

Sustainability in commercial laundering processes

Module 1
Usage of Water

Chapter 5

Waste water treatment Biological treatment

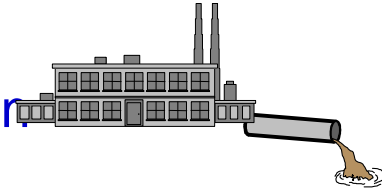


- Introduction
- Laundry-wastewater
- Microorganisms
- Wastewater installation engineering
- Examples of WWTP's in laundries



After finishing this chapter, you will

- know the composition of waste water in laundries
- know when and why waste water should be treated
- know and be able to explain biological waste water treatment
- know the role of micro organisms in biological waste water treatment process
- know 4 different (biological) possibilities to treat waste water and be able to explain them
- be able to point out the differences between the individual processes

Why wastewater treatment in laundries ?

- To reduce environmental pollution 
- To reduce consumption of natural resources 
- To avoid disruption to natural circuits 
- To comply with licensing requirements and orders
- To reduce costs

Content:

Laundry wastewater contains substances mainly from 3 sources:

- Substances from the raw water (tap water, well, etc.)
=> salts
- Detergents
=> tensides, phosphates, silicates, etc.
- Dirt from the clothes
=> particles, fat, oil, colour, etc.

Important: limiting parameters for discharge?

=> e.g. P, AOX, heavy metals



Concentrations (3 examples of laundry wastewater):

▪ Temp [°C]	35	41	36
▪ pH	9,3	9,9	9,6
▪ Conductivity [mS/cm]	1,7	3,0	2,4
▪ COD [mg/l]	1.100	900	1.450
▪ BOD ₅ [mg/l]	n.n.	350	670
▪ N,tot. [mg/l]	25	22	35
▪ P,tot. [mg/l]	11	55	7

T Temperature (heat exchanger? Thermal or chemo-thermal disinfection?)

pH => Alkalinity !

COD „**C**hemical **O**xxygen **D**emand“ => parameter for the organic pollution

BOD₅ „**B**iochemical **O**xxygen **D**emand“ after 5 days
=> parameter for the biodegradable pollution

P,tot. Total Phosphorous (P-free detergents ?)

Other Contents:

- AOX (=> use of Chlorine in main wash ?)
- Heavy metals (=> textiles from metal working industry, kitchen wear)

What is biological wastewater treatment ?

Wastewater treatment with

- **Bacteria**
- Other microorganisms
(fungi, special processes only)



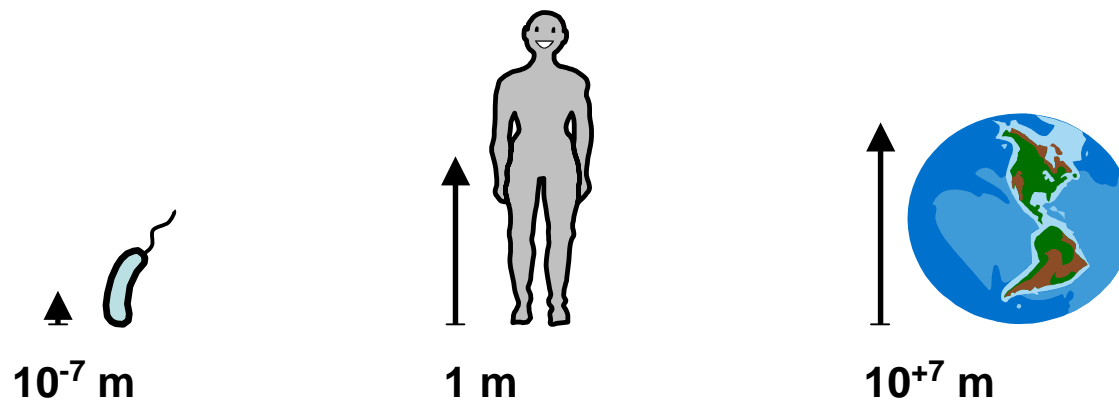
Picture of a typical bacteria community from a municipal wastewater treatment plant

What is biological wastewater treatment ?

