

# Change in dissolved oxygen concentrations during aeration and mixing using a combined system

V Singrova<sup>1</sup> and P Hlustik<sup>1</sup>

Institute of municipal water management, Brno University of Technology, Faculty of Civil Engineering, Žižkova 17, 602 00 Brno, Czech Republic

**Abstract.** Combined mixing and aeration systems are not given priority in the Czech Republic. Still, they are installed at several WWTPs. Their advantage is mixing and aerating at the same time. This article provides data from actual measurements where a combined system was used for drinking water including necessary chemicals. The text below evaluates the course of changes in the concentration of dissolved oxygen in different points in the reactor depending on time.

## 1. Introduction

Wastewater aeration is one of the basic processes of biological aerobic treatment. At wastewater treatment plants, this is very important for the proper progress of treatment and it also entails the highest electricity demand at the WWTP. This process has a hydrodynamic and oxygenating effect.

In most wastewater treatment plants, blowers and diffuser are used to aerate the activation reactors. The combined mixing and aeration systems are generally used to a lesser extent, which results in less knowledge and operating experience. In addition, these systems are fundamentally different from conventional fine-bubble diffusers.

The research measurement the data of which is presented in this article, were made according to ČSN EN 12 255-15 Wastewater treatment plants - Part 15: Measurement of standard oxygenation capacity in the activation reactor. Some findings and information related to the measurement are also specified in the TNV 75 66 11 standard - Determination of the oxygenation capacity of aeration systems which has been valid since 1997 and has become obsolete.

The combined Triton 3HP system was used for the measurement- this system can mix the reactor content or even mix and aerate it at the same time. This article only contains an evaluation of the decrease and increase in oxygen in clean water.

## 2. Description of the real measurement

This chapter briefly describes the basic information about the combined system, the environment in which the measurement took place and the progress of the tests themselves.

### 2.1. Reason for the measurement

Wastewater treatment plant operators who use these systems tend to discover certain advantages and differences compared to other aeration systems. It is therefore necessary to apply an individual approach to the system design and its location in the reactor and better characterize the system in order to make full use of its potential. These are the reasons why the actual measurements took place.

### 2.2. System description



Conventionally used fine-bubble aeration systems use diffusers fitted to the reactor bottom and air bubbles travel from the bottom up to the surface. The combined systems often differ from these systems in terms of shape, immersion depth, direction of bubble flow and location in the reactor, etc. This can affect oxygen transfer [4].

A combined Triton 3HP system was used for aeration and mixing. This system can ensure separate mixing or combine mixing and aeration. This system is fitted with a motor and a small blower located above the surface. A hollow shaft guiding the air is slightly submerged and directed towards the bottom. This can be seen in figure 1 and figure 2. Thus, the bubble flow is discharged downwards at a certain angle and only then the bubbles rise towards the surface. Longer air bubbles retention in the wastewater and different trajectories are related to increased oxygen transfer to the reactor [3].



**Figure 1.** Triton combined system.



**Figure 2.** Propeller detail.

### *2.3. Preparatory work*

First, it was necessary to find a suitable reactor that is large enough and with walls that can withstand water pressure and flow rates. Finally, a storage tank at a wastewater treatment plant was chosen. It had to be properly cleaned and painted using a suitable paint. Furthermore, access to the tank from all sides was addressed, including the possibility of access above the centre of the tank, which was resolved by two additional footbridges. One of the footbridges was brought on site and installed using a crane, the other required a scaffolding inside the tank and construction of the footbridge on site.

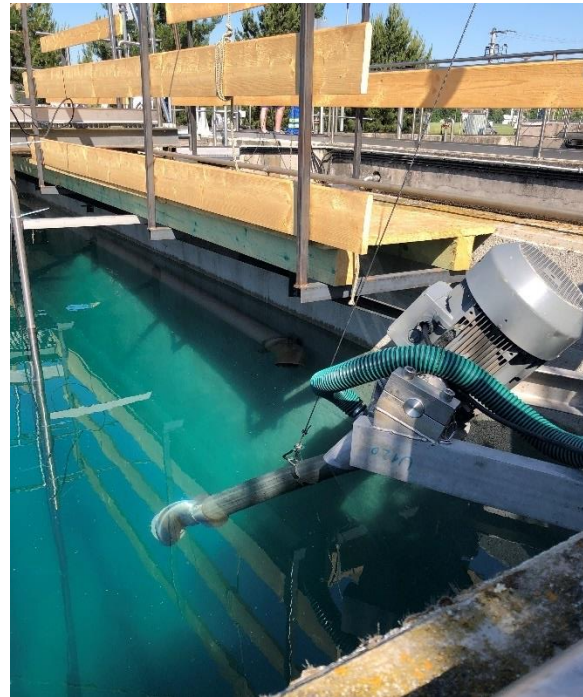
Due to legal water quality requirements, the tank was filled with drinking water. The problem was a large amount of water needed in the summer months and at the same time insufficient flow rate as there was no hydrant nearby. When filling the tank, a water meter was installed to determine the exact volume of water in the tank. Due to the water quality, the conductivity had to be checked after each measurement, the limiting value of which is specified by the above mentioned standard. The water tank can be seen in figure 4.

