# Aeration

Lecture 12



Politechnika Wrocławska

# Wastewater aeration

## Basic information

**Goals of aeration:**

• Aeration is used for biological wastewater treatment by the activated sludge method.

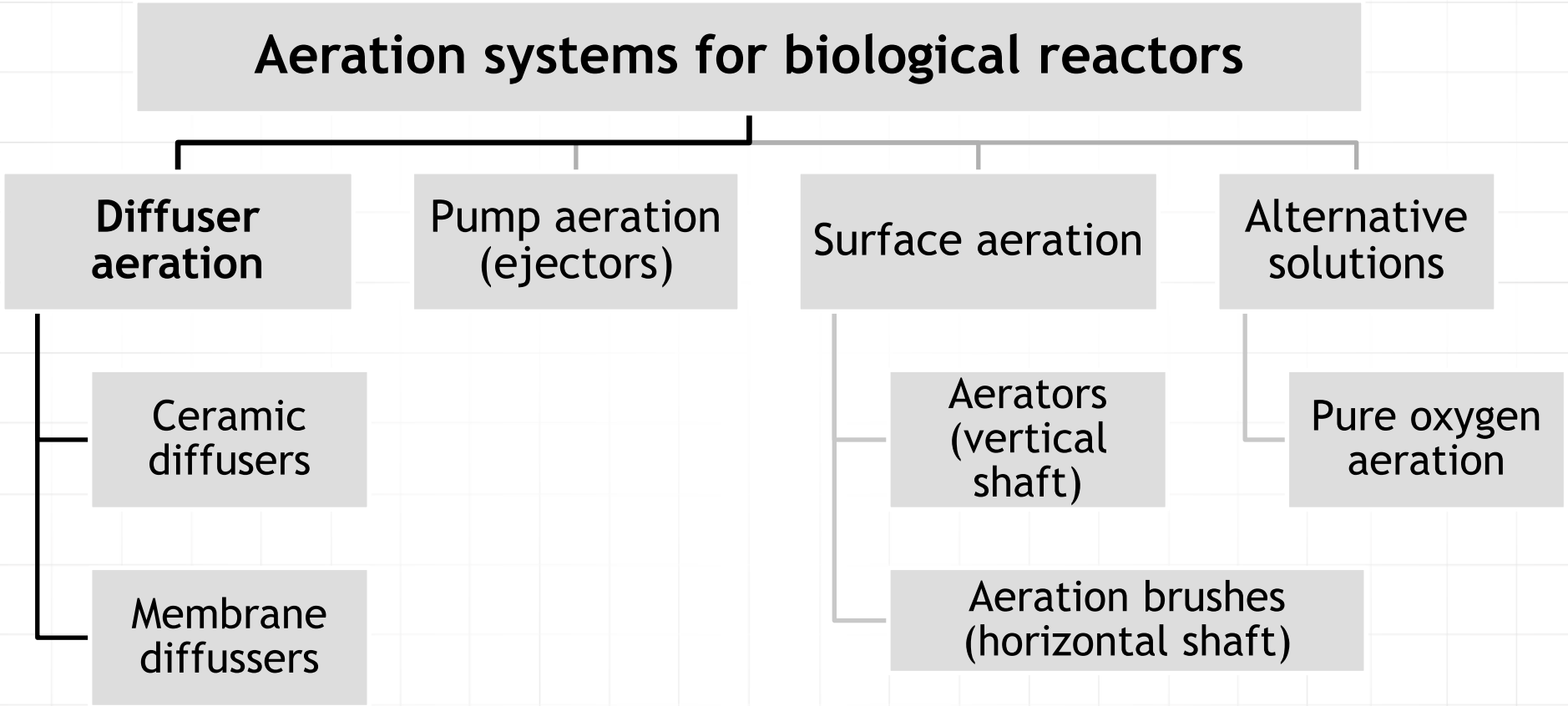
• Oxygen is a substrate for the bio-oxidation of organic pollutants.

• The aerobic activated sludge process aims to reduce the concentration of non-settling dissolved and colloidal organic compounds.

• Keeping the wastewater in constant motion prevents the activated sludge from settling at the bottom, where the lack of oxygen would cause it to die.

# Wastewater aeration

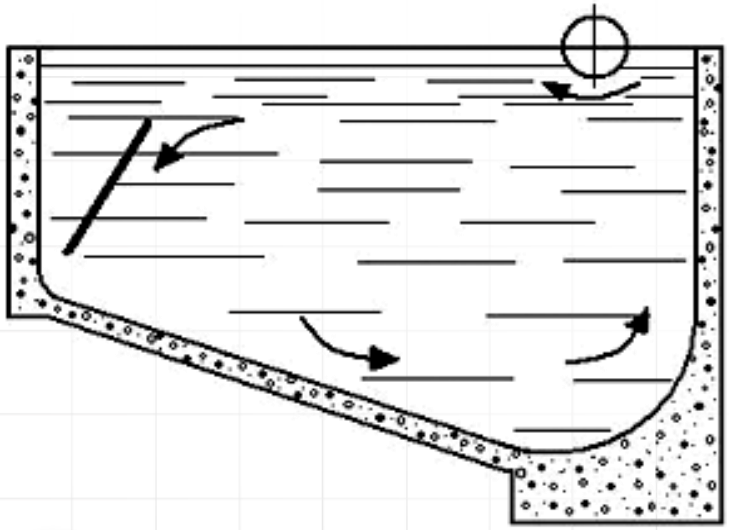
## Aeration systems



# Wastewater aeration

## Surface aeration

- Commonly used in the 1980s.
- Currently used less frequently.
- Low oxygen transfer efficiency (- - -).
- Low investment costs (+).
- No additional equipment in the aeration system (+).
- Ability to mix and aerate (+).