Wastewater treatment with

- Size of **Bacteria**: „*Micro organisms*“ => *micro meter* !

size-comparison bacteria – human beings – earth:



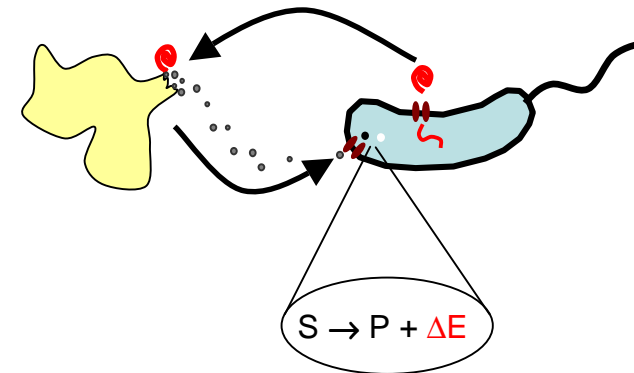
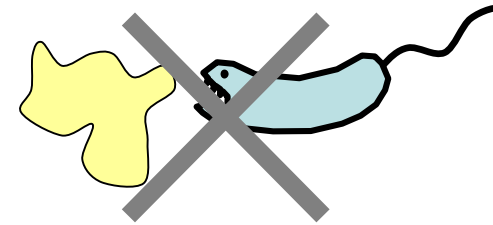
What can microorganisms do ?

- MO's do not „eat“ the pollution
- MO's do wastewater treatment by conversions with **enzymes**

S (Substrate, in ww-treatment the **pollution**)

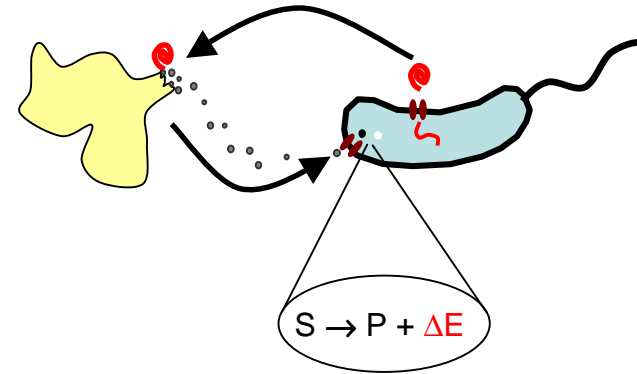
=> **P** (Product, CO₂, N₂, etc)

+ **Energy** (which is used for growing
=> surplus biomass !)



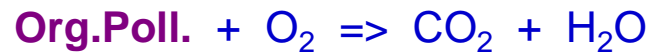
What can microorganisms do ?

- **Suitable conditions:**
 - MO's do the work for free
 - Often the only way for **cost-effective wastewater treatment**



Conversions by microorganisms

- **Aerobic** degradation of **organic pollutants** („COD, BOD₅“)



truly:

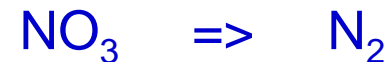


- Surplus bacteria = up to 50 % of org.Poll. in municipal WW-treatment !
- Residual Pollution = usually 10-20 % of org.Poll. in municipal WW-treatment
= 5-50 % in industrial WW-treatment (biodegradability !)
= could be less than 5 % in laundry-WWTP's (good biodegr.)

Conversions by microorganisms

- **Degradation of nitrogen**

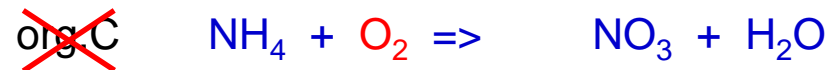
3 steps: **org.N** => NH_4



Conversions by microorganisms

- **Degradation of nitrogen**

3 steps: **org.N** => NH₄



- 3 steps
- Total different conditions (org.C, O₂) !