Another point was to obtain more probes. Companies usually do not rent out probes and their purchase would be too expensive. Finally, in cooperation with several companies, the probes were obtained and connected. The probes were connected to a datalogger with one-minute-interval records, which was sufficient. The method of mounting the probes and their fixed location at a certain point and at a specific depth was also addressed. For this purpose, steel bars were placed in the tank. The empty tank with probes can be seen in figure 3.

The possibility of using nitrogen to remove oxygen from the water was considered. Finally, sodium sulphite and cobalt chloride were used as catalysts. These chemicals were handled according to safety instructions. The weighed quantity was mixed in barrels with water and then poured into a mixed tank.



**Figure 3.** Tank with footbridges and the fixed probes.



**Figure 4.** Combined system in a filled tank.

#### *2.4. Description of the environment*

The measurement took place in outdoor conditions and with real dimensions. During the measurement, a rectangular concrete tank with floor plan dimensions of 4.2 m and 8.7 m and a depth of 6.6 m was used. The combined system described above was installed in one of its corners. Furthermore, optical probes measuring dissolved oxygen concentrations were placed in the tank at various points and depths. The tank was properly cleaned and filled with drinking water with a total volume of 237 m<sup>3</sup>. During the research, a number of other parameters related to the surrounding environment were also recorded according to the standard. These are listed in the tables below.

The location of the dissolved oxygen probes was selected at random but in accordance with the standard. According to the standard, the probes should be in a minimum distance of 0.5 m from the walls and at the same time they should be outside the directly aerated zone [1]. Probe 1 was placed at a depth of 3 m below the water surface, probe 2 at a depth of 2 m, probes 3 and 5 at a depth of 4 m and probe 5 at a depth of 5 m.

#### *2.5. Course of the measurement*

The measurement was performed in accordance with the standards mentioned in the introduction above. In each experiment, oxygen was artificially removed from the water by dosing a calculated volume of sodium sulphite. Cobalt chloride catalyst was used to accelerate this reaction. When the dissolved oxygen concentration was decreasing, the above equipment was used to ensure mixing. When the oxygen dropped to zero, aeration was also switched on (the combined system therefore mixed and aerated at the same time).

The measurement was completed several hours later when the dissolved oxygen saturation concentration for the corresponding temperature was reached.



### 3. Measurement evaluation

The measurement took place twice in total, in two different days during June this year. The altitude of the site is 174 m above sea level. The following tables (table 1 and table 2) show parameter values which were also recorded during the measurement.

**Table 1.** Values of other parameters for the first measurement.

1st measurement	Water temperature [°C]	Water conductivity [ $\mu\text{S}/\text{cm}$ ]	Air humidity [%]	Air pressure [hPa]	Air temperature [°C]
Before measurement	20.5	1596	77	991	22.6
After measurement	20.8	1715	63	992	27.1

