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ORGANIC CARBON REMOVAL AND SLUDGE RETENTION TIME

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

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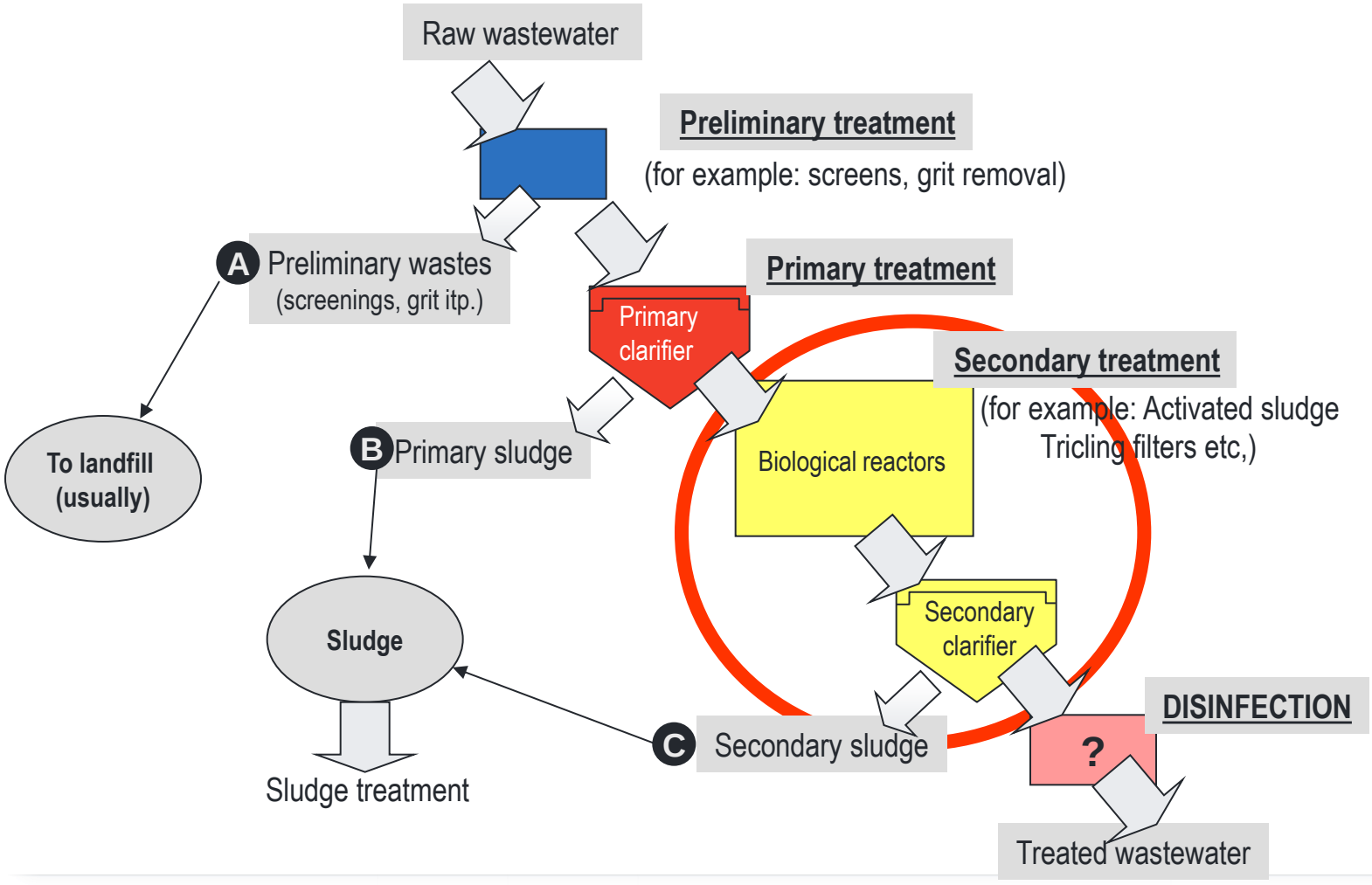
Presentation plan