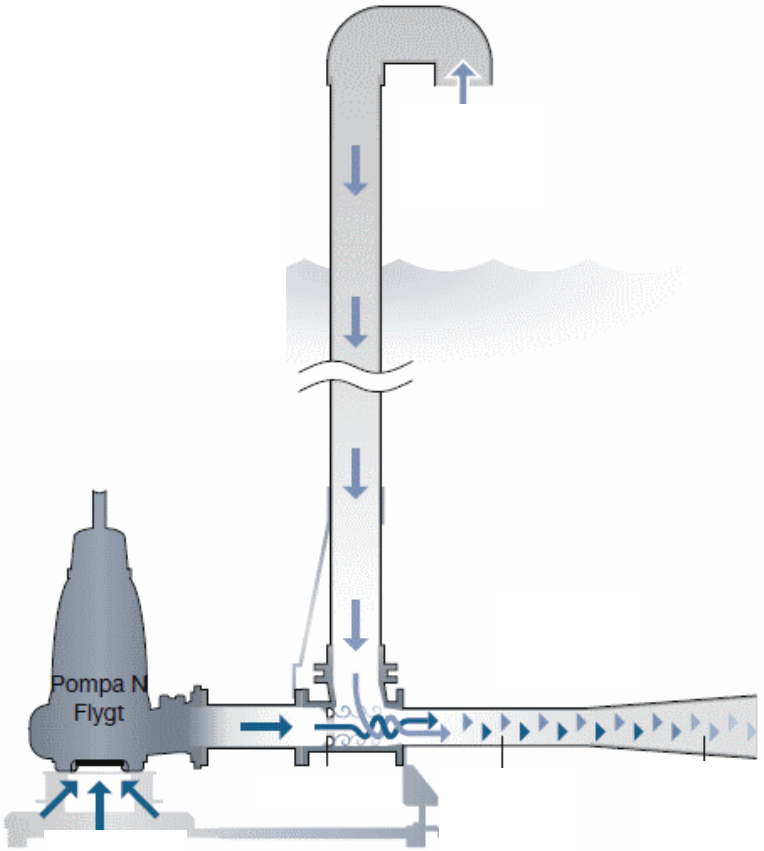
# Wastewater aeration

## Surface aeration

# Wastewater aeration

## Ejectors

- Commonly used in very small facilities.
- Alternatively used where a small amount of oxygen is needed to be introduced into the reactor (retention tanks).
- Low investment costs (+).
- No additional equipment in the aeration system (+).
- Ability to mix and aerate (+).
- Small amount of oxygen obtained with the operation of a single device (- - ).



# Wastewater aeration

## Ejectors

# Wastewater aeration

## Ejectors

# Wastewater aeration

## Diffuser aeration

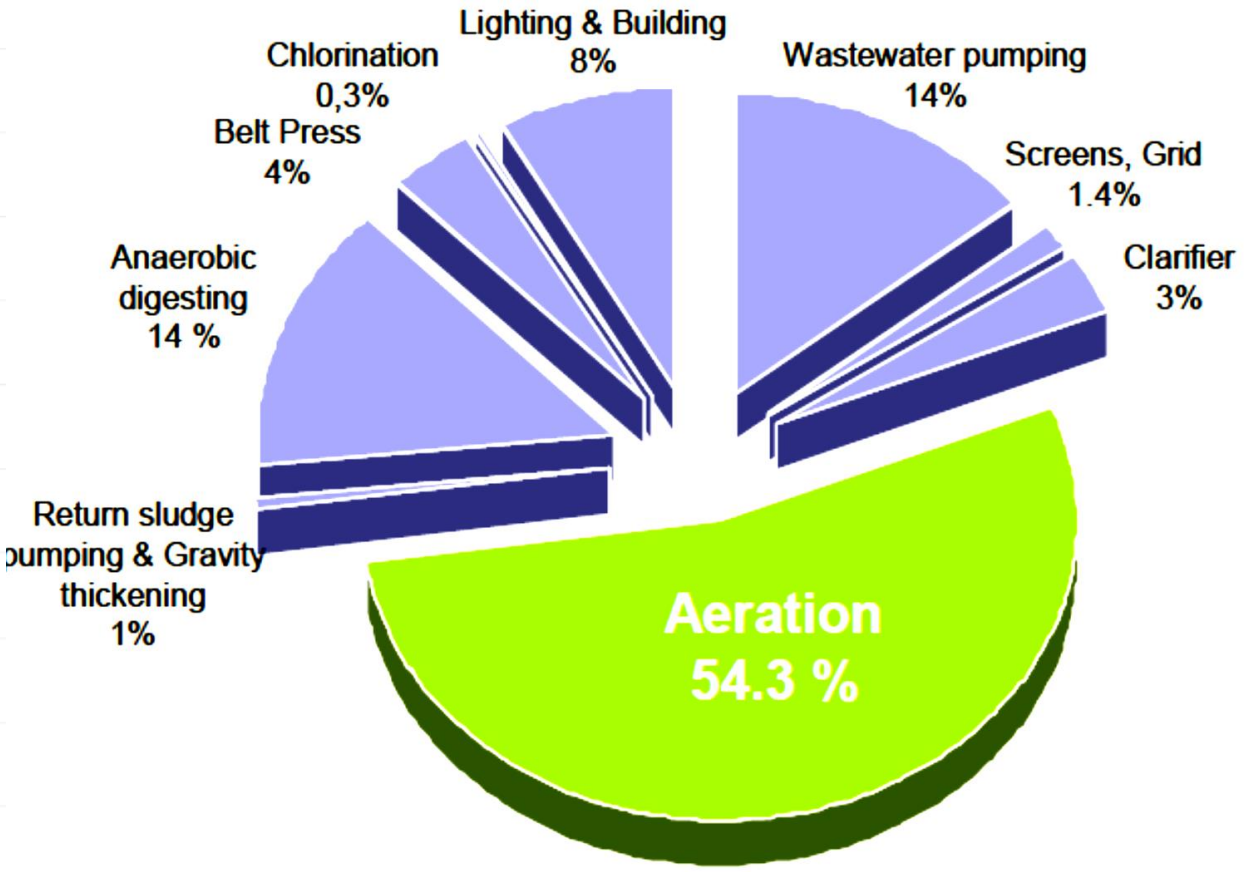
•Compressed air is supplied through porous plates (known as filters or diffusers).
•Aeration with air is carried out through coarse, medium, and **fine bubble diffusers.**
•To increase oxygen transfer to the wastewater, diffusers should be placed as deep as possible (as technology allows). This prolongs the contact between air bubbles and wastewater and increases oxygen saturation concentration at higher pressure.