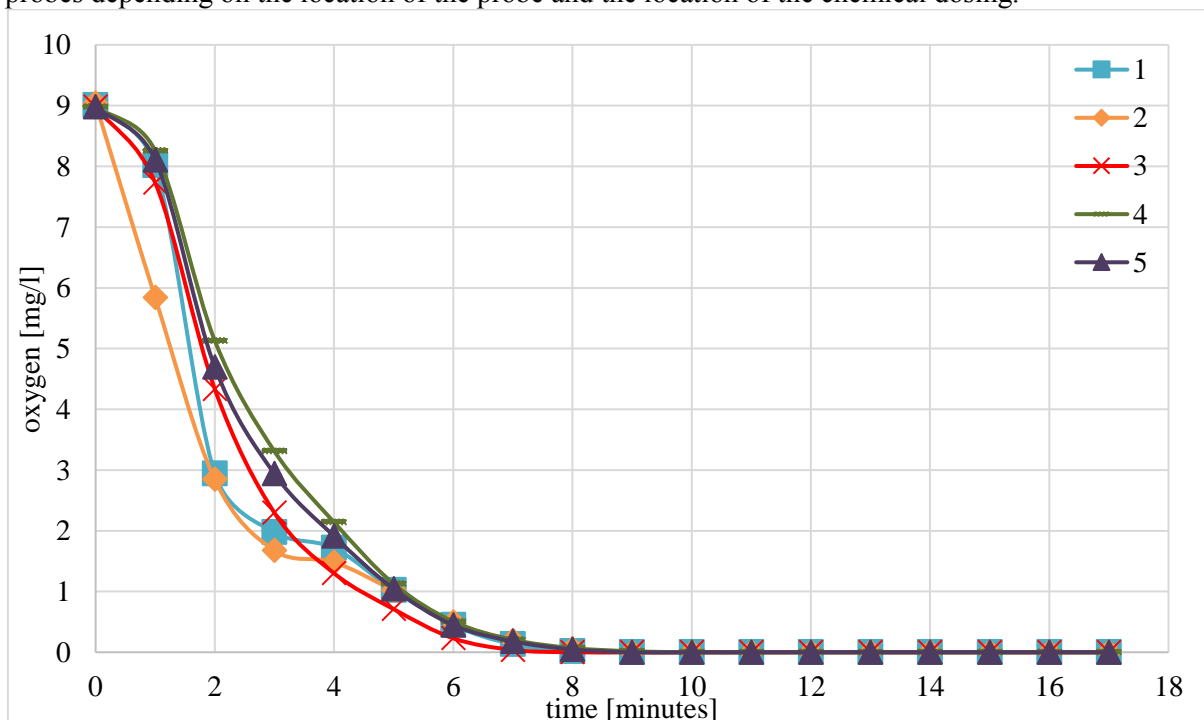
**Table 2.** Values of other parameters for the second measurement.

2nd measurement	Water temperature [°C]	Water conductivity [ $\mu\text{S}/\text{cm}$ ]	Air humidity [%]	Air pressure [hPa]	Air temperature [°C]
Before measurement	20.8	1715	69	992	25.3
After measurement	21.3	1836	64	989	29.0

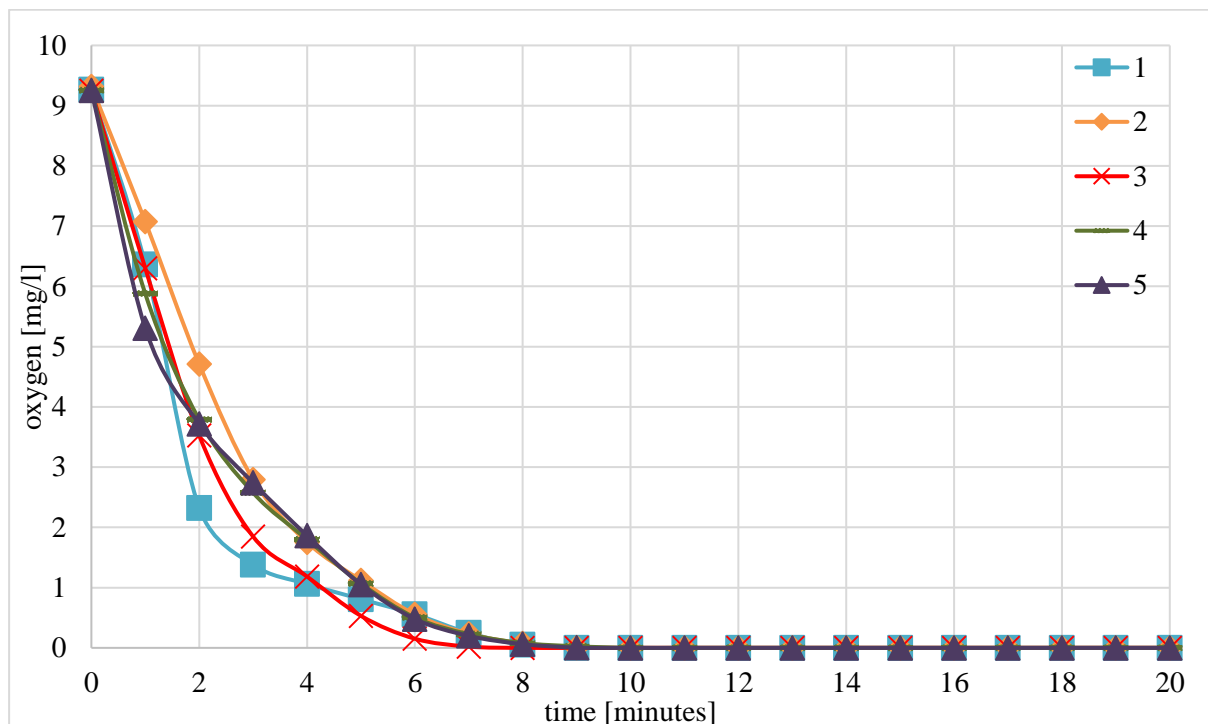
In addition to these parameters, electricity demand, air flow and spot speed were measured at various locations and depths of the tank.