1. Organic carbon removal
2. Sludge retention time

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

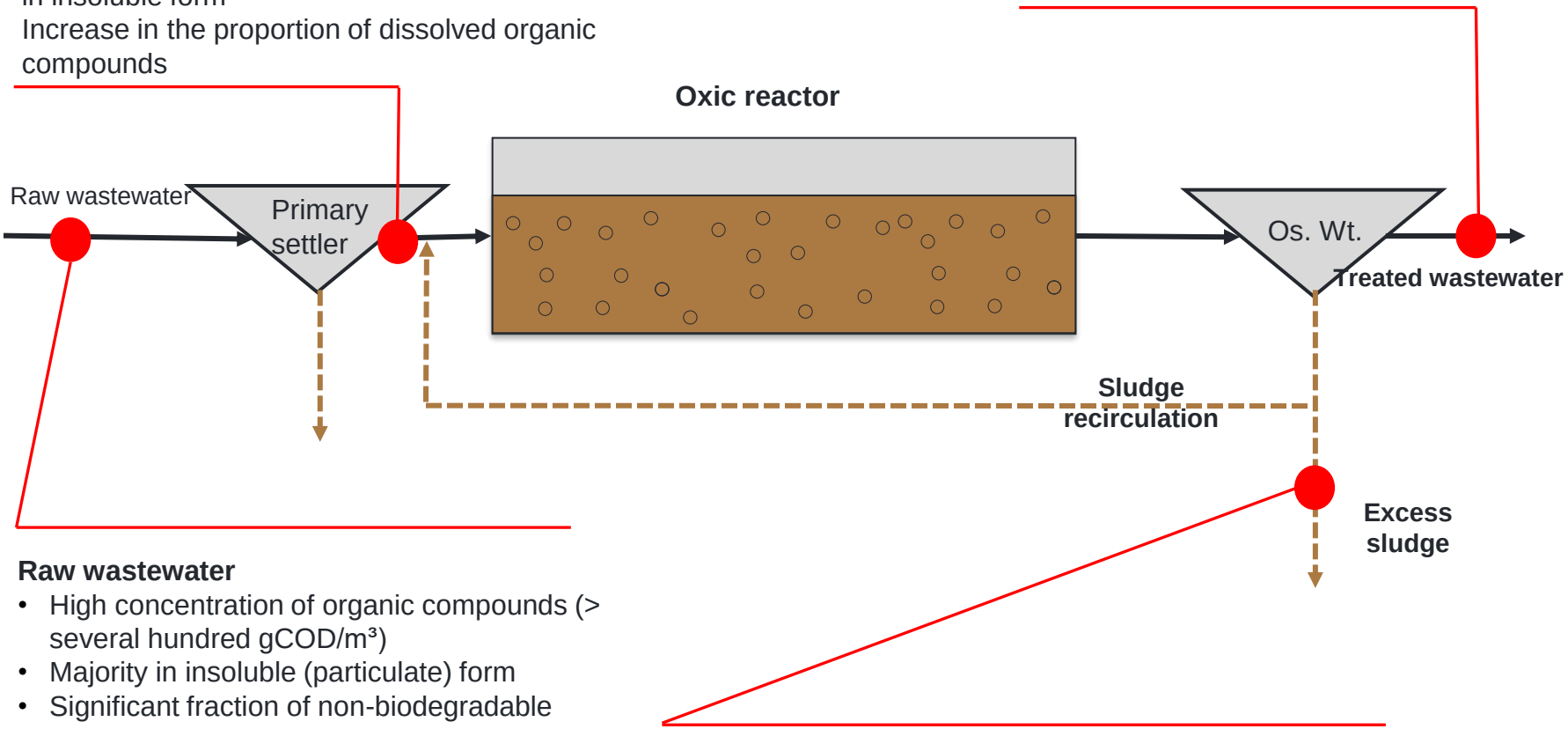
Organic carbon removal

Organic carbon removal

Mechanism

Mechanically treated wastewater
- Decrease in concentration by approximately 30%
- All organic compounds removed in the primary settler are in insoluble form
- Increase in the proportion of dissolved organic compounds

Treated wastewater
- All dissolved non-biodegradable compounds leave the treatment plant

