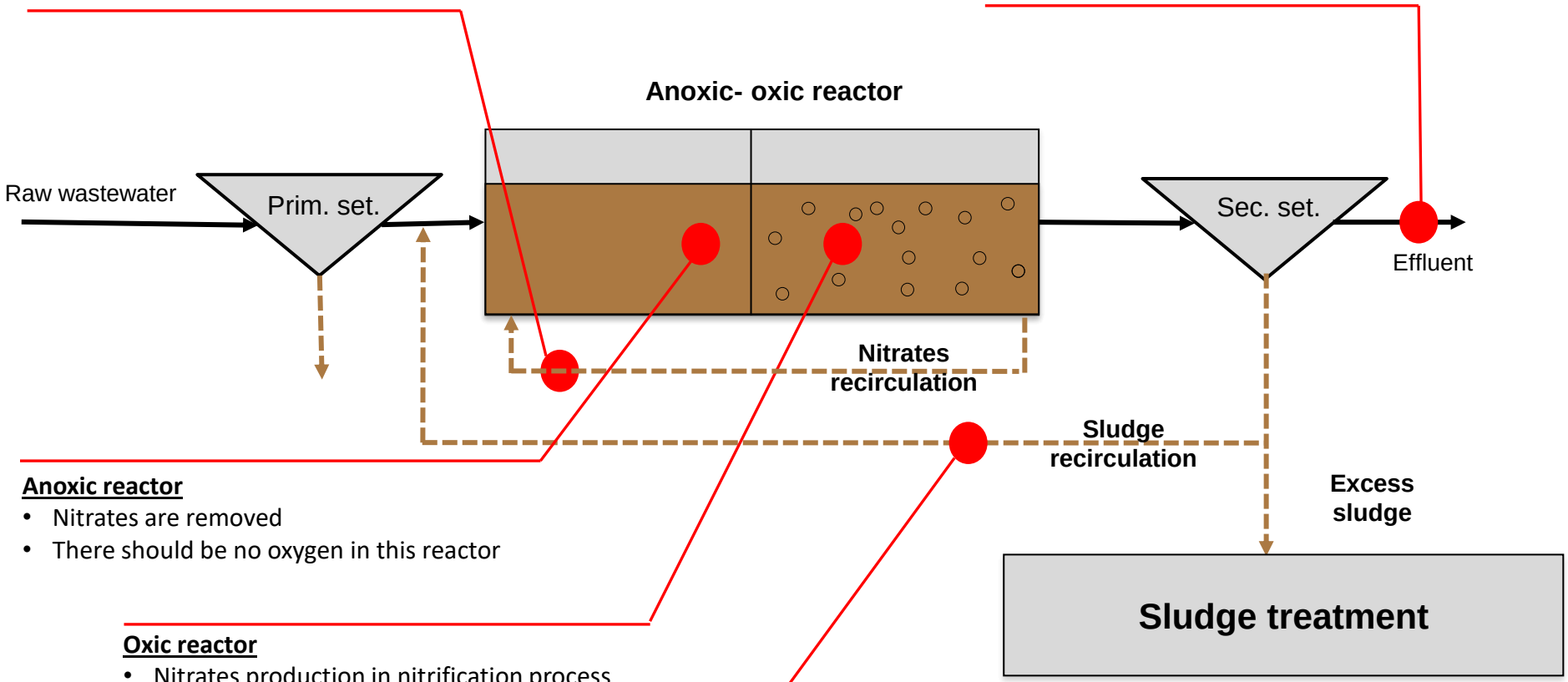
WWTP overall scheme



Simplest scheme

Nitrate recirculation
- Nitrites created in oxic reactor are recirculated
- Stream is intense - usually few hundred % of Q_{inf}

Treated wastewater
- Definetely less nitrates than in aerobic only process

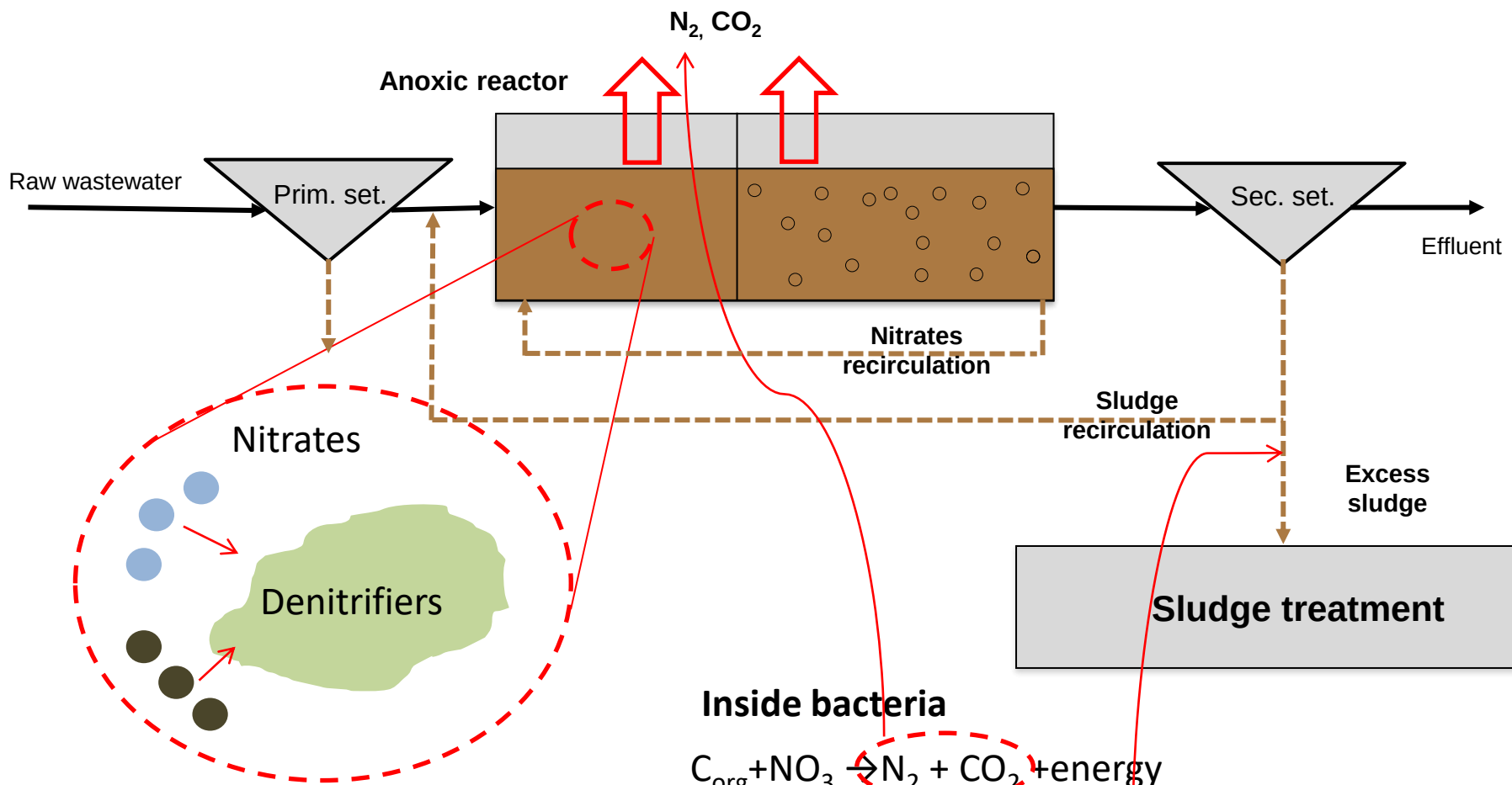


Anoxic reactor
- Nitrates are removed
- There should be no oxygen in this reactor

