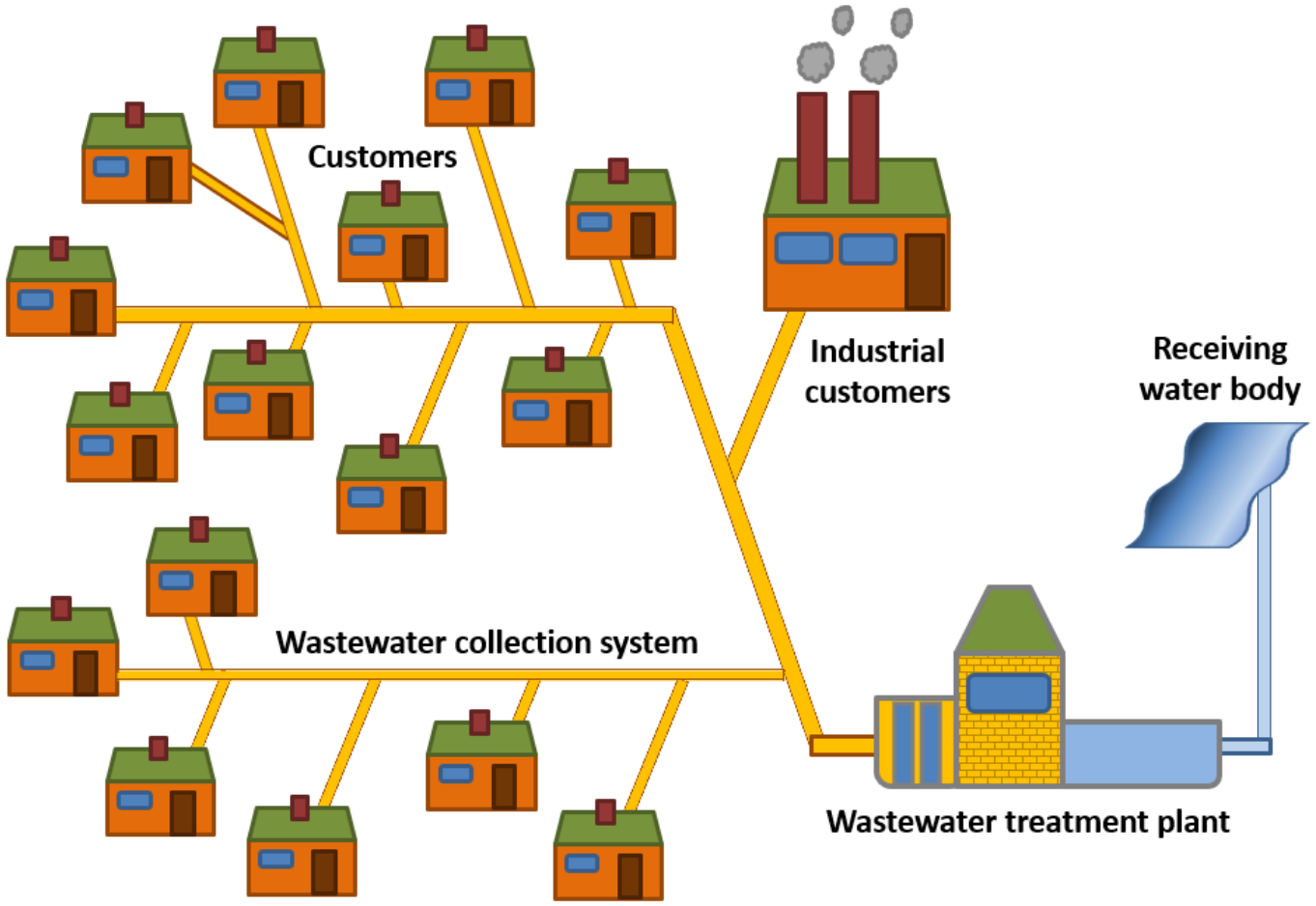
Reducing nutrient load from catchments

4.4. Basics of Wastewater Treatment

The presentation contains only the overall description of the main processes of wastewater treatment.

Water Chain

Municipal wastewater, including sewage, is treated in a multistep process before the treated water is released into the environment.
Each city has a wastewater collection system that moves wastewater by gravity and pumps it to the wastewater treatment plants.



All man-made systems including wastewater treatment plants (WWTP), filter systems, bioreactors are developed to decrease biogen or nutrient load to the environment or clean environmental systems.