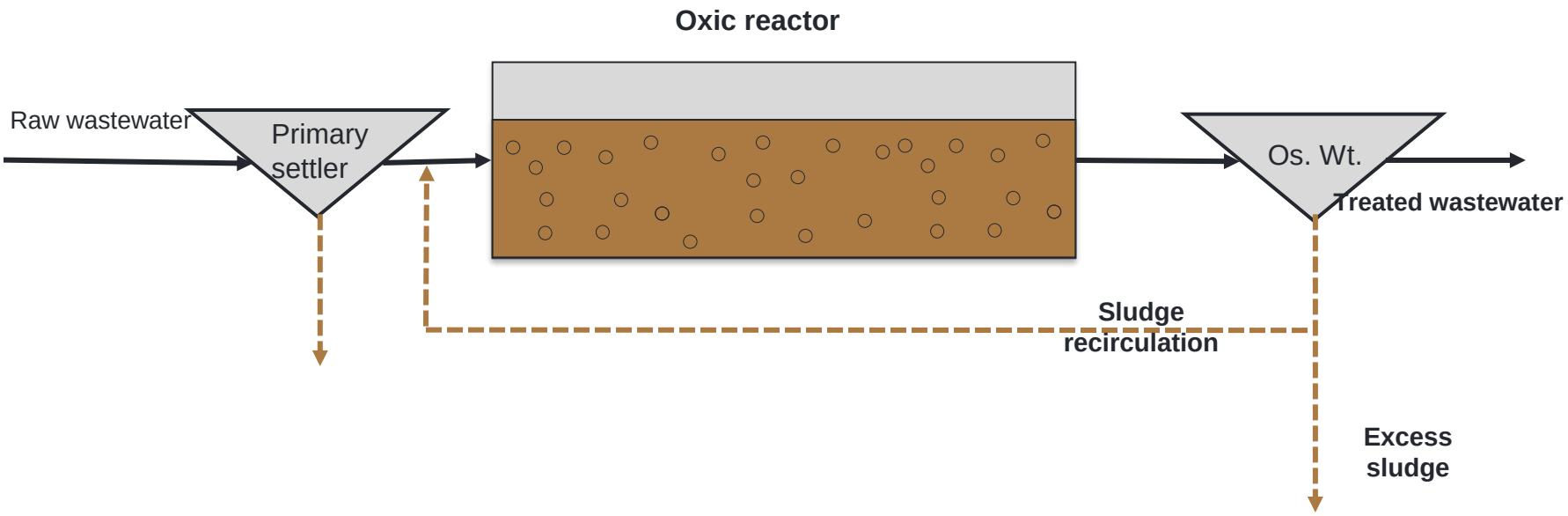


Raw wastewater
- High concentration of organic compounds (> several hundred gCOD/m³)
- Majority in insoluble (particulate) form
- Significant fraction of non-biodegradable matter (approximately 30%)

Waste activated sludge
- All insoluble non-biodegradable compounds are present in the waste activated sludge
- It also contains a certain amount of slowly biodegradable organic matter