# Wastewater aeration

## Diffuser aeration

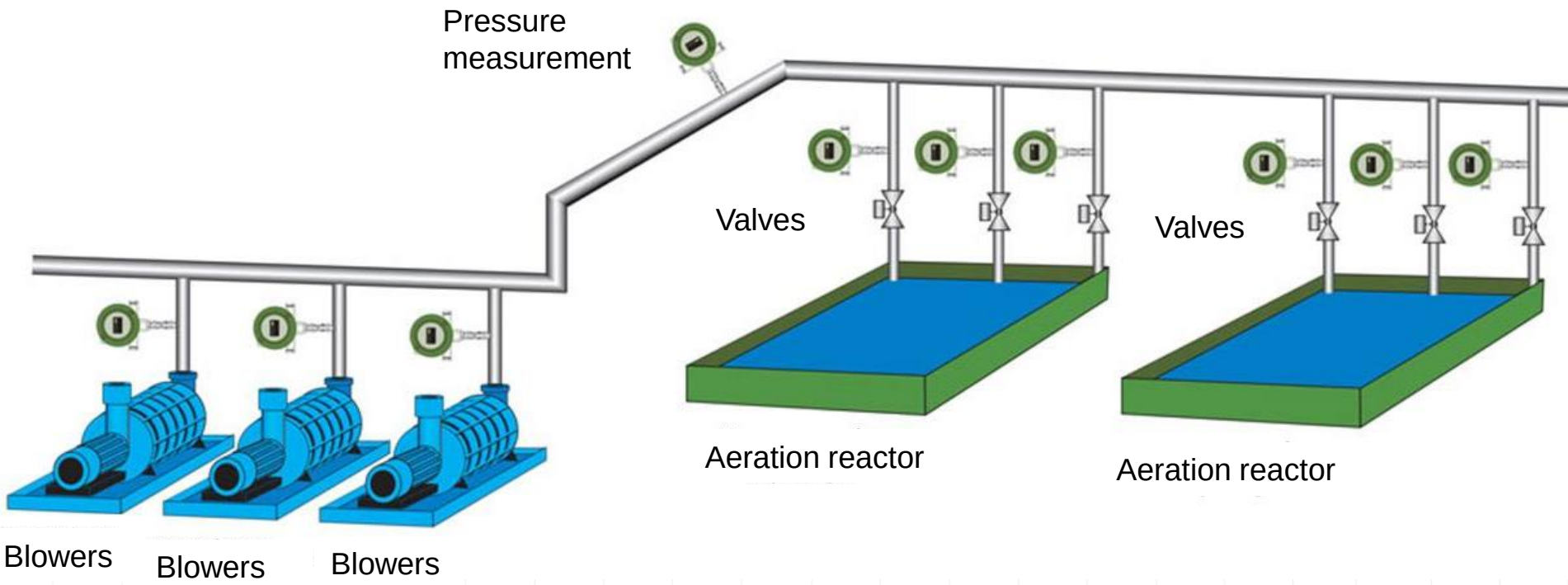
# Energy Consumption for Wastewater Aeration