Water Chain

Conventional WWTPs consist of primary and secondary treatment stages

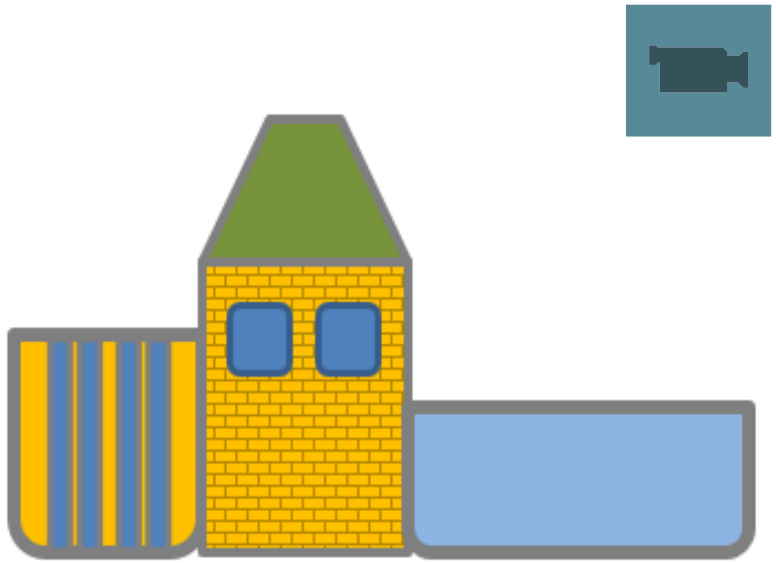
Primary treatment:

1. Screening;
2. Grit chamber and sand catchers;
3. Sedimentation tank (settling tank or clarifier).

Secondary treatment:

4. Activated Sludge process followed by a sedimentation step;
5. Sedimentation tank (settling tank or clarifier);
6. Trickling Filters;
7. Lagoons.

Learn more about WWTPs:



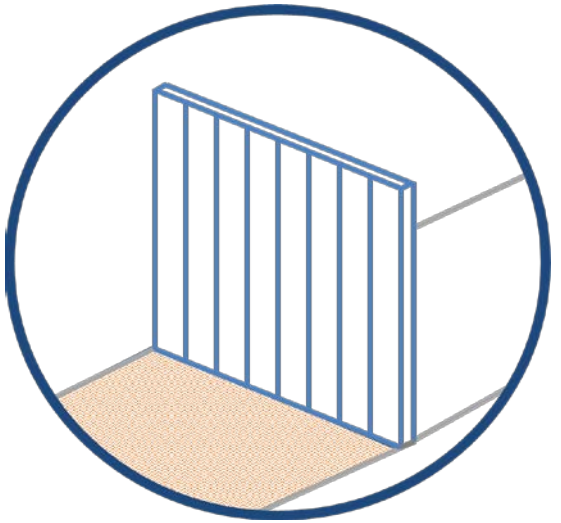
After primary and secondary treatment, municipal wastewater is sometimes disinfected (using chlorine, ozone or ultraviolet light).

REF [1, 2]

Water Chain

Screening (1)

Sand Catchers and Grit Chambers (2)



Screening is the first stage of the wastewater treatment process.

Screening removes large objects like stones or sticks, diapers, nappies, sanitary items, cotton buds, face wipes and even broken bottles, bottle tops, plastics and rags that may block or damage equipment.

The water then travels into grit tanks where heavy items settle to the bottom. From this point, the water flows by gravity to the Primary Clarifiers.

Special equipment is also used to remove grit that gets washed into the sewer.

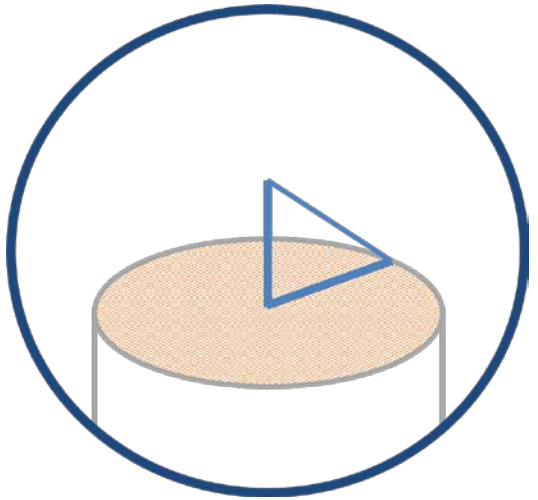
Sand Catchers at Helsinki city wastewater treatment plant Viikinmaki

REF [1, 2]

Water Chain

Primary sedimentation (3)

Primary Clarifiers



Primary wastewater treatment is the physical or chemically enhanced settling of suspended particles.