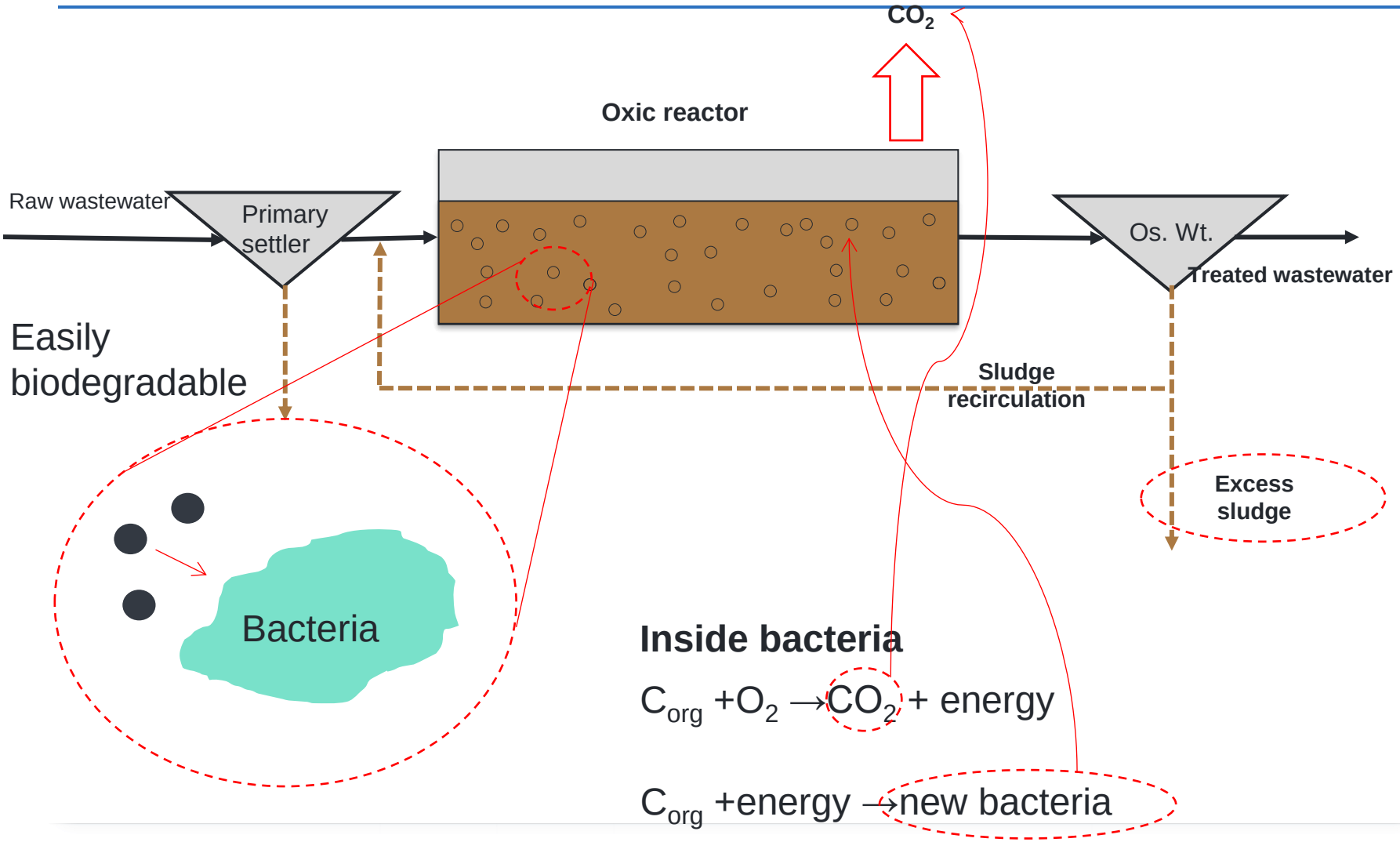
Organic carbon removal

Mechanism



Organic carbon removal

Easily biodegradable compounds



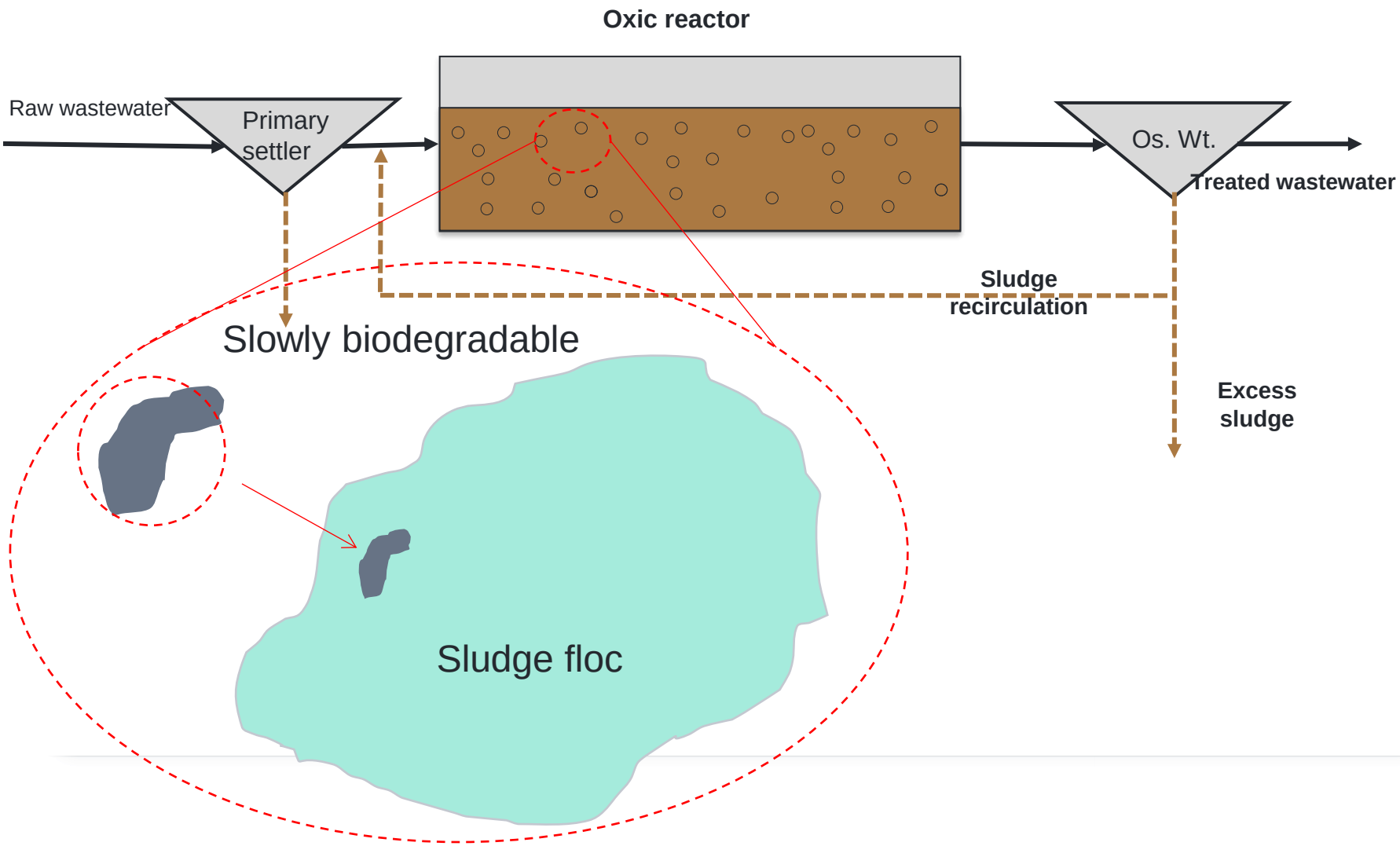
Organic carbon removal

Easily biodegradable compounds

1. Directly assimilated by heterotrophic bacteria when oxygen (or nitrates) is present.
2. Inside the cell, part of it is oxidized, and part is converted into cell biomass.
3. Oxidation leads to CO_2, which mostly escapes to the atmosphere (a portion dissolves in the wastewater and is discharged to the receiving body).
4. This process results in bacterial biomass growth.
5. Under stable conditions, the equivalent amount of newly formed biomass should be removed with the waste activated sludge.