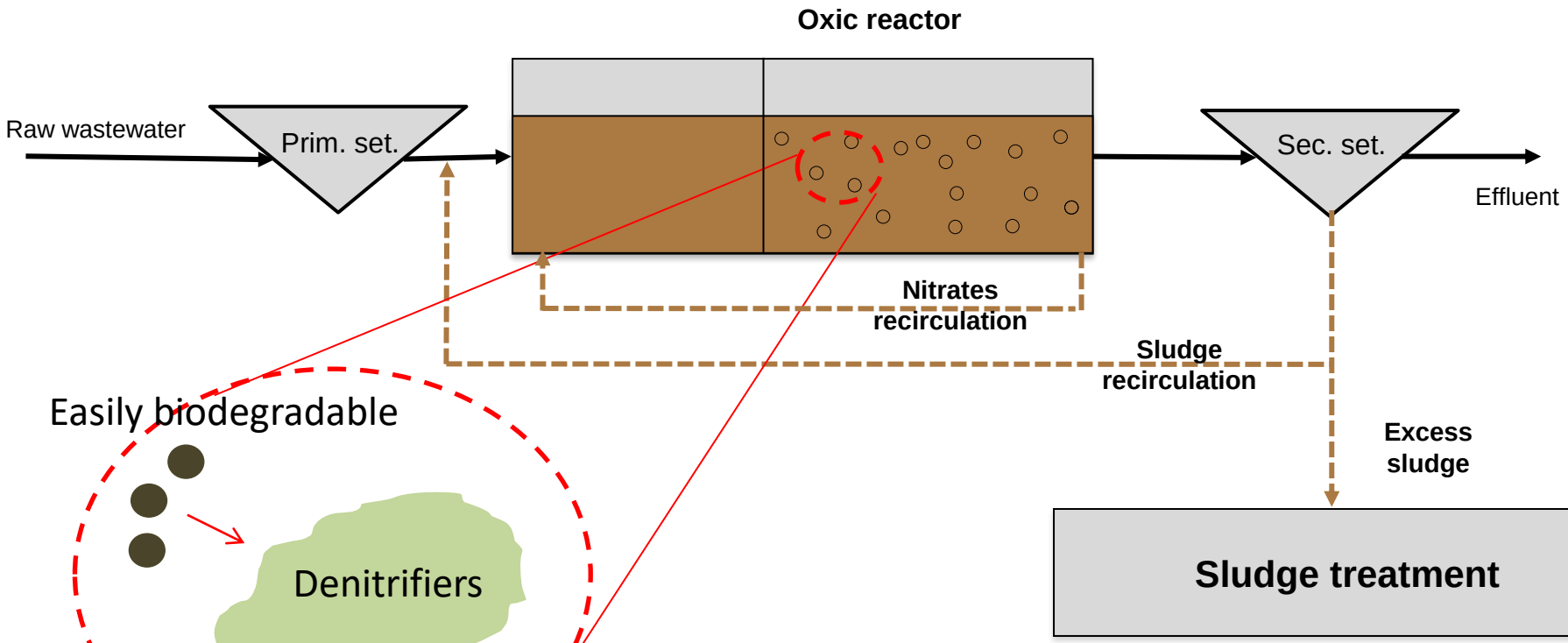
Oxic reactor
- Nitrates production in nitrification process