It includes: aeration of the wastewater. Many compounds with intense odors, such as sulfides and thiols, can be oxidized in air to compounds that don't have a bad smell.

The addition of coagulants as $Al_2(SO_4)_3$, $Fe_2(SO_4)_3$, and $Ca(OH)_2$ enhance settling of suspended particles. The waste goes into a tank where the undissolved solids fall to the bottom. Suspended particles form flocks with added coagulants and settled by gravity forces.

Settleable solids settle out and floatable compounds are floated to the top and are skimmed off.

Primary treatment removes only one-third of the BOD. This doesn't remove soluble materials or toxic chemicals.

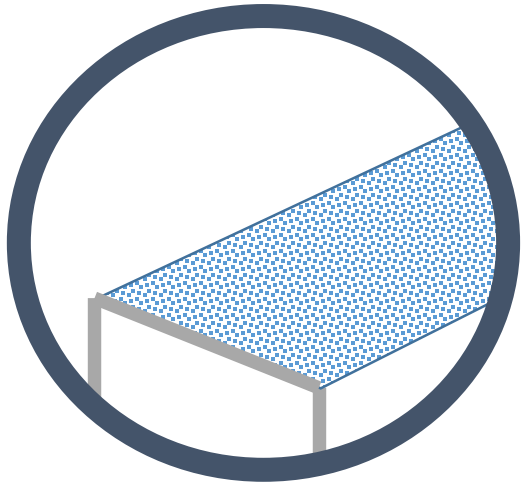
After primary sedimentation the water retains a high BOD.

REF [1, 2]

Water Chain

Aeration tank (4)

Bioreactors

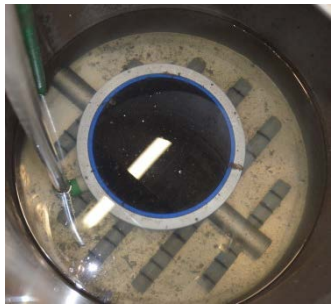


The treated wastewater is mixed with aerobic heterotrophic bacteria, fungi and protozoa. These microorganisms break down the dissolved organics and use it to produce new cells or biomass which then settle out of suspension, together with undigested material, as "sludge”.

The system is well aerated using large pumps and membranes to keep dissolved oxygen levels high and promote the growth of the aerobic organisms.

As the microbial populations increase, foam appears on the surface and cells begin to clump together and settle. Some of the activated sludge is used to inoculate incoming effluent from the primary tanks.

The microorganisms consume nutrients like phosphorus and ammonia, and organic matters. After several hours, the water flows to the secondary clarifiers.



Different membranes are used for aeration system in the aerotanks to increase dissolved oxygen ability for microorganisms.

REF [1, 2]

Water Chain

Aeration tank (4)

Bioreactors

PRINCIPLE

A method of contact between microbes and substrate.

THE GOAL

- Coagulate and remove suspended solids;
- Remove the nutrients as phosphorus (P) and nitrogen (N);
- Reduce the organic matter or convert it to non-biodegradable form so that it does not exert oxygen demand.

REQUIREMENTS

Environmental conditions that affect microbial growth:
pH, temperature, amount of nutrients (N:P:C ratio), concentration and composition substrate, concentration of dissolved oxygen and contact time.

Aeration tank, Ādaži, Latvia

ĀDAŽU ŪDENS

REF [1, 2, 3]

Water Chain

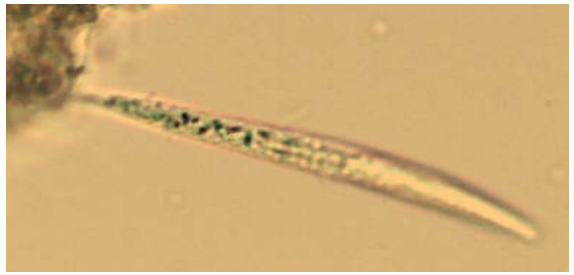
Aeration tank (4)

Sludge

There are 12 main indicator microorganisms. Changes in number and type of these can indicate the condition of the treatment process and predict problems.