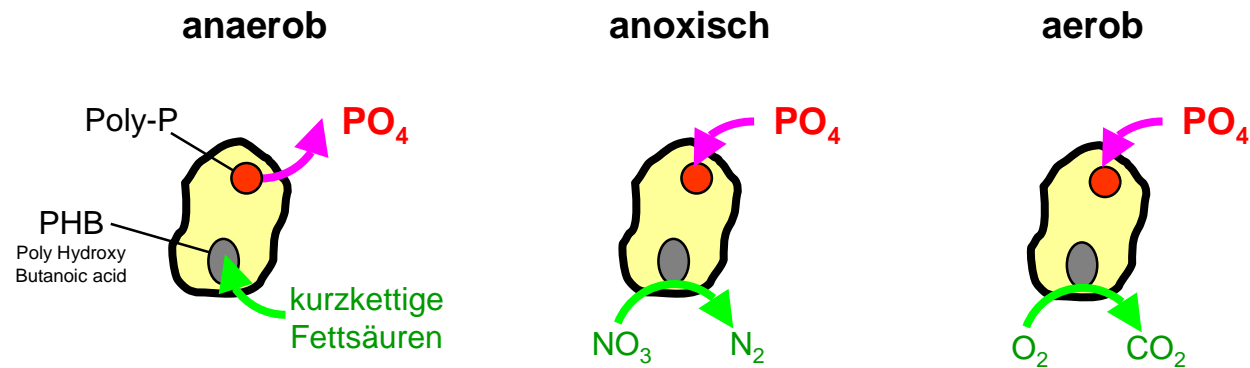
Conversions by microorganisms

- **Degradation of phosphorus**

... precipitation (non-biological, see below)

Conversions by microorganisms

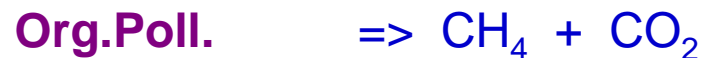
- **Degradation of phosphorus (biological way)**



- **Surplus P-uptake in bacteria, removal with surplus sludge**
(P-removal from wastewater limited, different conditions, not easy to handle)

Conversions by microorganisms

▪ Anaerobic degradation of organic pollutants



- No aeration
- High-energetic product (burning => energy, electricity)
- Considerably less surplus sludge

- High substrate concentrations (COD > 10.000 mg/l)

- Used in anaerobic sludge stabilisation

Conversions by microorganisms

- **Anaerobic degradation of organic pollutants**

Org.Poll. => $\text{CH}_4 + \text{CO}_2$

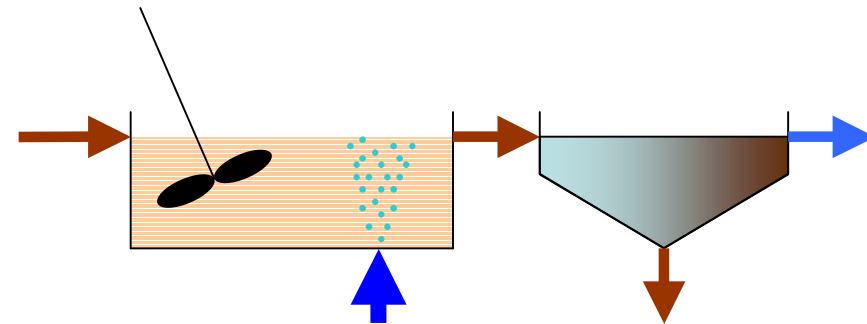
- Truly:

Org.Poll. => (Hydrolysis) => fragments, diluted Poll.
 => (Acidification) => $\text{H}_2 + \text{CO}_2 + \text{organ. Acids} + \text{Alcohol}$
 => (Acetogene) => $\text{H}_2 + \text{CO}_2 + \text{Acetic Acid}$
 => (Methanogene) => **$\text{CH}_4 + \text{CO}_2$**

- 4 steps
- 4 different MO-species
- Stable conditions important (temperature, product-concentrations)

Construction of WWTP's:

- **Diluted**
- Fixed bed
- Constructed wetlands
- Combinations

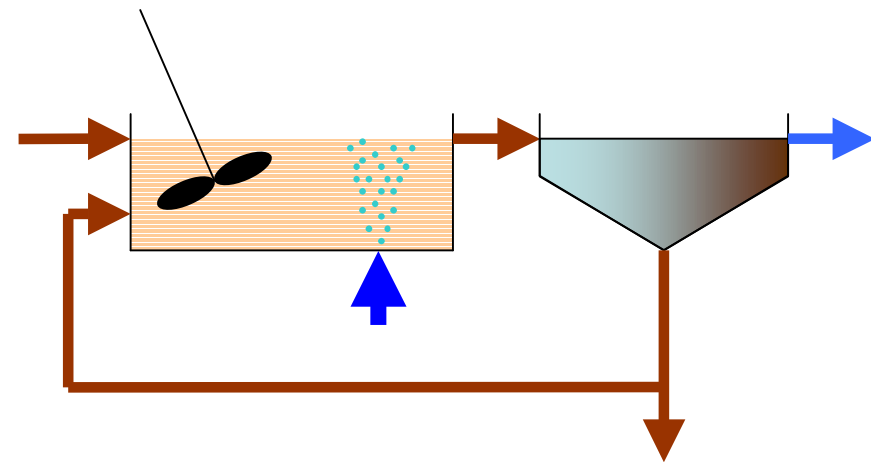


Very simple process
Low maintenance
For low and medium polluted WW

MO's could be washed out

Construction of WWTP's:

- **Diluted**
- Fixed bed
- Constructed wetlands
- Combinations

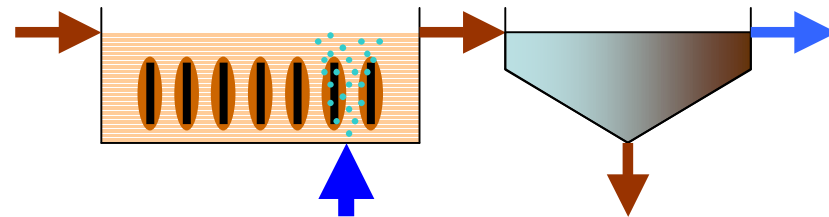


➤ „activated sludge process“

➤ Recirculation of the MO's
=> (higher MO-concentration for
better removal rates)

Construction of WWTP's:

- Diluted
- **Fixed bed**
- Constructed wetlands
- Combinations

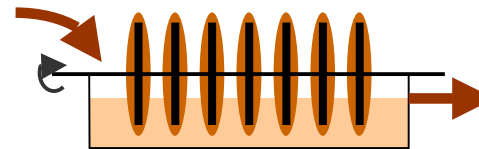


MO's fixed
no wash out
higher flow rate
Biofilm less sensitive
Less surplus sludge

MO-separation also required

Construction of WWTP's:

- Diluted
- **Fixed bed** - rotating disk reactor
- Constructed wetlands
- Combinations

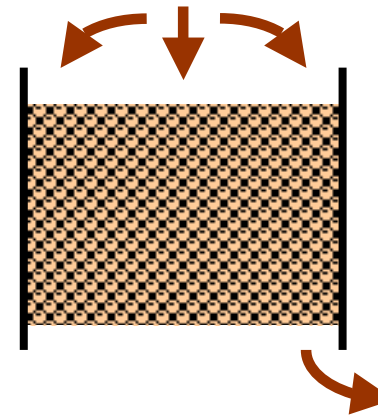


MO's rotate
Alternating Contact air / WW
No aeration required
Less energy consumption

„tube-reactor“ (no dilution of toxic load)

Construction of WWTP's:

- Diluted
- **Fixed bed** - trickling filter
- Constructed wetlands
- Combinations

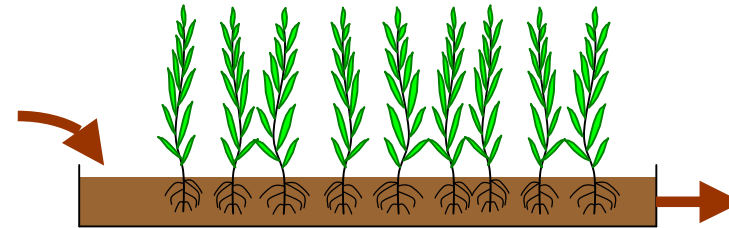


MO's at packing material (e.g. lava)
WW „trickles“
No aeration required
Low energy consumption

2nd step in N-degradation

Construction of WWTP's:

- Diluted
- Fixed bed
- **Constructed wetlands**
- Combinations



Treatment by MO's in root area
treatment also in winter time (ca. 80 %)
O₂ supply by the plants (e.g. reed)
Beautiful optical appearance („ecological“)

High space requirement
Accumulation of toxic substances possible (in soil area)

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands

- **Combinations**

biological - chemical

UV, H₂O₂, Ozone

- Oxidation of persistent substances
- Detoxification
- Increase of biodegradability

- High energy consumption
- Chemicals must be added

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands
- **Combinations**

biological - chemical

Precipitation Flocculation Flotation

- Removal of non-biodegradable components
- Additional solid-liquid-separation
- Chemicals to be added
- waste disposal !