Sludge recirculation
- This stream also includes nitrates

Course of denitrification



Denitrifiers in oxic reactor



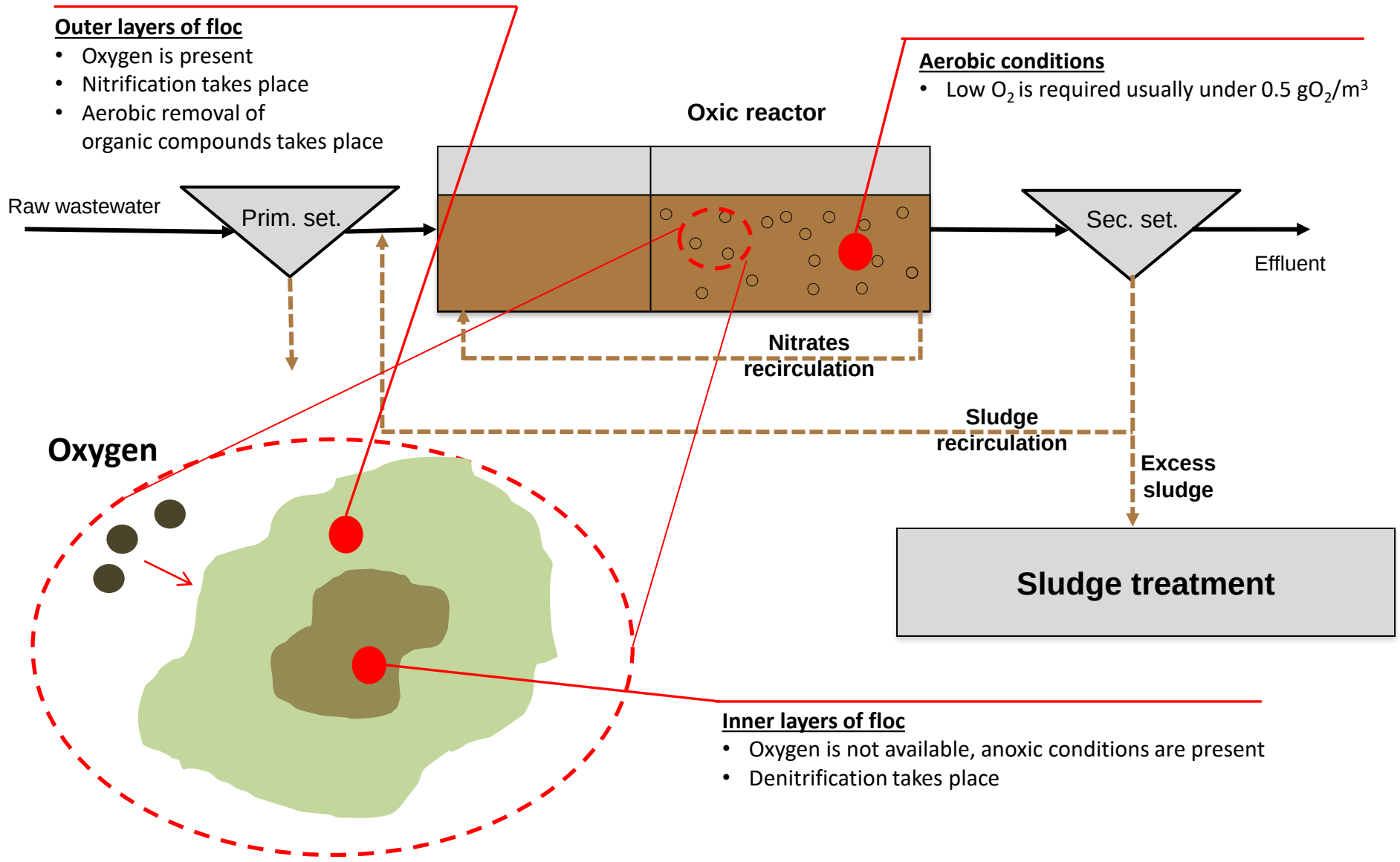
Inside bacteria

$C_{org} + O_2 \rightarrow CO_2 + energy$

$C_{org} + NH_4 + energy \rightarrow bew\ bacteria$

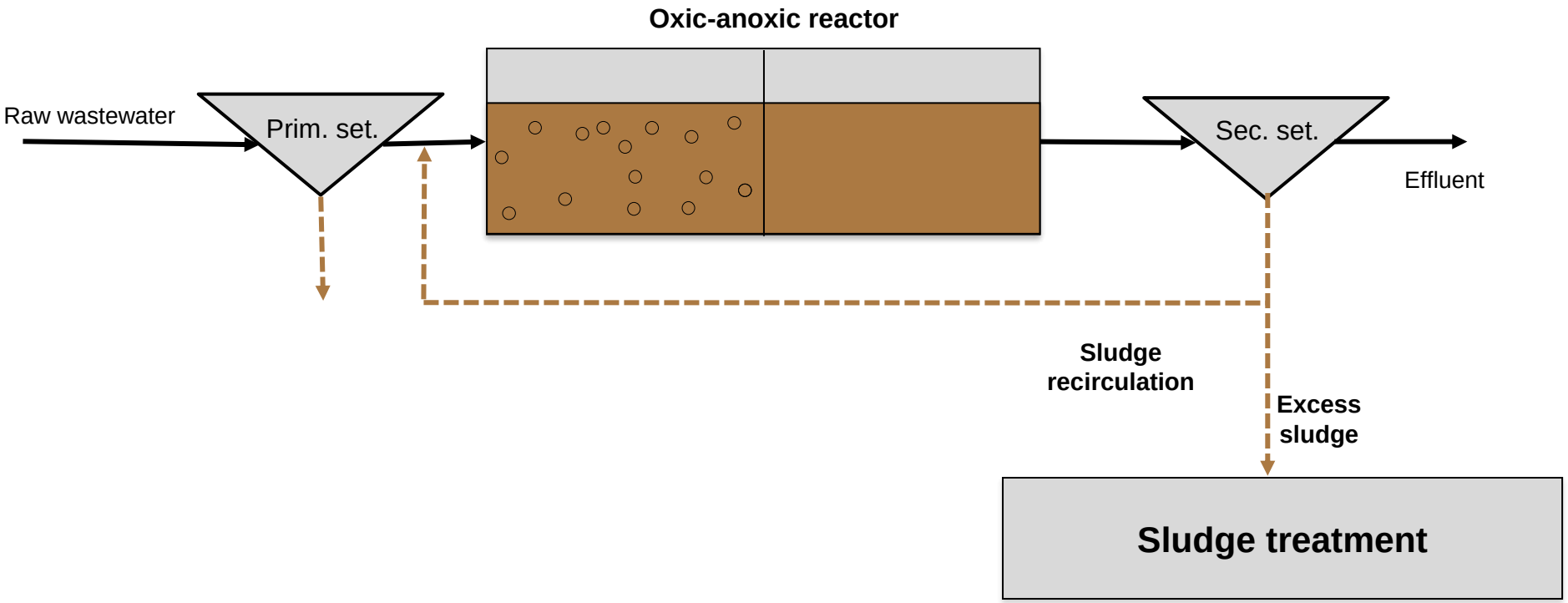
Denitrifiers are usually also capable of aerobic processes. They are ordinary heterotrophs