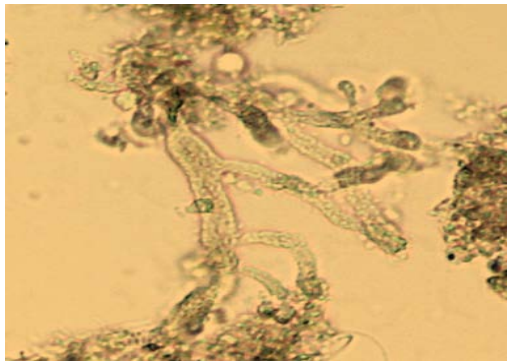
Some examples:

Nematoda (worm)



Causes
① Rooting sludge
② Poor mixing of sludge
③ Low dissolved oxygen

Zoogloea (*Ramigera*)



Causes
① Zoogloea predominate when active sludge not settle properly

Algae (*Spirogyra*)

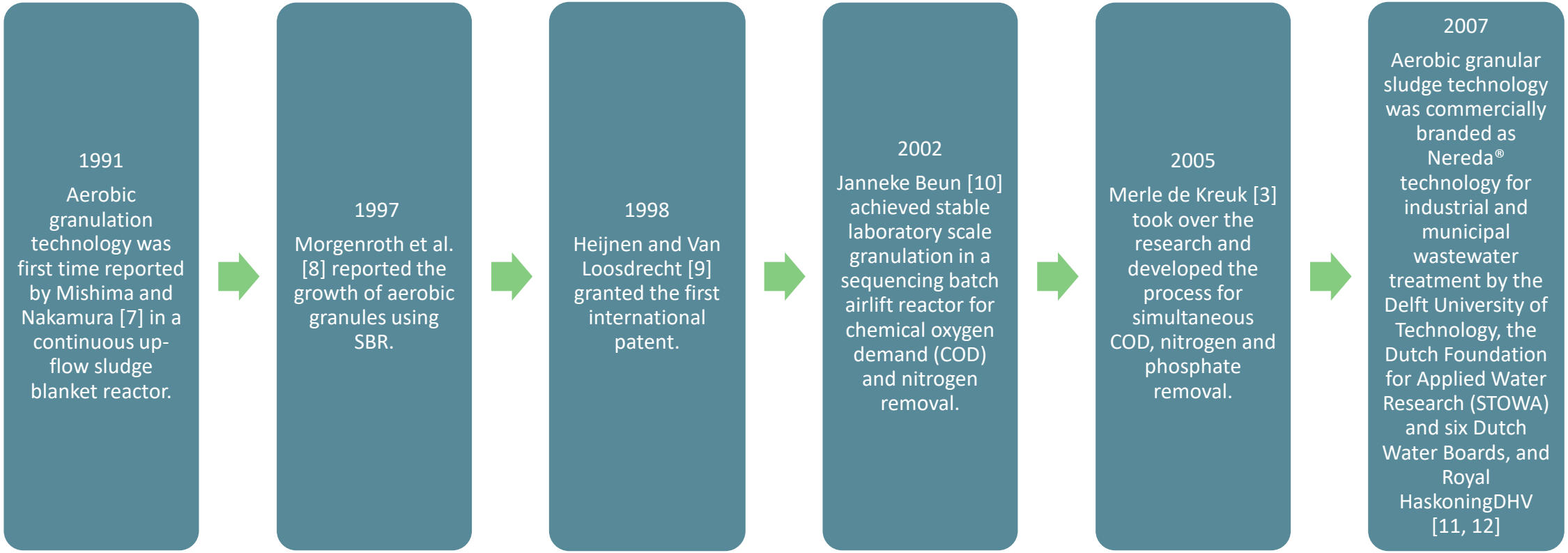
Causes
① Poor mixing of sludge

Waterbear

Water Chain

Advanced Bioreactors (4)

A relatively new biological wastewater treatment technology called aerobic granular sludge (AGS) is usually applied in sequencing batch reactor (SBR) systems. AGS has been investigated as an alternative to classical activated sludge process.



REF [3-12]

Water Chain

Advanced Bioreactors (4)

Nereda® technology uses an optimized SBR cycle, in which the 4 steps of a typical SBR cycle are simplified into 3 steps (see Figure 1):

① simultaneous fill and draw;

② aeration;

③ settling.