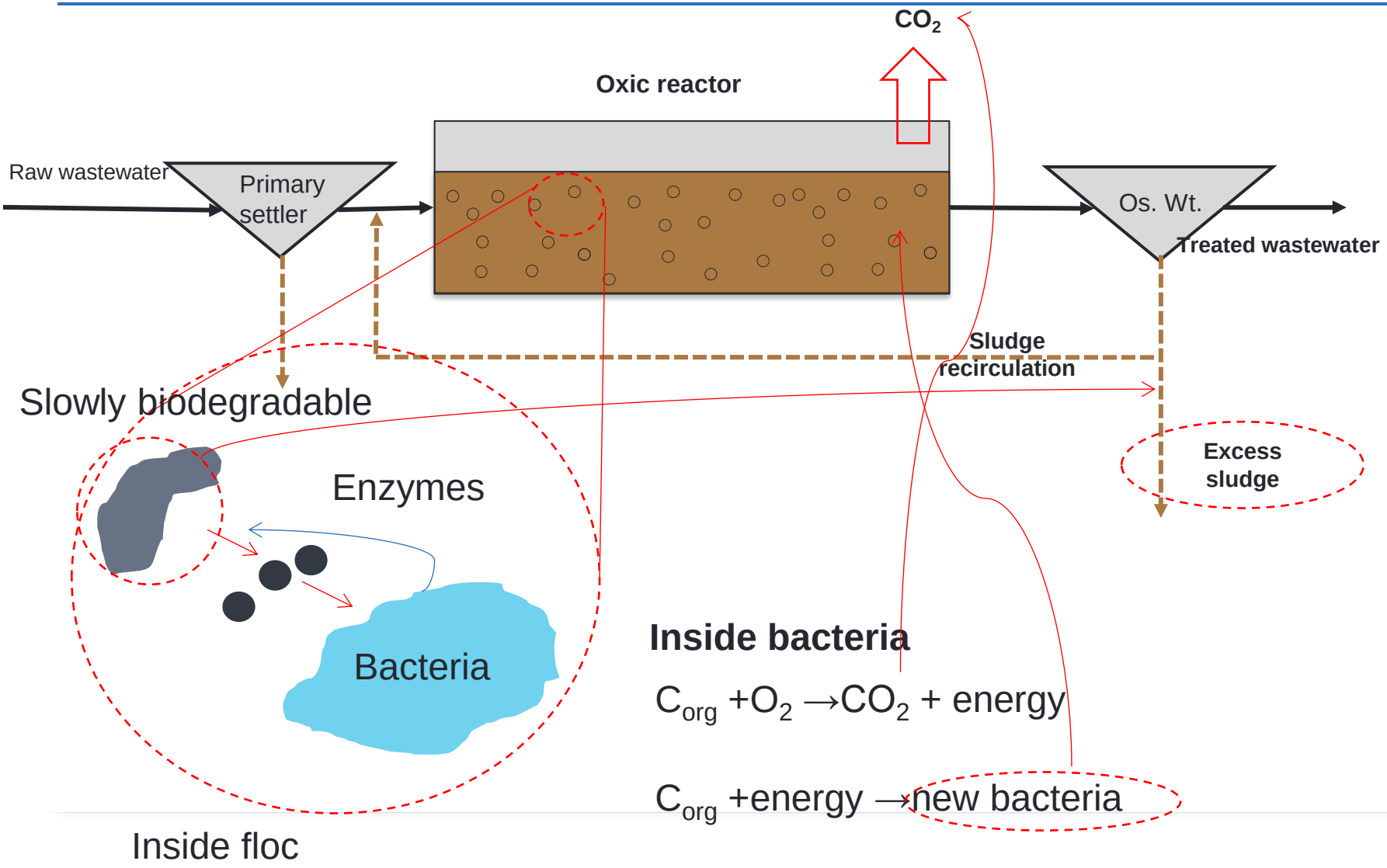
Organic carbon removal

Slowly biodegradable compounds



Organic carbon removal

Slowly biodegradable compounds



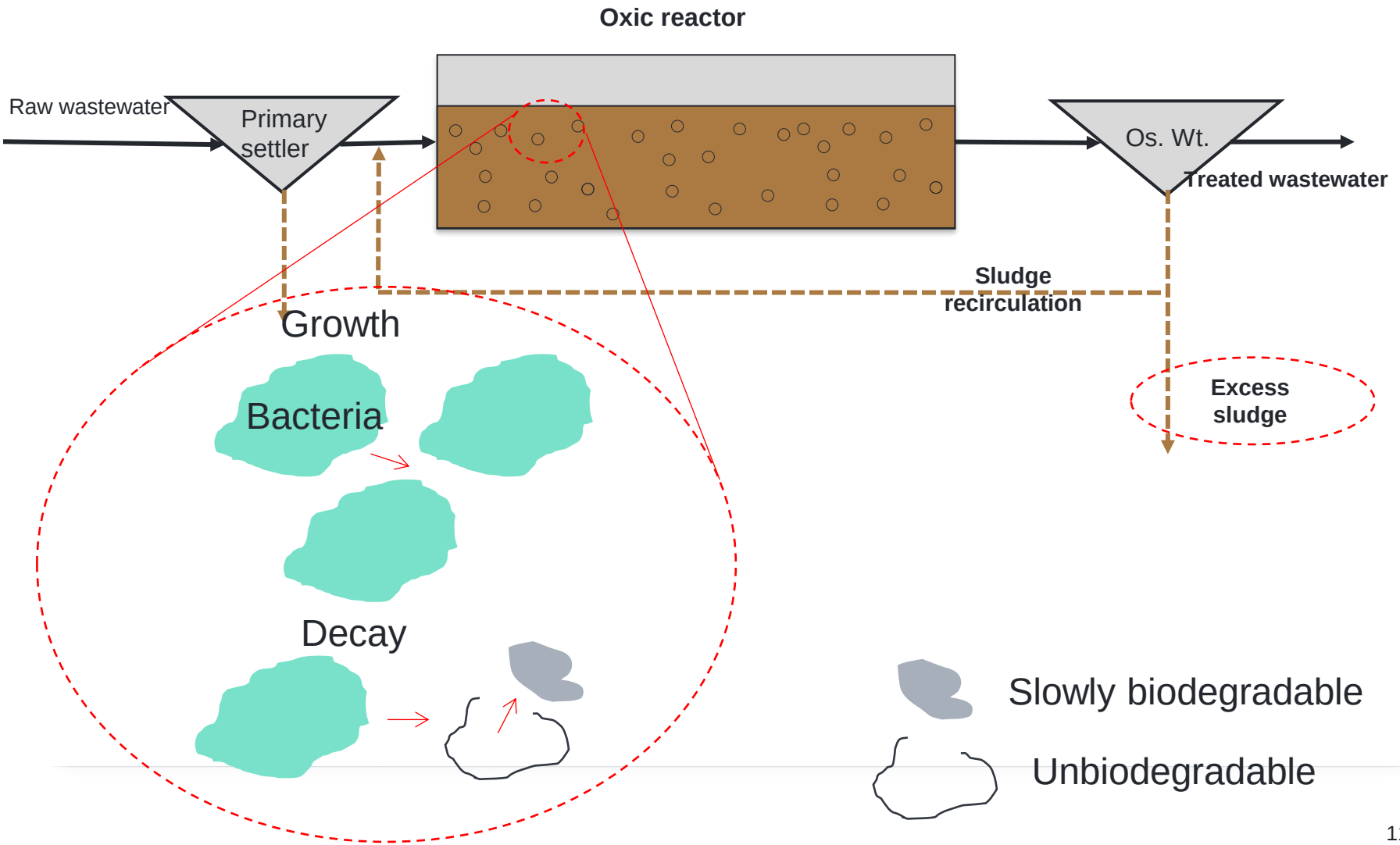
Organic carbon removal

Slowly biodegradable compounds

1. They are trapped within the activated sludge flocs.
2. There, they undergo enzymatic hydrolysis carried out by heterotrophic bacteria.
3. As a result of hydrolysis, they are converted into readily biodegradable organic matter.