Denitrification in oxic reactor

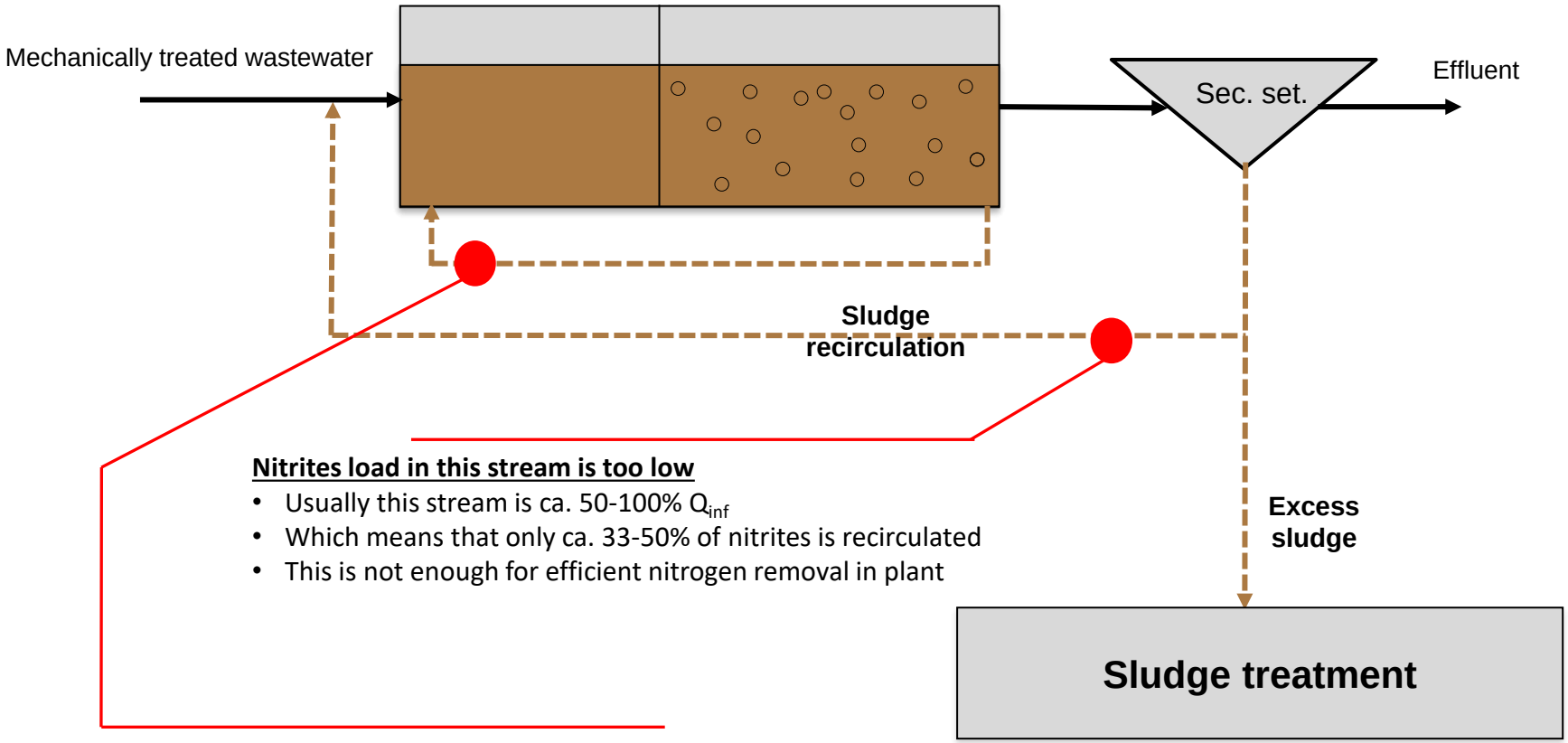


Activated sludge floc

Why not this scheme?



Role of nitrates recirculation



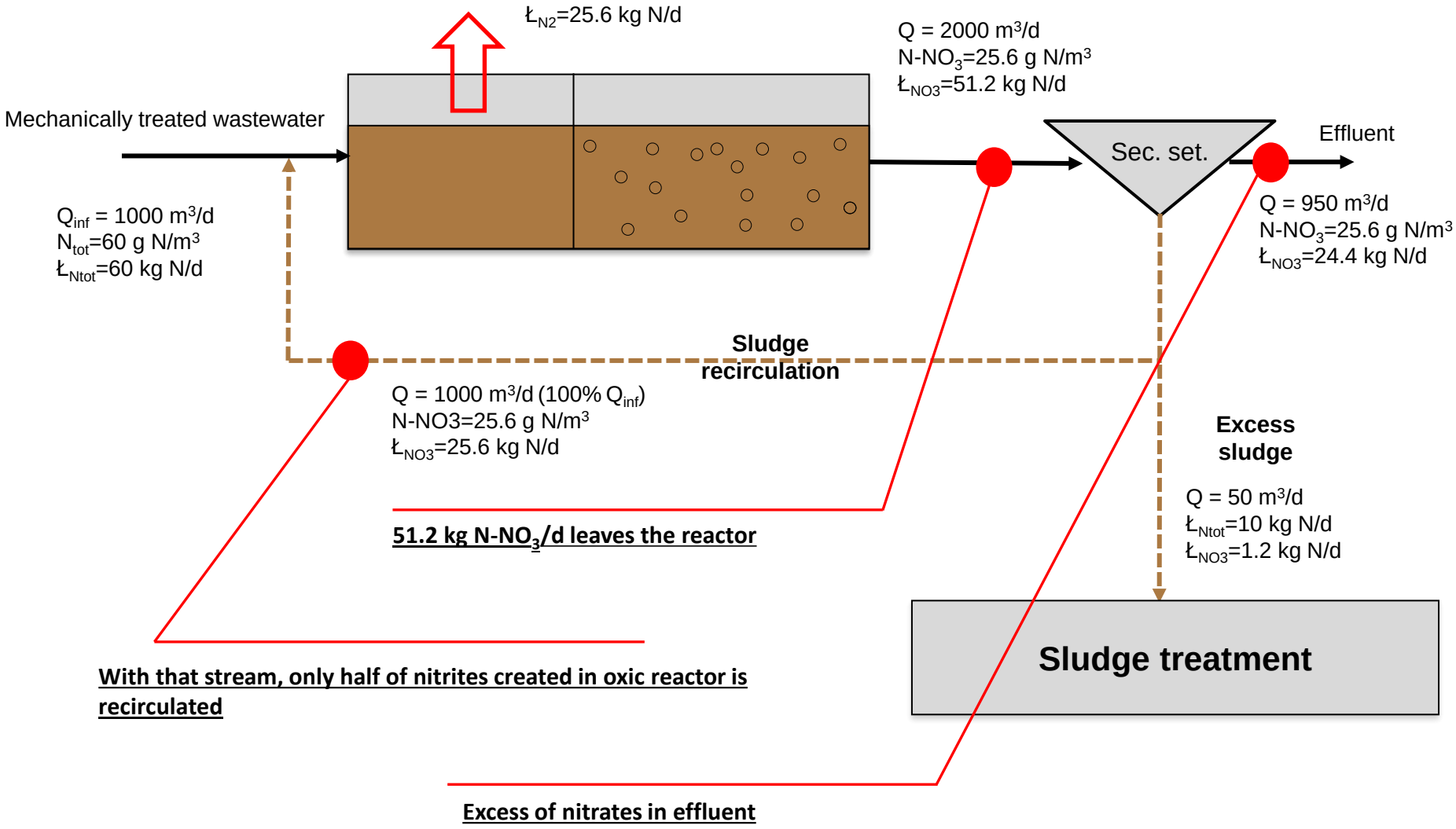
Nitrites load in this stream is too low

- Usually this stream is ca. 50-100% Q_{inf}
- Which means that only ca. 33-50% of nitrites is recirculated
- This is not enough for efficient nitrogen removal in plant