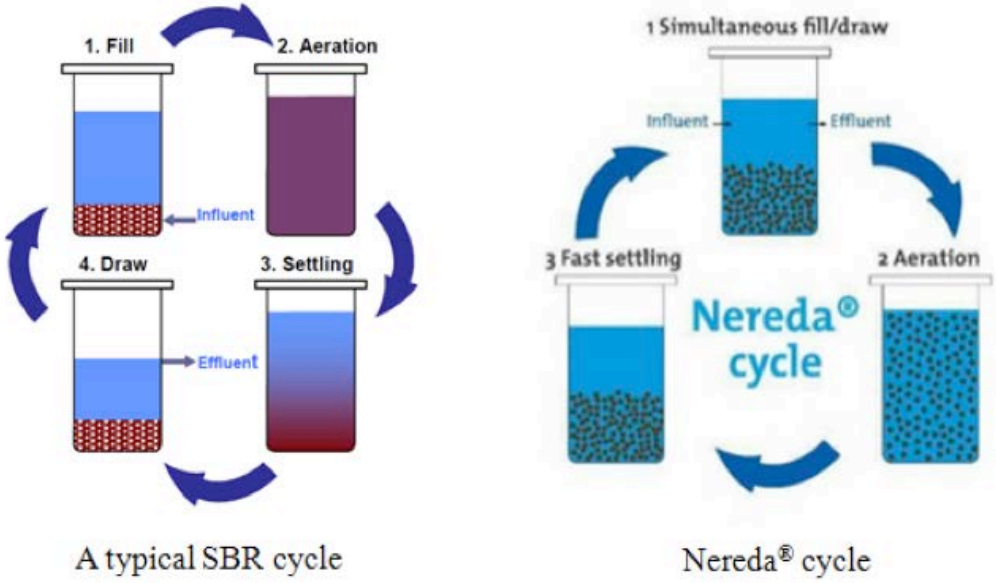


Figure 1. Operation phases of traditional SBR cycle and Nereda® cycle (adapted from Giesen et al. [11, 12]).

Nowadays, the Nereda® technology is used in many places in Europe (the Netherlands, Ireland, Poland, Portugal, Switzerland, and United Kingdom), South America (Brazil), Africa (South Africa) and Australia.

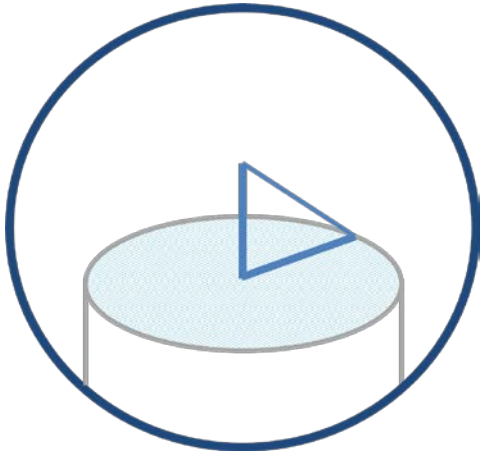
This method is promising, as it does not require addition of chemicals thus providing great advantages for small wastewater treatment plants.

REF [11, 12]

Water Chain

Secondary sedimentation (5)

Secondary Clarifiers



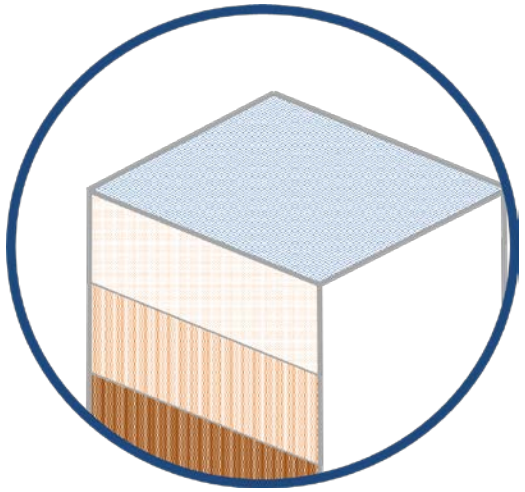
Following biological treatment, the effluent flows into post-secondary sedimentation tanks where it is allowed to settle once again. The surface of the tank is slowly swept by a skimmer to remove surface growth on residual organics and solids.