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands
- **Combinations**
biological - chemical

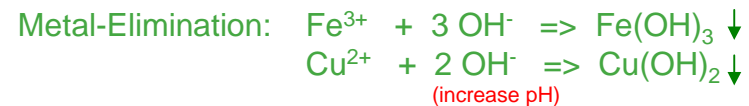
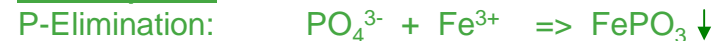
Precipitation

e.g. P-Elimination in WW-treatment
(Fe-III-salts, Al-salts)

Principle:

Formation of low soluble components &
sedimentation or separation

Examples:



Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands
- **Combinations**
biological - chemical

Flocculation

Additional separation of MO's from treated water

Problem:

- Settling velocity of small MO-flocs or single MO's too low for technical application
- Settling velocity = f (particle diameter)²

Principle:

- Small flocs or single MO's are coalesced by flocculation agents (organic, synthetic, high molecular and water soluble poly-electrolytes, Fe(III)-salts, ...)
- Increase of floc-size => increase of settling velocity
- Better sludge-drainage

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands

- **Combinations**

Biology & Filters

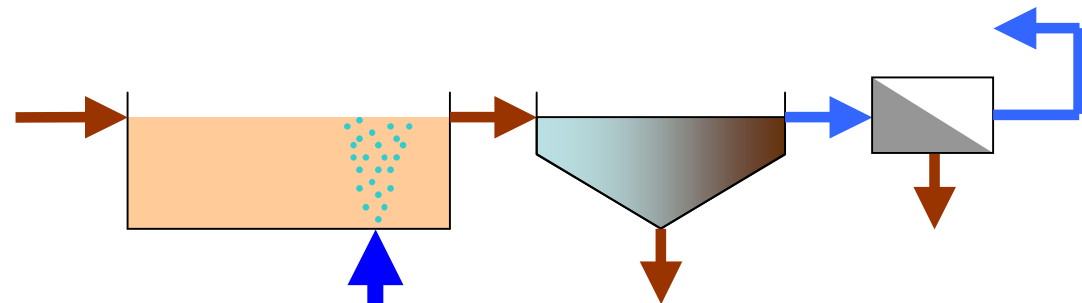
e.g. sand filter

- For supplement sludge separation
- Better effluent quality
- Separation of single MO's
- Adsorption

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands
- **Combinations**

Biology & Membranes

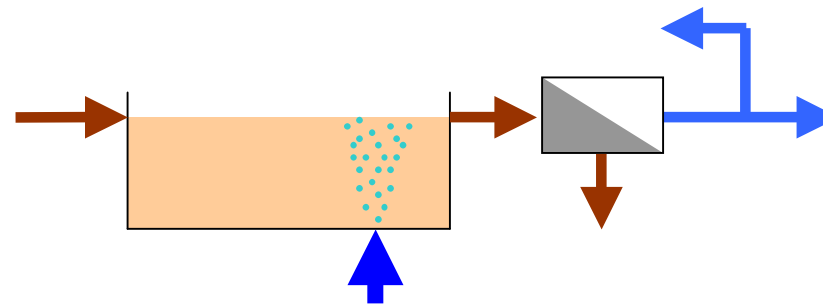


Wastewater Recycling

- => Germfree effluent
- => Elimination of residual pollution
- => Elimination of heavy metals
- => Elimination of salts

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands
- **Combinations**
Biology & Membranes