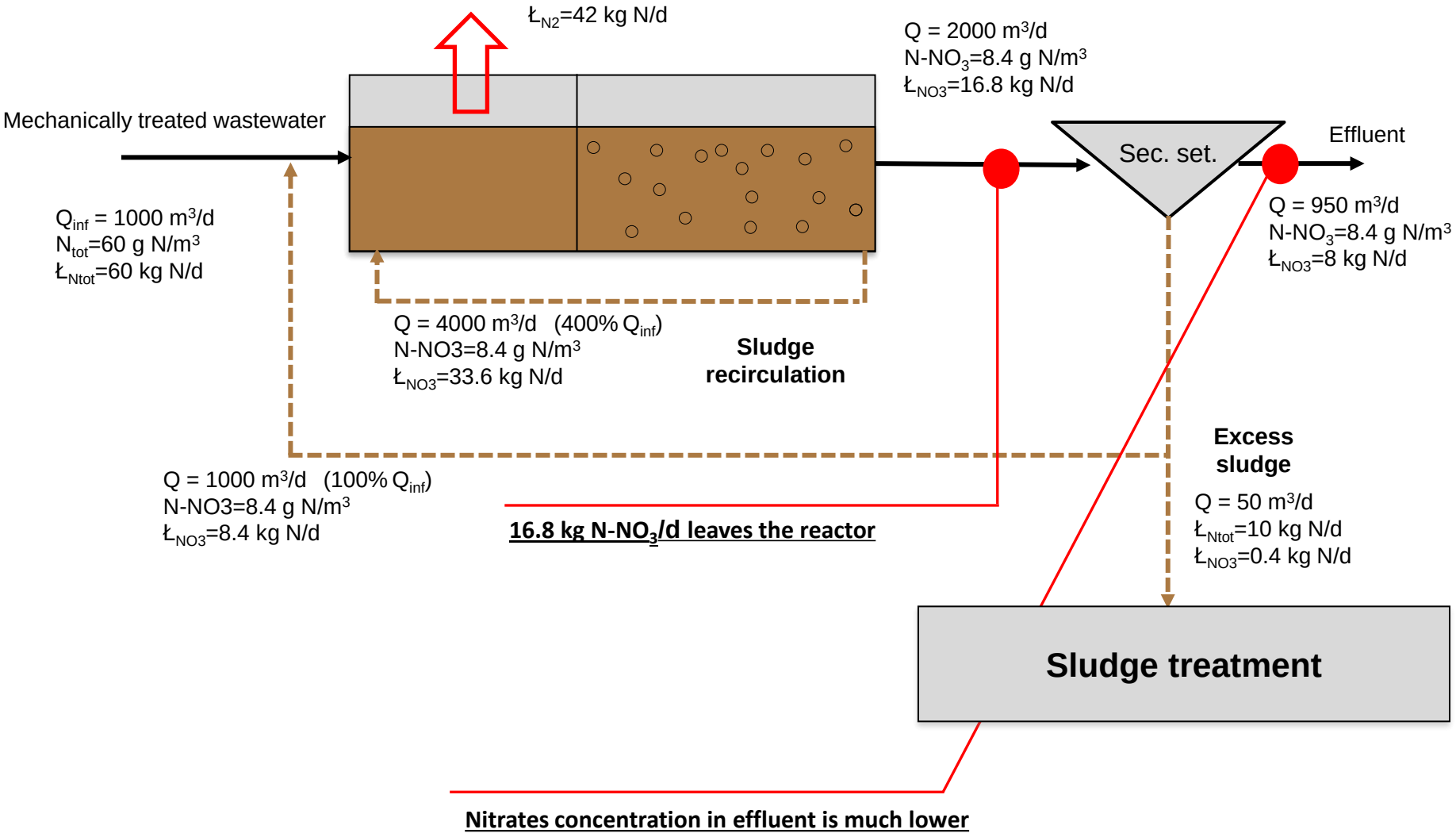
Aim of this recicrulation is to provide enough nitrates in anoxic reactor

- Usually this stream is few hundred % Q_{inf}
- This stream recirculates most of nitrates to anoxic reactor
- Thanks to that stream the required removal rate of nitrogen can be achieved