## Diffuser aeration



# Wastewater aeration

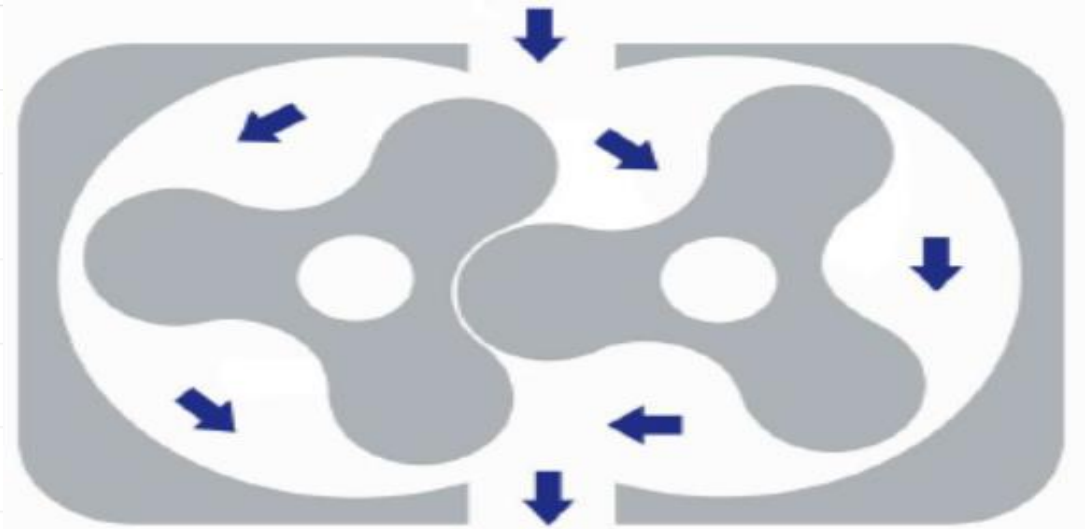
## Blower station

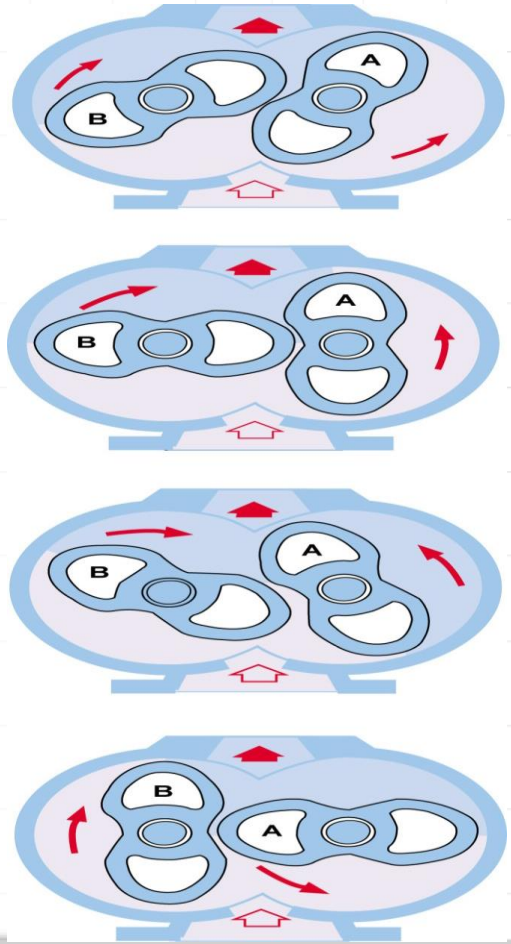


# Wastewater aeration

## Roots blowers

- Also known as displacement blowers.
- Small and medium wastewater treatment plants.
- Operating principle similar to piston pumps.





# Napowietrzanie ścieków

## Turbo blowers

•Also known as centrifugal or rotary blowers.
•Medium (the boundary is lowering) and large wastewater treatment plants.
•Operating principle similar to centrifugal pumps.

# Wastewater aeration

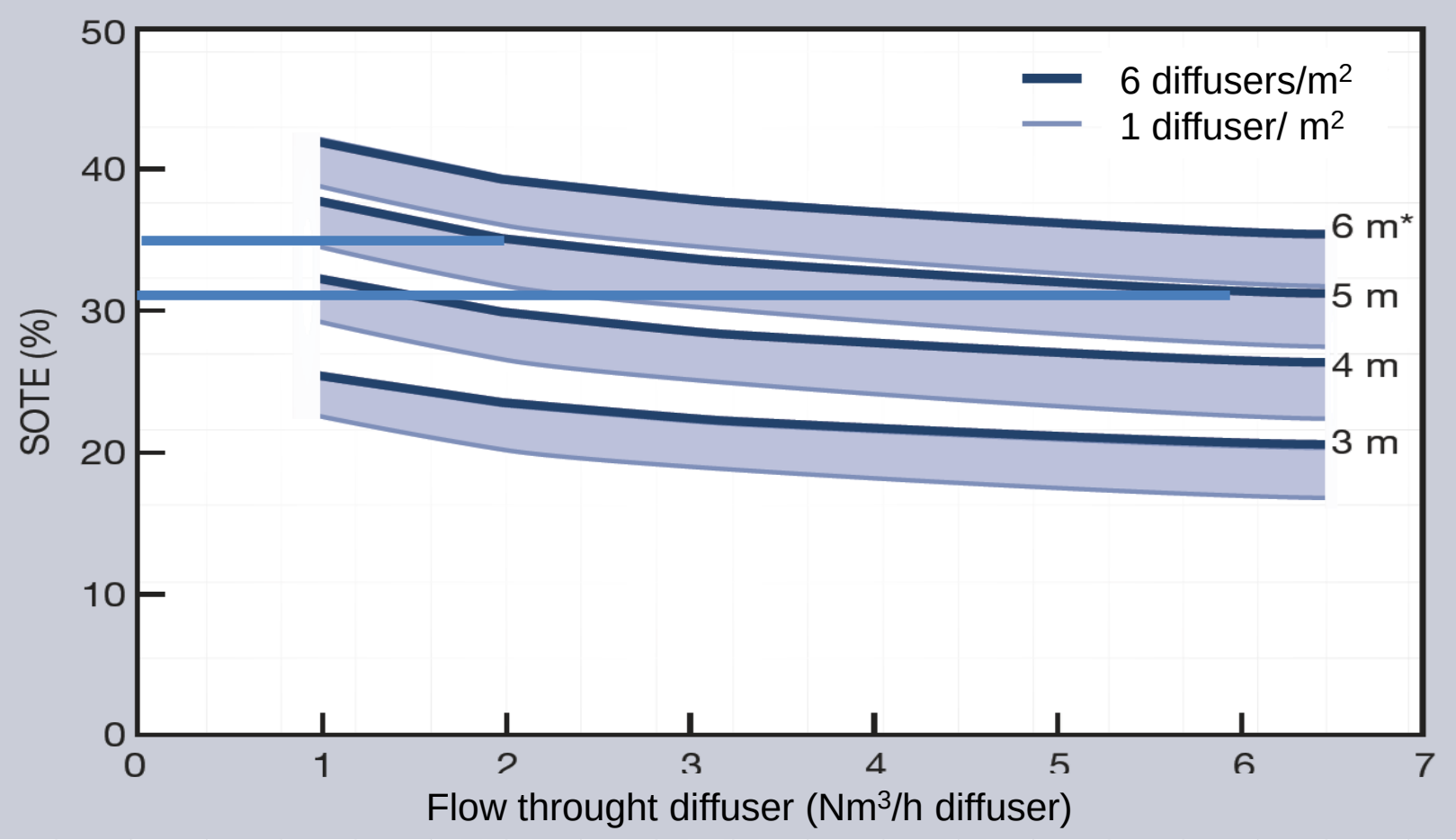
**Oxygen Content in Air?**

- 21%.
- Considering the density, approximately 299 g/m³.

**How well does oxygen dissolve in clean water?**

- Rather poorly.
- Realistically no more than 20% (very little) - 40% (extremely much).
- Approximately 60-120 g $O_2$/m³ of air.

# Wastewater aeration



# Wastewater aeration

- Approximately 60-120 g $O_2$/m³, on average 90 g $O_2$/m³.
- Average air demand for wastewater treatment plants (WWTP) is:
- Approximately 2,600 kg $O_2$/h.