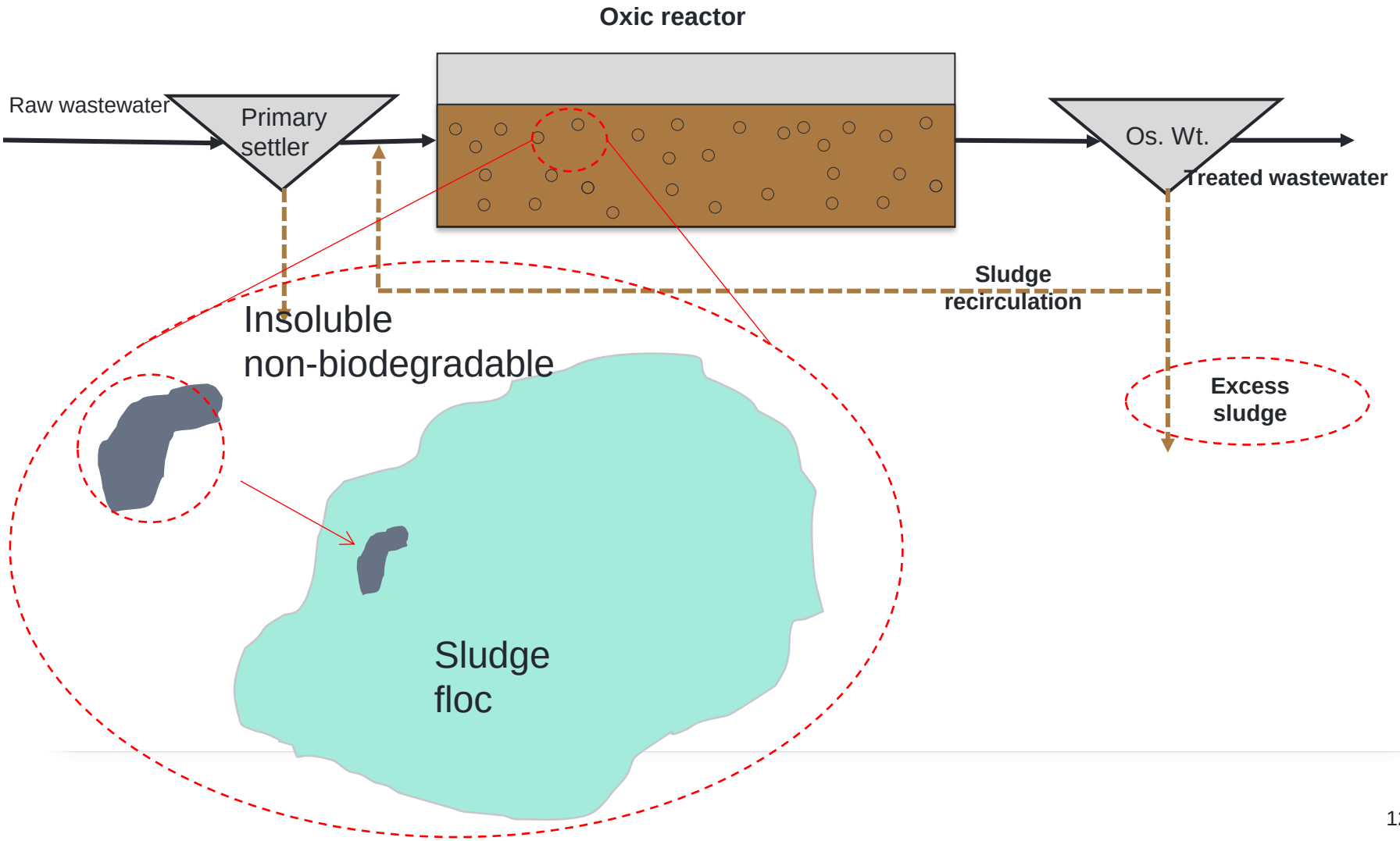
Organic carbon removal

Bacteria



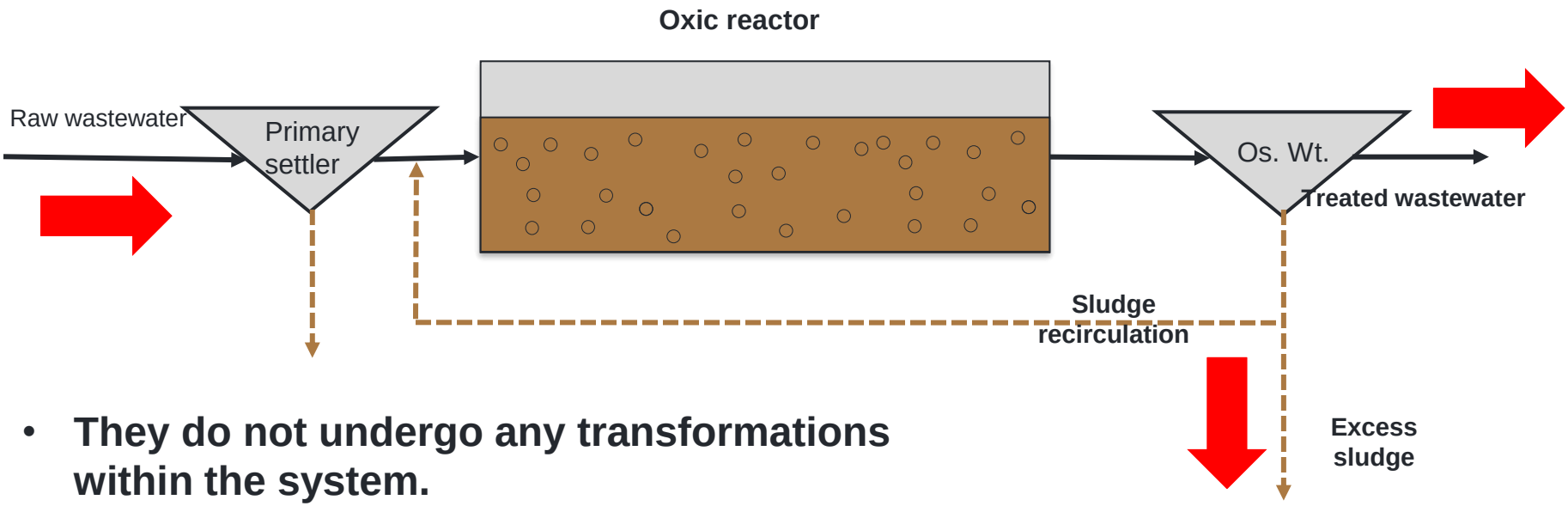
Organic carbon removal

Particulate non-biodegradable compounds



Organic carbon removal

Soluble non-biodegradable compounds



- They do not undergo any transformations within the system.
- The amount in the effluent equals the amount in the influent.
- The concentration in the treated wastewater = the concentration in the waste activated sludge = the concentration in the influent.

Organic carbon removal

Organic compound fractions in relation to BOD and COD

1. The concentration of readily biodegradable compounds can be determined using soluble BOD_5.
2. By measuring BOD_5 in an unfiltered sample, one determines the total content of readily biodegradable compounds, as well as a portion of the slowly biodegradable compounds (those for which hydrolysis and subsequent oxidation occur within 5 days), along with a small amount of slowly biodegradable matter released due to bacterial decay.
3. Non-biodegradable fractions can only be determined using COD.
4. The soluble non-biodegradable fraction can be calculated as: COD_{soluble} – BOD_5_{soluble}.
5. The particulate non-biodegradable fraction and bacterial biomass are difficult to quantify and cannot be determined directly.