Alternative for sedimentation tank
- external arrangement

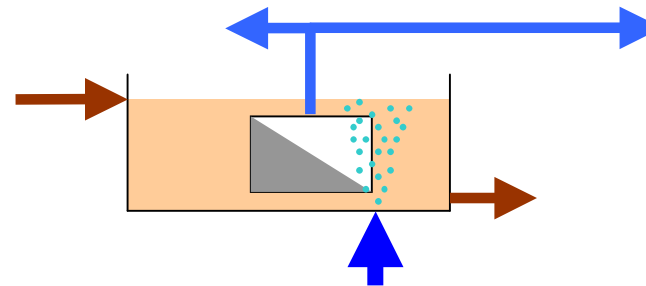
- => Germfree effluent
- => Elimination of residual pollution
- => Less space requirement
- => modular
- => Recycling of process water

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands

- **Combinations**

Biology & Membranes



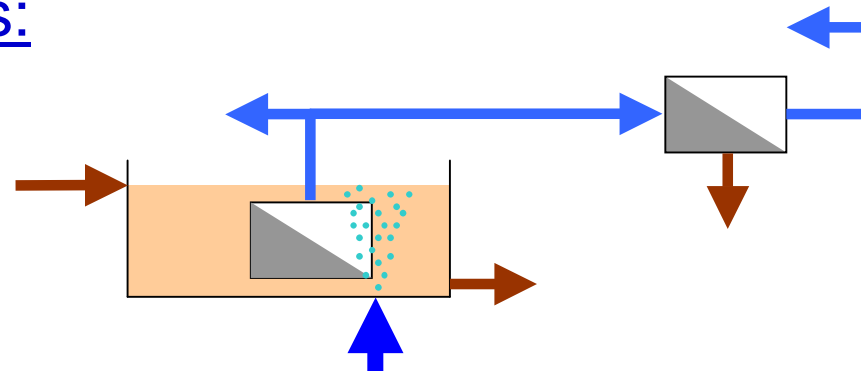
Alternative for sedimentation tank
- internal arrangement

- => Germfree effluent
- => Elimination of residual pollution
- => Less space requirement
- => modular
- => Recycling of process water
- => MO's stay in the reactor (specialised MO's)

Construction of WWTP's:

- Diluted
- Fixed bed
- Constructed wetlands
- **Combinations**

Biology & Membranes



Combination of membranes

- => Recycling of process water
- => Additional elimination of salts and other pollutants

WWTP's in laundries

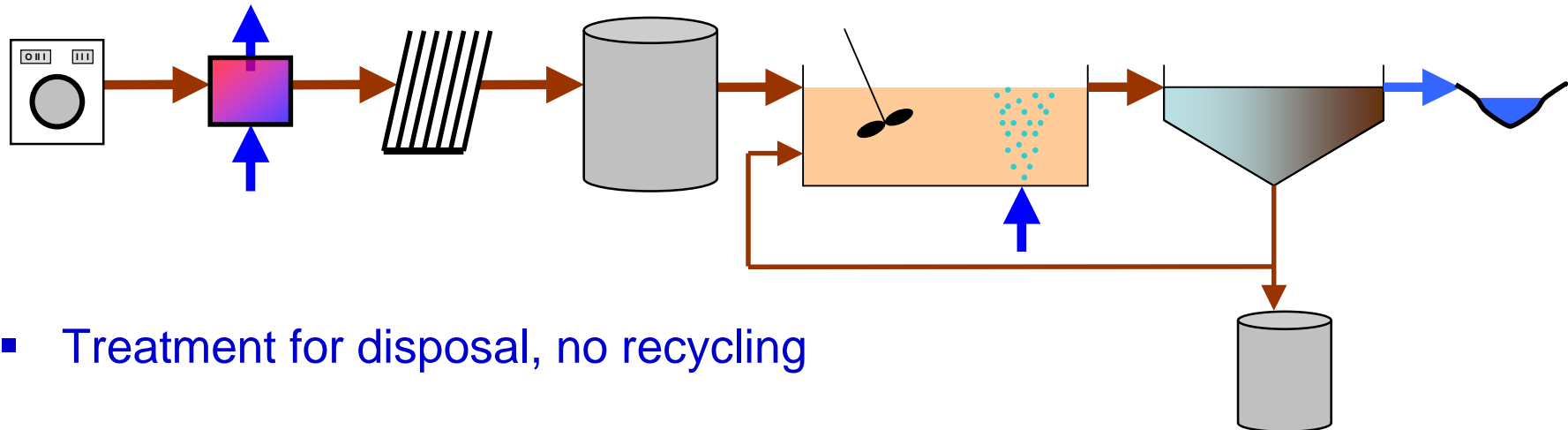
- All solutions are applicable depending on problem & situation