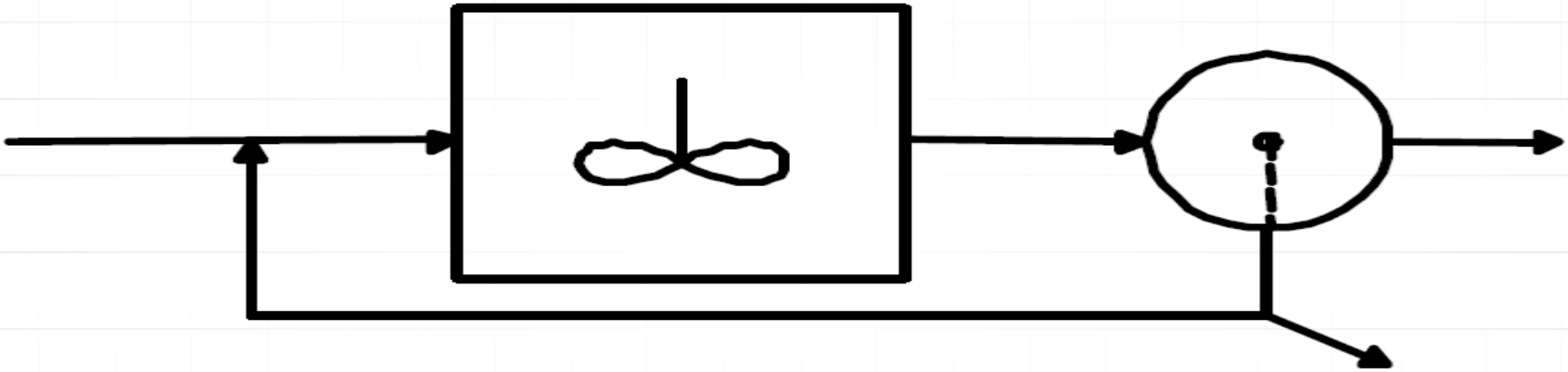
**How much air is that?**

- 28,900 m³/h, and this estimate is still underestimated.
- We use 1,000 kWh of electrical energy for this, which is as much as 4,600 households

# Activated sludge

## Dissolved oxygen concentration

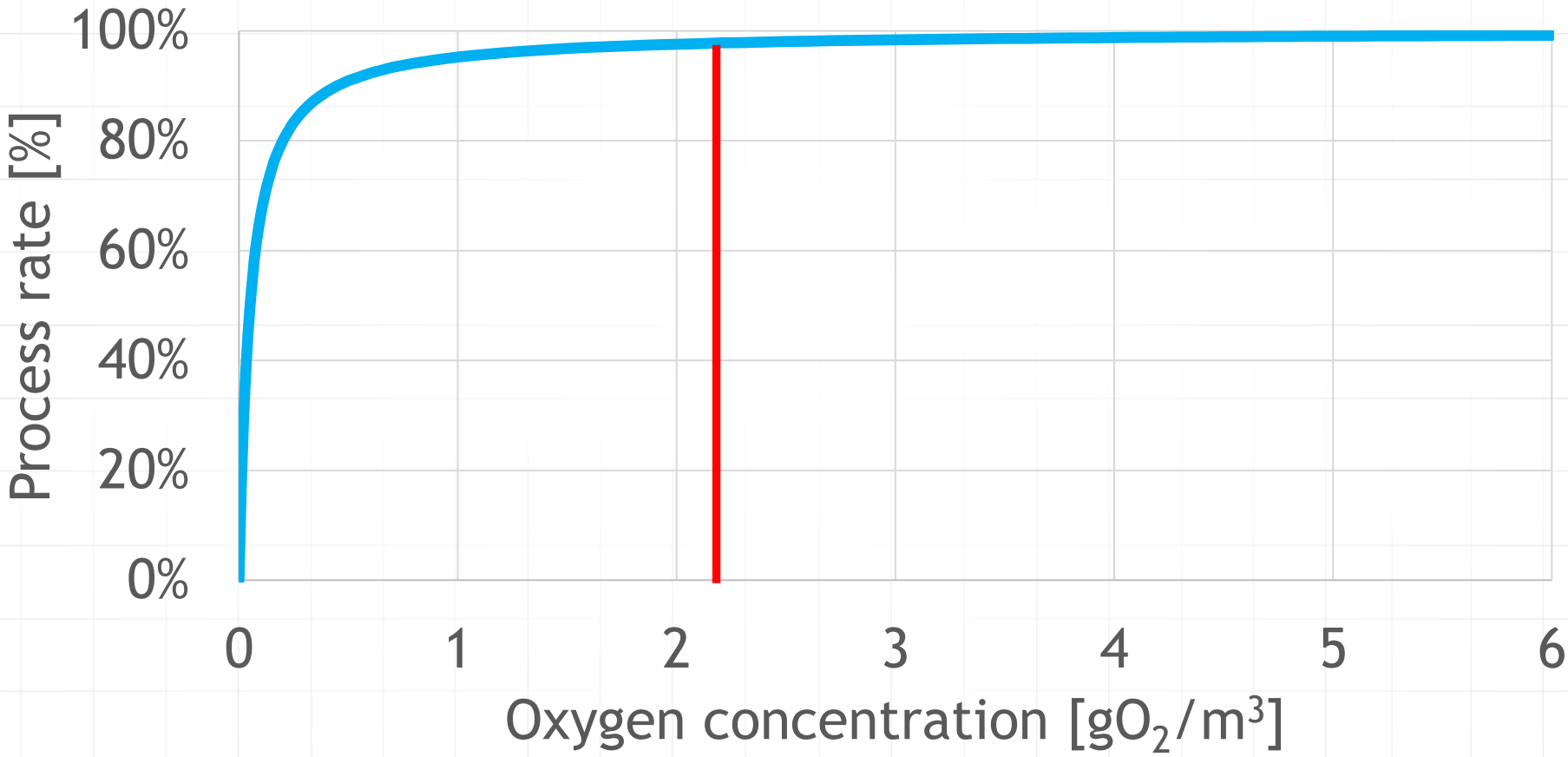
### Aerobic activated sludge



- Dissolved oxygen concentration: approximately 2 g $O_2/m^3$.
- What happens if it is less?
- What happens if it is more?