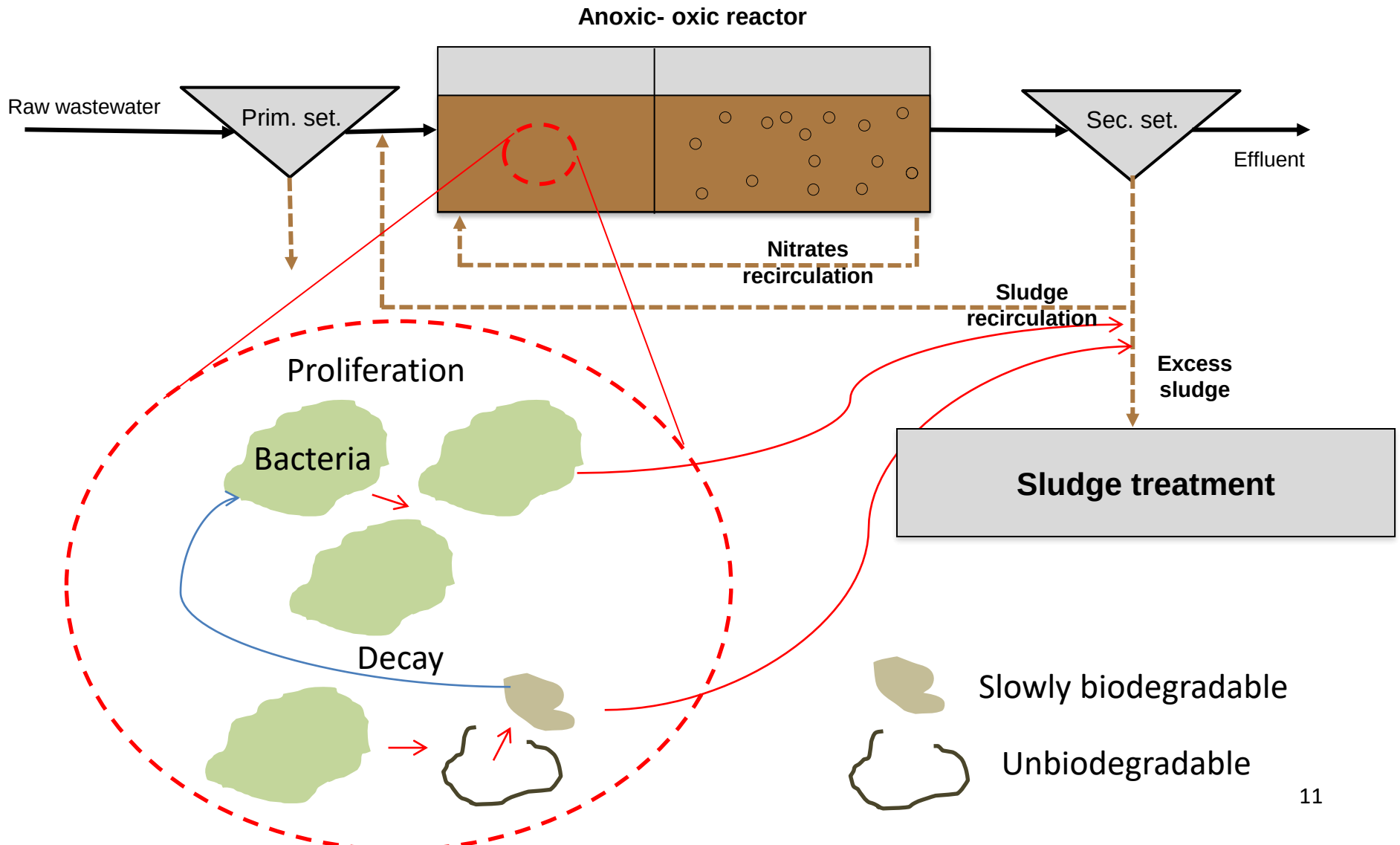
Role of nitrates recirculation



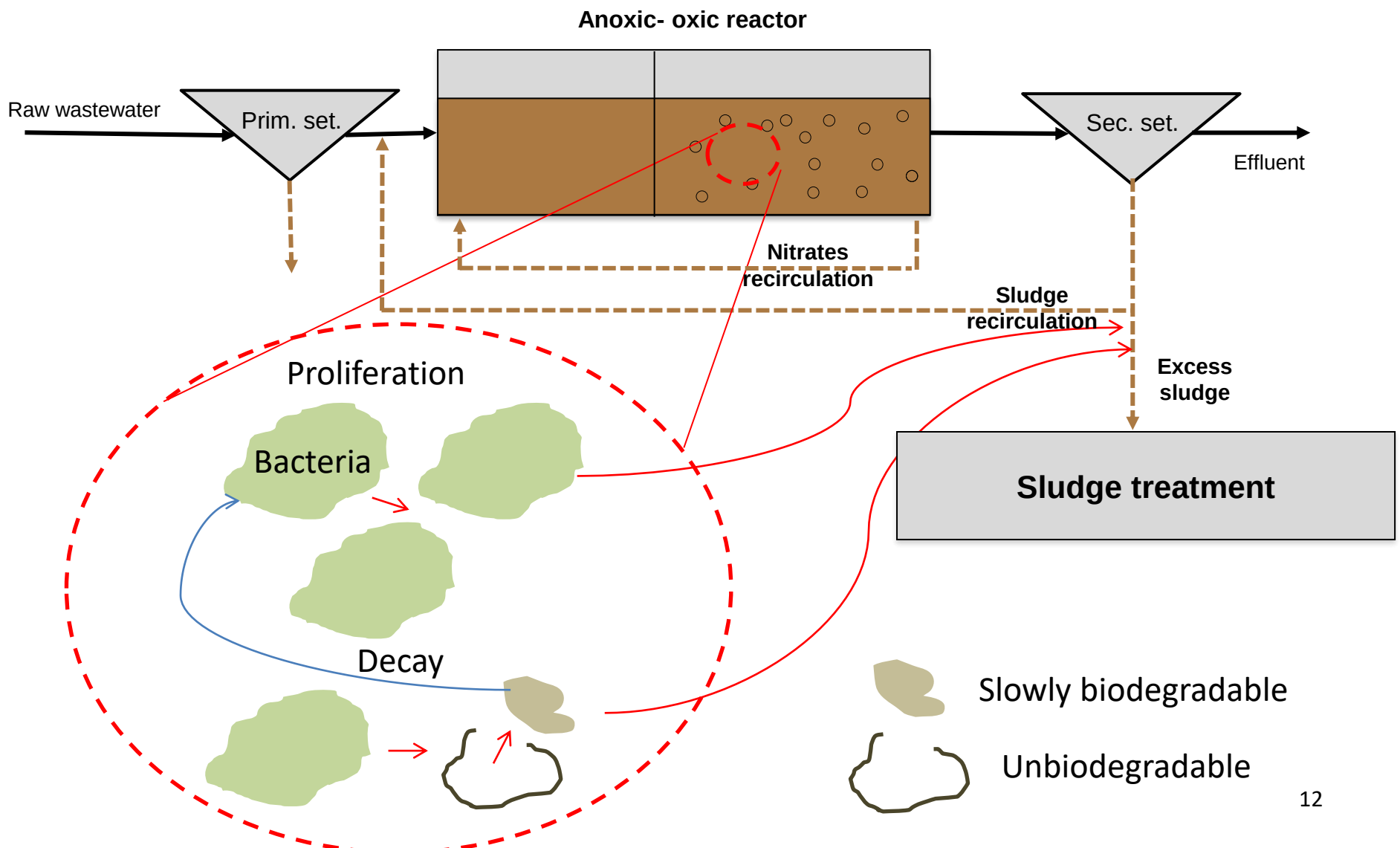
Role of nitrates recirculation



Denitrifiers



Denitrifiers



Basic data

SRT> 10 d (in AX/OX)

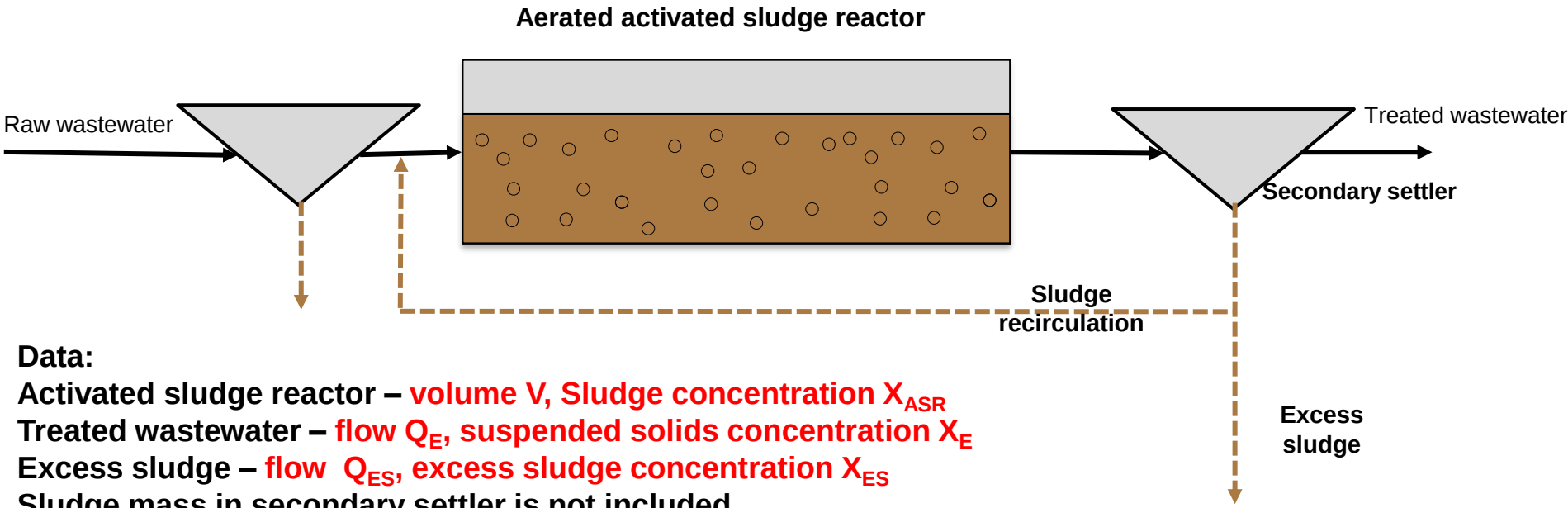
pH – 6.0 – 8.0

T >8°C

O_2 < 0.5 gO_2/m^3 in denitrification reactor

Aerobic sludge retention time

Sludge retention time definition (SRT)