- No continuous WW feed
 - requires storage tank

- Self-monitoring, maintenance & repair
 - manpower requirement
 - manpower with „keen sense for the plant“

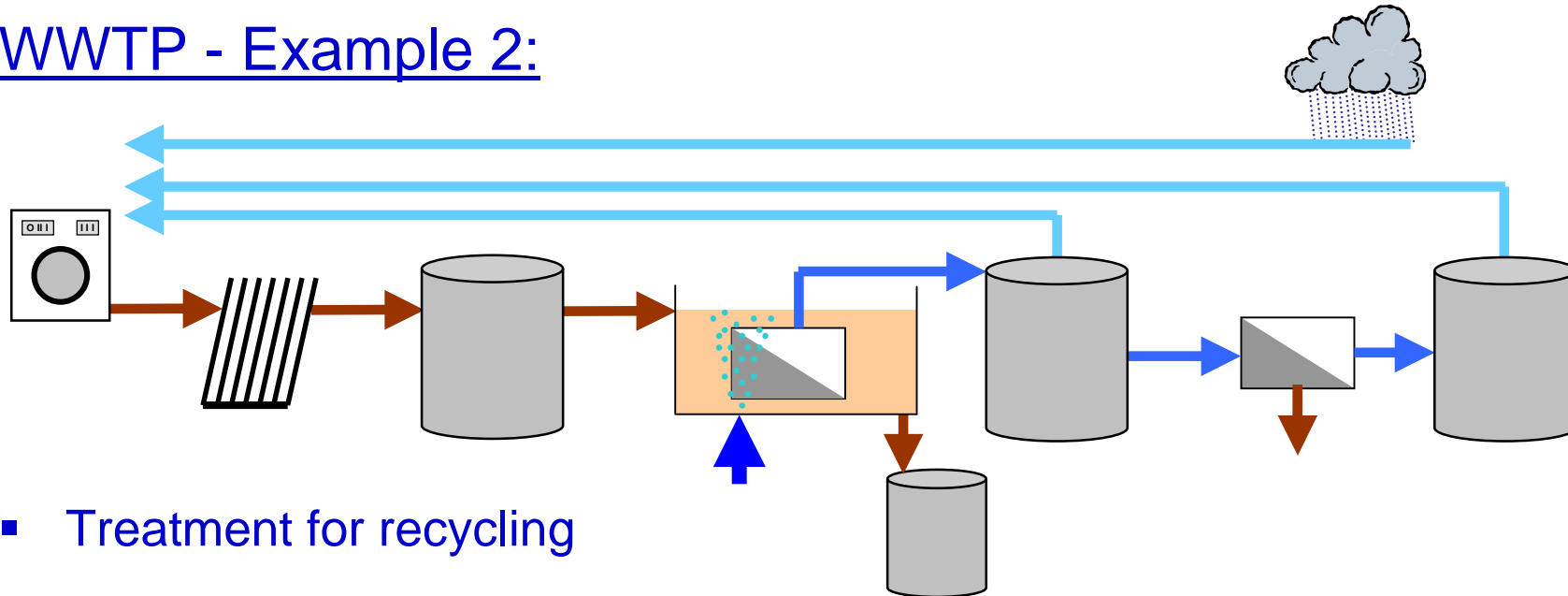
- Cost accounting
 - economy of operational costs „not worldshaking“
 - investment relatively high (=> long payback period)

WWTP - Example 1:



- Treatment for disposal, no recycling
 - 700-800 m³/d
 - 3000 kW
 - COD-Elimination > 93 %
 - disposal in river
 - reduction of operational costs 50 %

WWTP - Example 2:



- Treatment for recycling
 - 150 m³/d
 - 2000 EW
 - COD-Elimination > 96 %
 - Disposal in municipal sewer system
 - Reduction of operational costs 50 % & recycling