# Activated sludge

## Dissolved oxygen concentration



# Control algorithms for aeration

## Aeration algorithms

- Low oxygen concentration values.
- The need to maintain 1.5-2 g $O_2/m^3$ is a thing of the past.
- After optimization, it is possible to conduct wastewater treatment processes often below 0.3 g $O_2/m^3$.

+ High oxygen transfer rate
+ Potential to induce simultaneous denitrification

- Problems with blower control
- Problems with mixing

# Control algorithms for aeration

## Aeration algorithms

### Intermittent Aeration

Aeration of the reactor to the required level for a predetermined time, then turning off aeration and maintaining anoxic conditions.

+ Conducting the denit/nit process in the aeration tank.
+ Better control under low load conditions at the WWTP.

- Frequent blower starts.
- Absolute need to install mixers in the aeration tank.

# Control algorithms for aeration

## Aeration algorithms

**Hourly Variability of Oxygen Concentration**

Changing the set oxygen concentration during the day depending on the wastewater inflow and energy costs during the day (energy tariffs).

+ Potential possibility to optimize electricity consumption (tariffs).

- Problems with blower control.
- Problems with mixing in the aeration tank.

# Control algorithms for aeration

## Aeration algorithms

**Ammonium Nitrogen Concentration Control**

Algorithm designed to maintain a constant ammonium nitrogen concentration at the outlet of the aeration tank.

+ Direct control of treated wastewater parameters.
+ Automatic detection of low and high loads in the wastewater.

- The need to have an ammonium nitrogen probe.