Data:
Activated sludge reactor – volume V, Sludge concentration X_{ASR}
Treated wastewater – flow Q_E, suspended solids concentration X_E
Excess sludge – flow Q_{ES}, excess sludge concentration X_{ES}
Sludge mass in secondary settler is not included

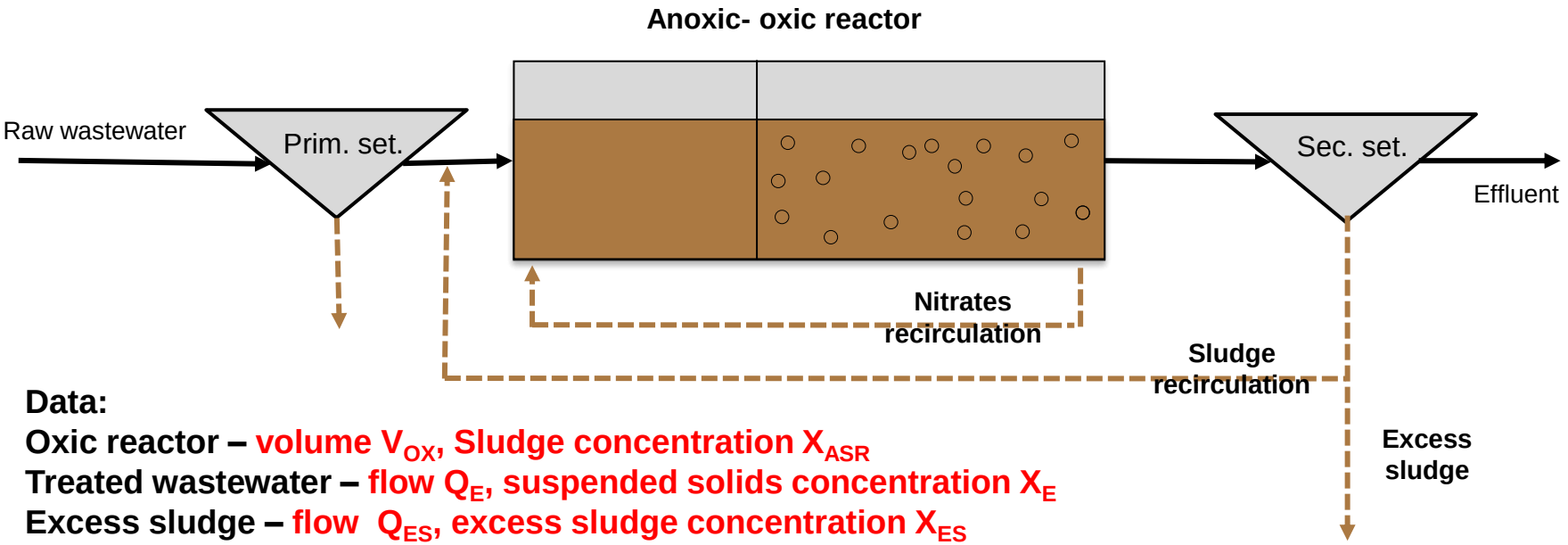
Sludge mass in reactor, kg ss

$$SRT = \frac{V \cdot X_{ASR}}{Q_{ES} \cdot X_{ES} + Q_E \cdot X_E}, \text{d}$$

Suspended solids mass in treated wastewater, kg ss/d

Sludge mass in excess sludge, kg ss/d

Aerobic sludge retention time definition (SRT_{OX})

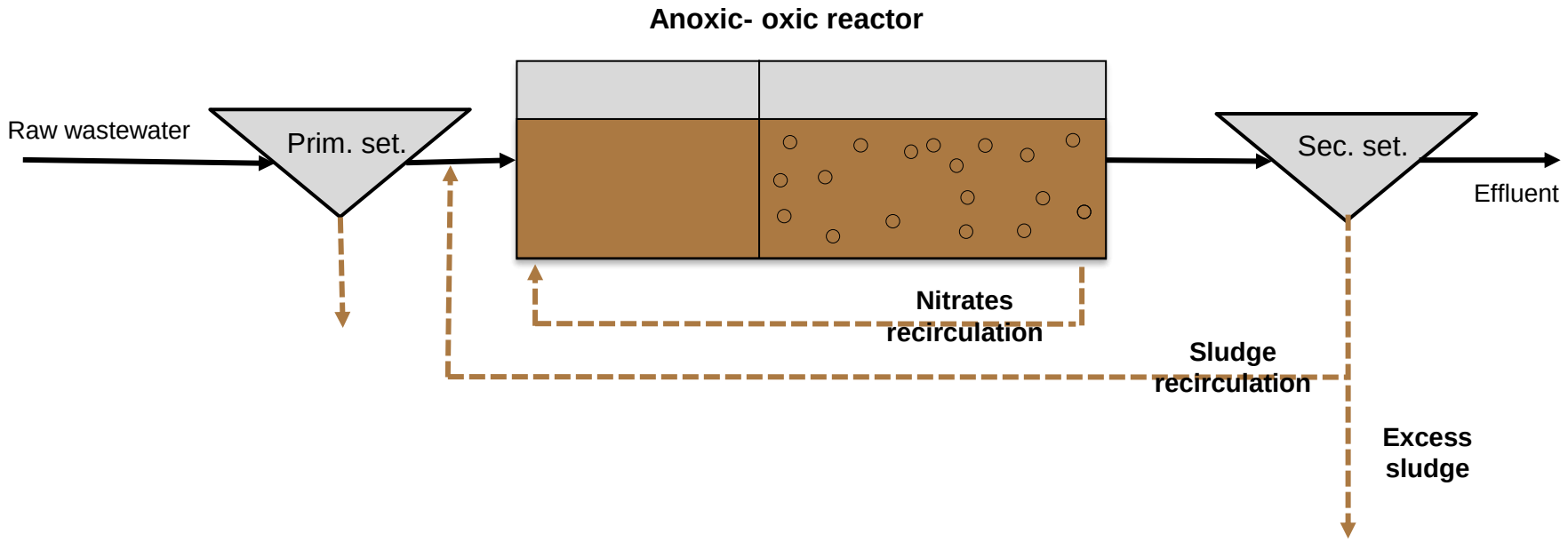


Data:
Oxic reactor – volume V_{OX}, Sludge concentration X_{ASR}
Treated wastewater – flow Q_E, suspended solids concentration X_E
Excess sludge – flow Q_{ES}, excess sludge concentration X_{ES}
Sludge mass in secondary settler is not included