Organic carbon removal

Maximum achievable removal efficiency of organic compounds

1. The lowest possible concentration of organic compounds in treated wastewater corresponds to the soluble non-biodegradable fraction, typically several tens of g O_2/m^3.
2. In practice, organic compounds present in suspended solids (usually a few g O_2/m^3, up to about 10 g O_2/m^3) must also be taken into account, as well as a very small amount of readily biodegradable matter (< 1 g O_2/m^3).
3. The removal efficiency of organic compounds usually exceeds 90%.

Organic carbon removal

Technological parameters

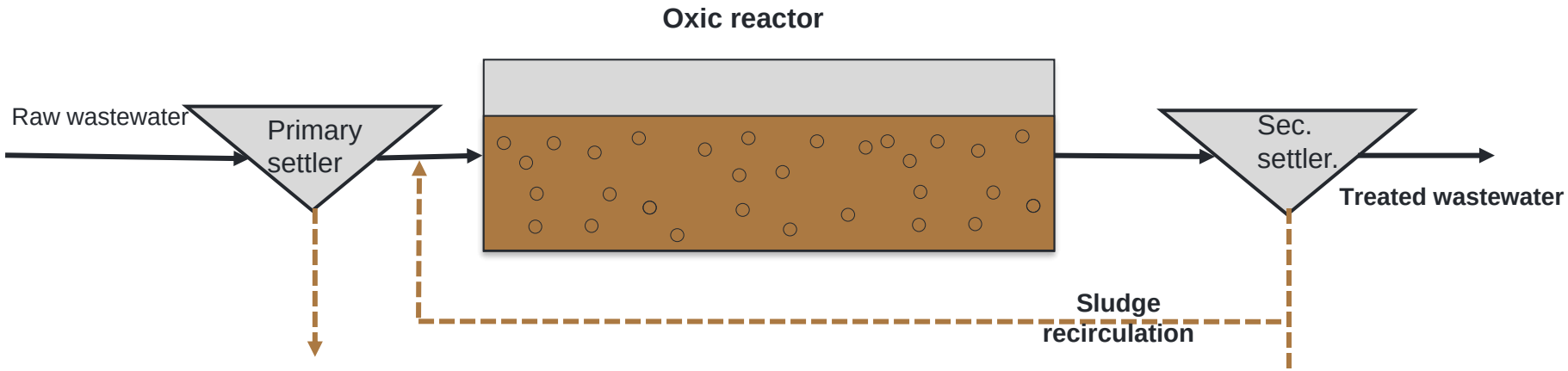
Sludge age > 3 days
Hydraulic retention time – several hours
pH range: 6.0 to 10.0
Temperature – full operational range
Dissolved oxygen in the reactor > 0.5 g O_2/m^3

Achieving complete removal of organic compounds from municipal wastewater is usually not a problem.

Sludge retention time

Sludge retention time

Definition



Essential data:
Reactor- volume V, suspended solids concentration $X_{reactor}$
Treated wastewater - flow Q_{eff}, suspended solids concentration X_{eff}
Excess sludge - flow Q_{ON}, excess sludge concentration X_{ON}
We are ignoring the mass of sludge in the secondary clarifier.

Sludge mass in reactor, kg SS

$$SRT = \frac{V \cdot X_{reactor}}{Q_{ON} \cdot X_{ON} + Q_{eff} \cdot X_{eff}}, \text{ d}$$

Suspended solids load in effulent, kg SS/d

Sludge load in excess sludge, kg SS/d

Sludge retention time

Example

Essential data:
Activated sludge reactor
volume V **– 1000 m^3,**
sludge concentration X_{KOCZ} **– 4 kg sm/m^3**
Treated wastewater
flow Q_{OCZ} **– 1000m^3/d**
Suspended solids X_{OCZ} **– 10 g sm/m^3**
Excess sludge
flow Q_{ON} **– 50m^3/d**
Excess sludge concentration X_{ON} **– 8 kg sm/m^3**

$$SRT = \frac{V \cdot X_{KOCZ}}{Q_{ON} \cdot X_{ON} + Q_{eff} \cdot X_{eff}} = \frac{1000 \cdot 4}{50 \cdot 8 + 1000 \cdot 0.01}$$

$$\frac{4000}{400 + 10} = 9.75\ d$$

Usually we can neglect it

Sludge retention time

Real meaning

Student’s drawning

Sludge retention time

Real meaning– oxygen consumption and excess sludge load

Student’s drawning

Control questions

1.What transformations are subjected to easily biodegradable and slowly biodegradable compounds?
2.What happens to non-biodegradable compounds?
3.For what do bacteria use organic compounds? Describe these processes
4.What determines the extent to which organic compounds are oxidized and assimilated?
5.Does the removal of organic carbon result in the removal of N and P? If so, how?
6.What is the age of sludge?
7.What is the physical meaning of sludge age?
8.How does sludge age affect the production of excess sludge and energy consumption?