# Aeration system testing

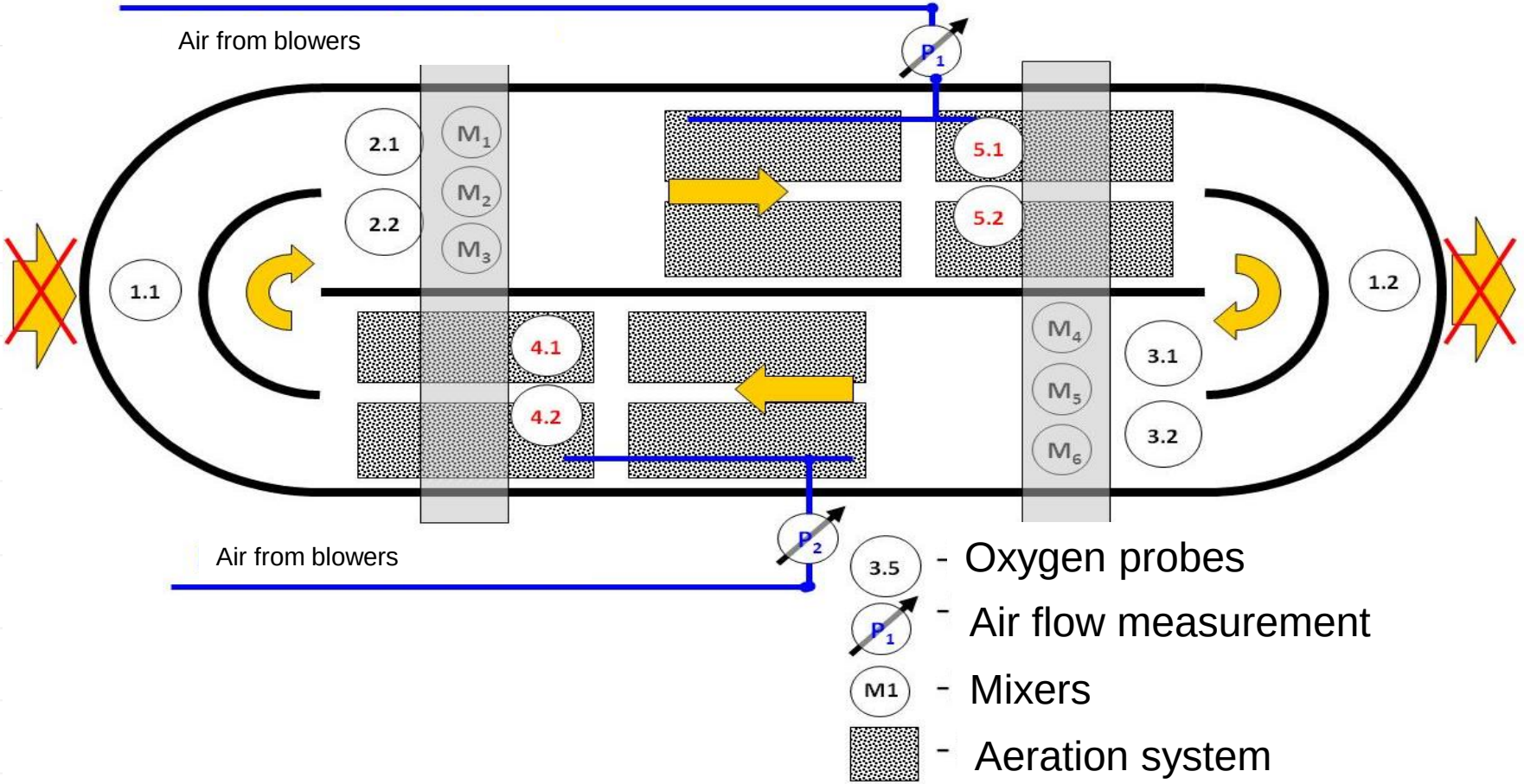
Oxygen transfer to reactor

**Methods for Determining Oxygen Transfer to Water/Wastewater**

- Absorption Method
- ~~Desorption Method~~
- Off-Gas Method

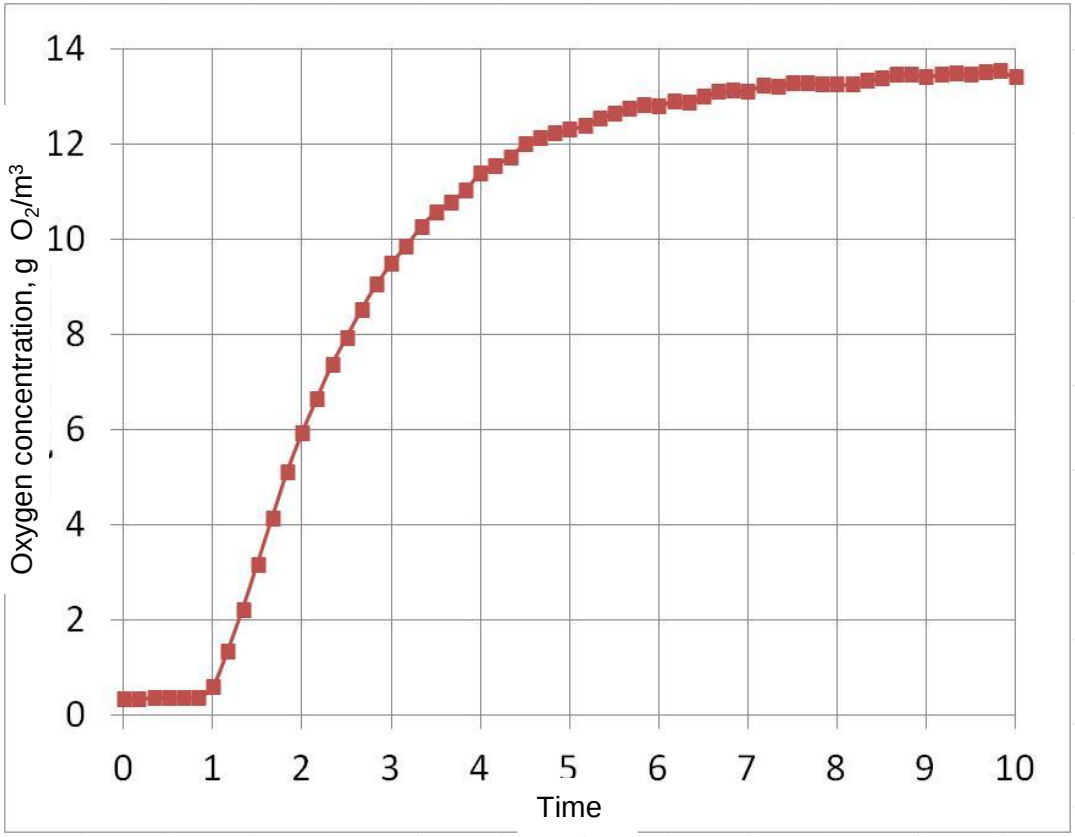
# Aeration system testing

## Absorption method



# Aeration system testing

## Absorption method



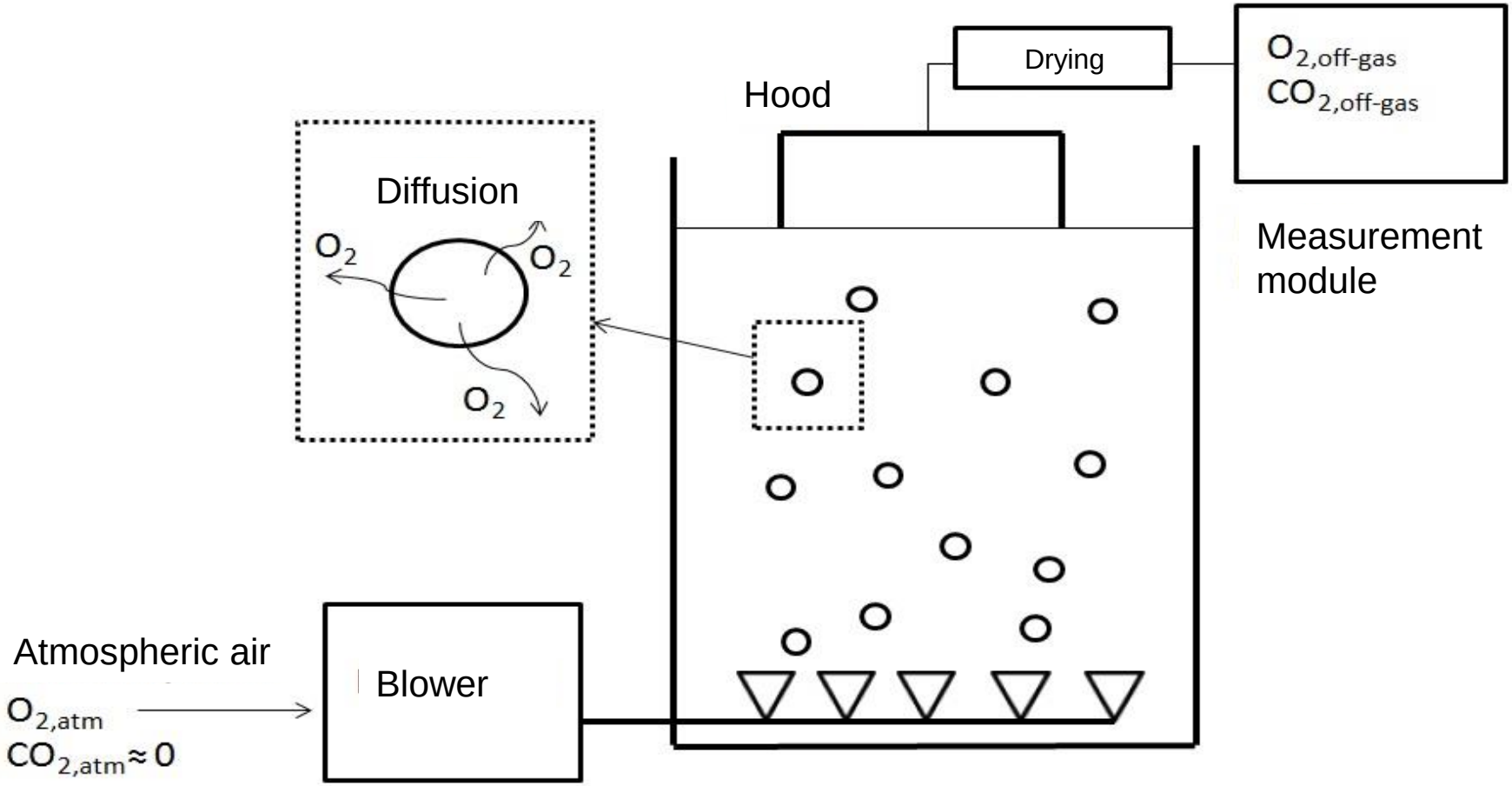
# Aeration system testing

## Absorption method

- Practically, it is necessary to stop the wastewater inflow during measurements.
- The possibility of determining the maximum efficiency of the aeration system.
- Allows determining the guaranteed parameters of the aeration system.