Sludge mass in oxic reactor, kg ss

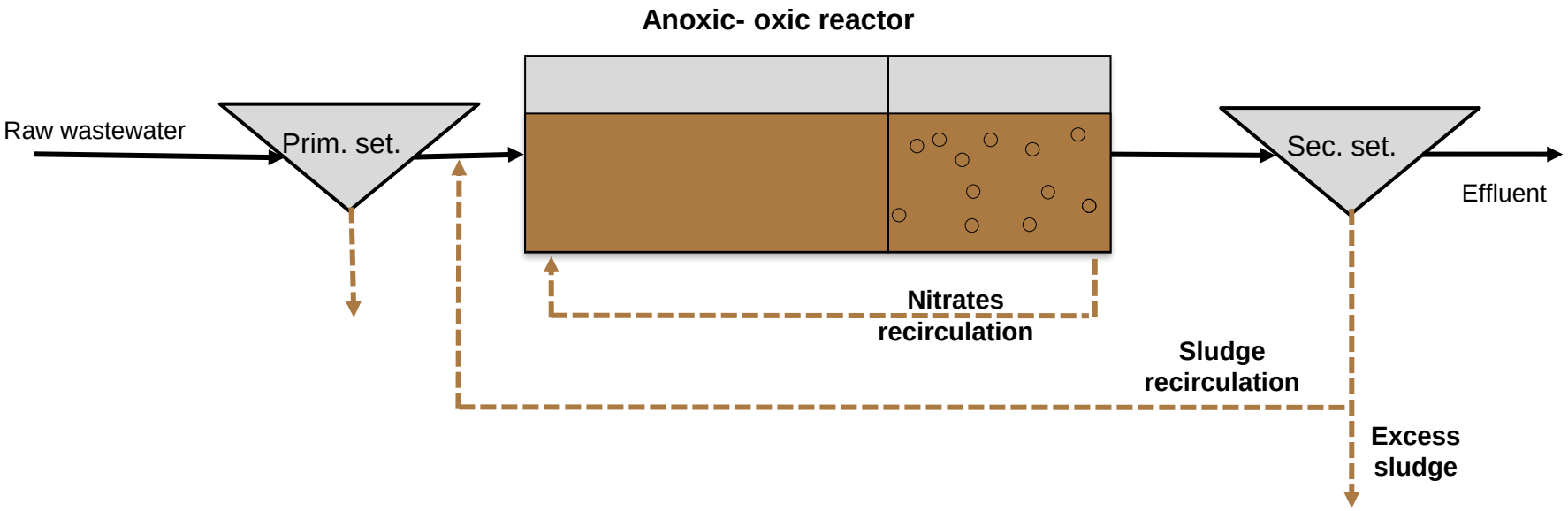
$$SRT_{OX} = \frac{V_{OX} \cdot X_{ASR}}{Q_{ES} \cdot X_{ES} + Q_E \cdot X_E}, \text{ d} \quad SRT = \frac{V \cdot X_{ASR}}{Q_{ES} \cdot X_{ES} + Q_E \cdot X_E}, \text{ d}$$

Aerobic sludge retention time definition (SRT_{OX})



$$\frac{SRT_{OX}}{SRT} = \frac{= \dfrac{V_{OX} \cdot X_{ASR}}{Q_{ES} \cdot X_{ES} + Q_E \cdot X_E}}{\dfrac{V \cdot X_{ASR}}{Q_{ES} \cdot X_{ES} + Q_E \cdot X_E}} = \frac{V_{OX}}{V}$$

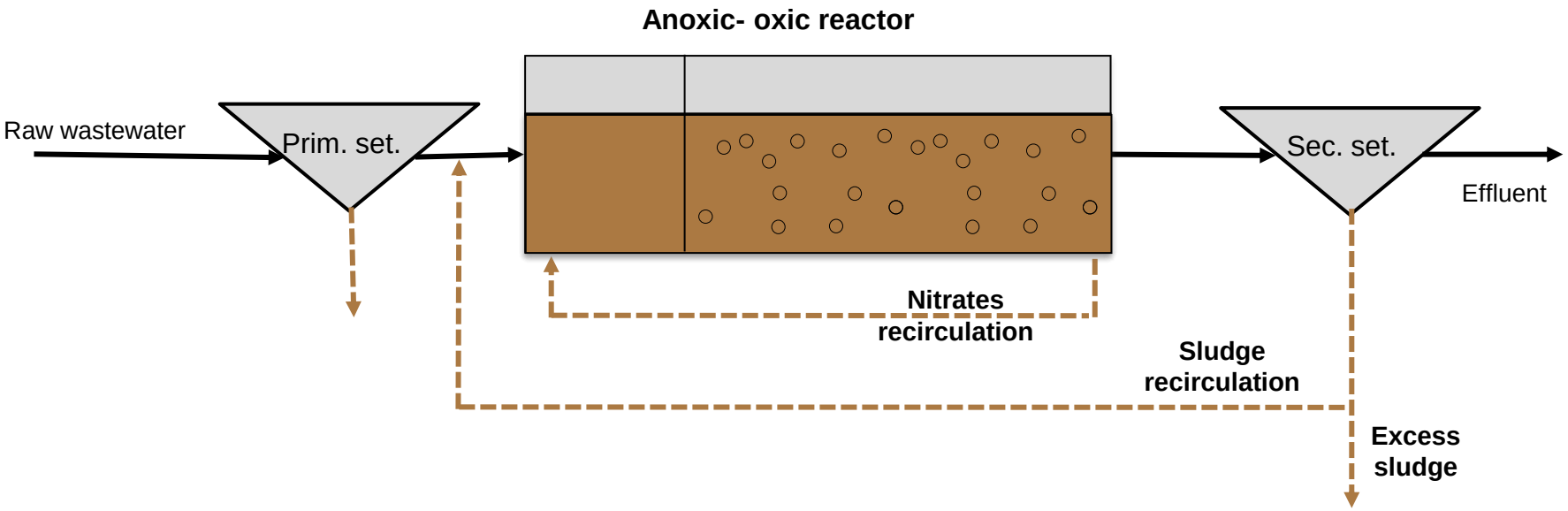
Warm period



Warm months:

1. Higher temperature
2. High nitrifiers growth rate
3. Aerobic sludge retention time can be lower
4. Oxic reactor's volume can be lower
5. Better nitrogen removal due to more efficient denitrification

Cold period



Cold months:

1. Lower temperature
2. Low nitrifiers growth rate
3. Aerobic sludge retention time has to be higher
4. Oxic reactor's volume has to be higher
5. Worse nitrogen removal due to less efficient denitrification

Effectiveness of nitrogen compounds removal

In good conditions:

>95% NH_4

>90% NO_3

Ok. 90 % Ntot

Questions

1. Describe the denitrification process?
2. Under what conditions is denitrification possible in an oxygen chamber?
3. What are the substrates of the denitrification process?
4. What role does nitrate recirculation play?
5. What does nitrate removal look like when there is no nitrate recirculation?
6. What is the aerobic sludge retention time?
7. Operation of the AX system in summer and winter – differences