Secondary Clarifiers at wastewater treatment plant Riihimaki, Finland

REF [1, 2]

Water Chain

Trickling Filters and Lagoons (6, 7)



Trickling Filters - filters with natural or synthetic filter media, where wastewater is sprayed into the air (aeration), then allowed to trickle through the media. Microorganisms attached to and growing on the media, break down organic material in the wastewater. Trickling filters are equipped with draining systems at the bottom; collected wastewater undergoes sedimentation.

Lagoons - slow filters based on the interaction of sunlight, algae, microorganisms, and oxygen (sometimes aerated).

REF [1, 2]

Water Chain

Discharge to the environment

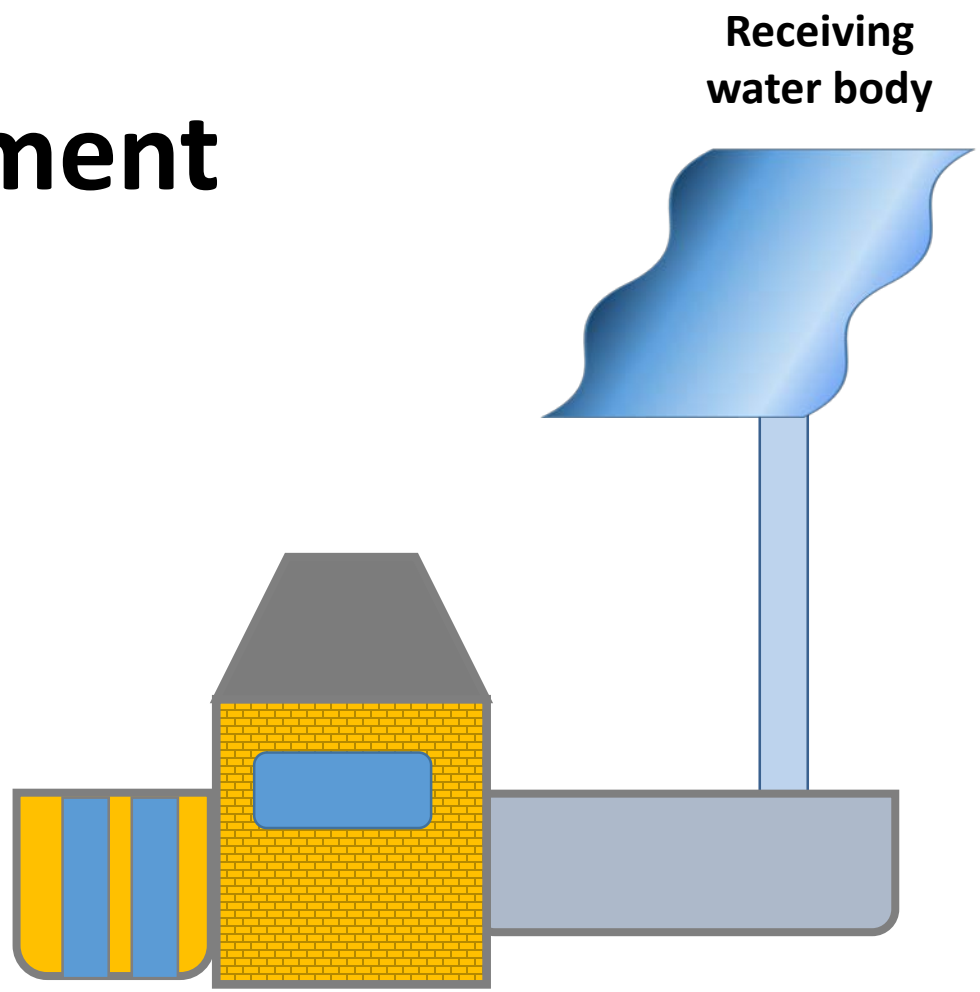
The treated wastewater is discharged to surface water bodies.

It’s clear, colorless, high in dissolved oxygen, and very low in solids, phosphorus, ammonia, nitrogen and disease causing micro-organisms.

Quality of wastewater is controlled by laboratories.

Experts collect samples at all stages of the wastewater treatment process.

Treated water meets the high EU standards and rules set by Environmental Protection agencies in each EU country.



Wastewater treatment plant

Water Chain

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Acknowledgments

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Photos of microorganisms by Viktorija Deņisova
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Faculty of Civil Engineering
Water Research Laboratory and Department of Water Engineering and Technology

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