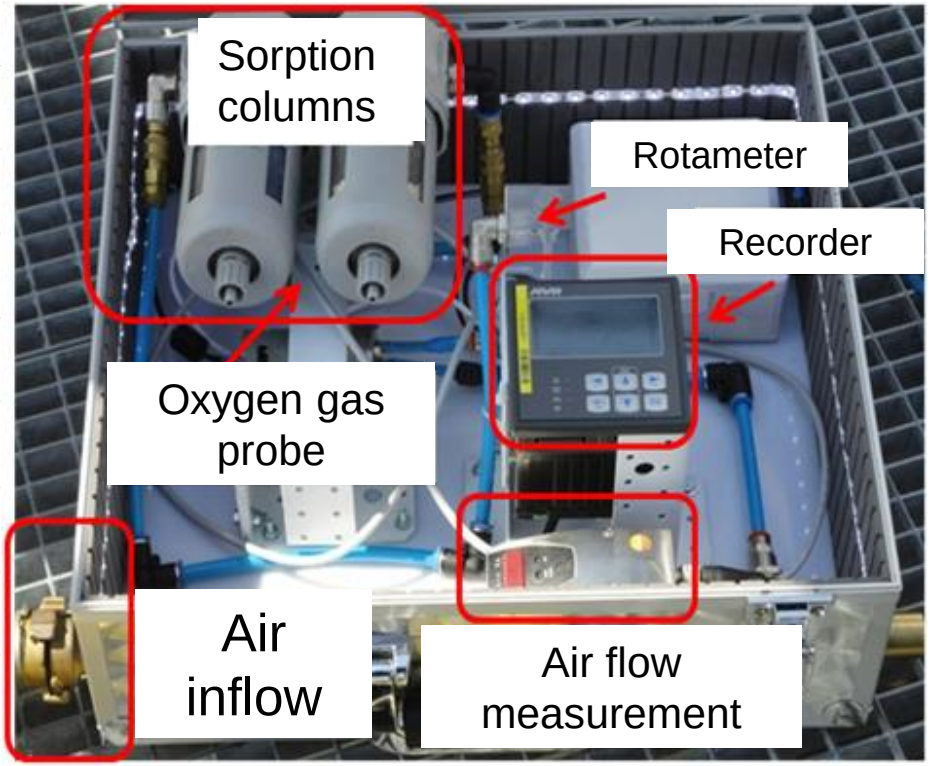
# Aeration system testing

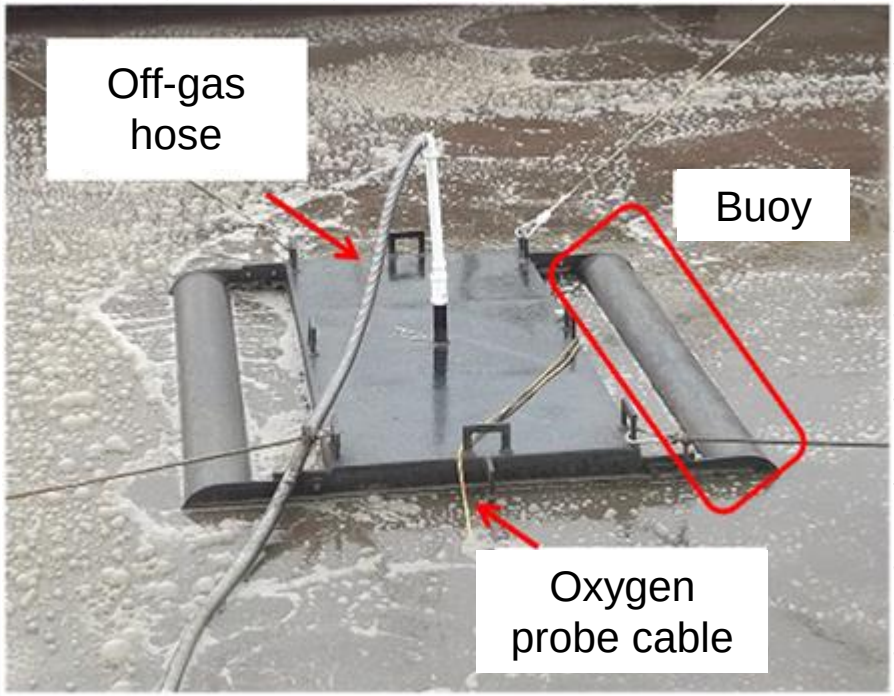
## Off-gas method



# Aeration system testing

## Off-gas method



# Aeration system testing

## Off-gas method

- The method allows for measurements under operational conditions.
- Point diagnosis of oxygen utilization.
- Determining the temporal variability of oxygen utilization and determining the dynamics of diffuser fouling.

# Aeration system testing

## Possibilities of Applying Research Methods

| | Absorption | Off-gas |
|---|---|---|
| Measurements during normal operation | No | Yes |
| Technological measurements | Yes/no | Yes |
| Diffuser fouling | Yes | Yes |
| Guarantee Measurements | Yes | No |

**Description of the methods included in ATV M209**

Measurements of the oxygenation capacity of aeration devices in activated sludge installations.