#### 3.1. Decrease in oxygen over time

The graphs (figure 5 and figure 6) show a decrease in oxygen level as measured by five probes over fifteen minutes. After ca. 8-12 minutes, after adding sodium sulphite, zero values were recorded by the probes depending on the location of the probe and the location of the chemical dosing.



**Figure 5.** Decrease in dissolved oxygen concentration during the first measurement.

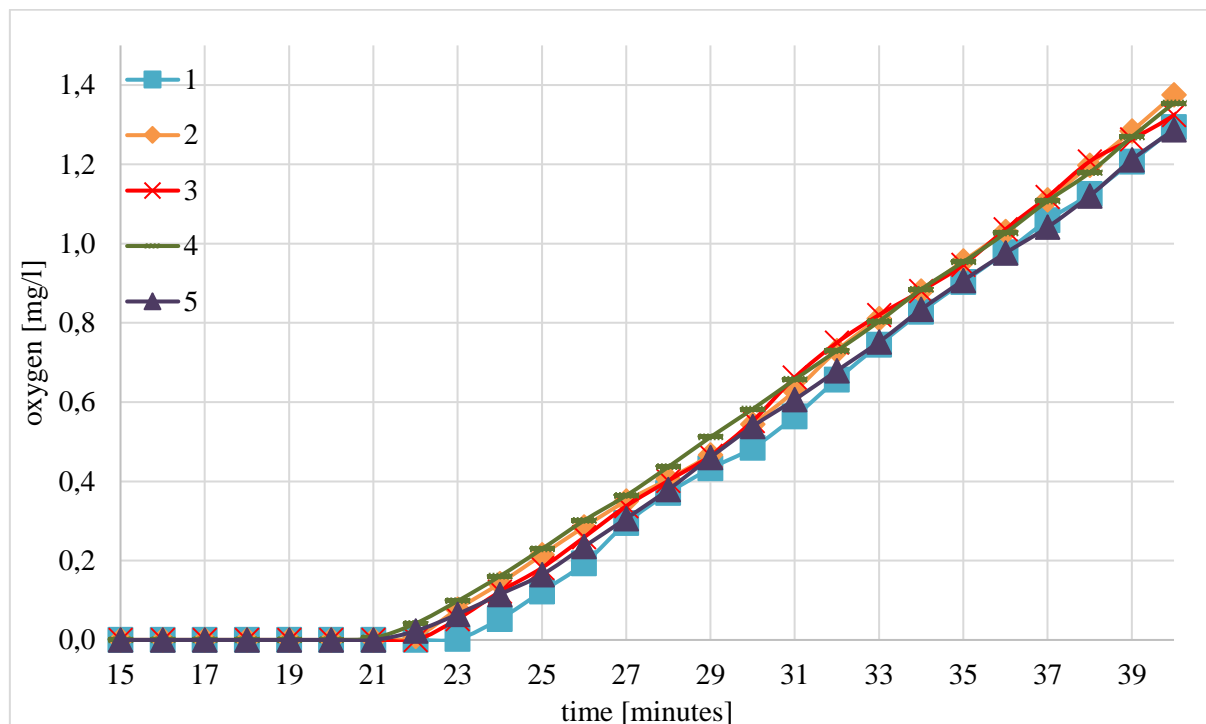


**Figure 6.** Decrease in dissolved oxygen concentration during the second measurement.

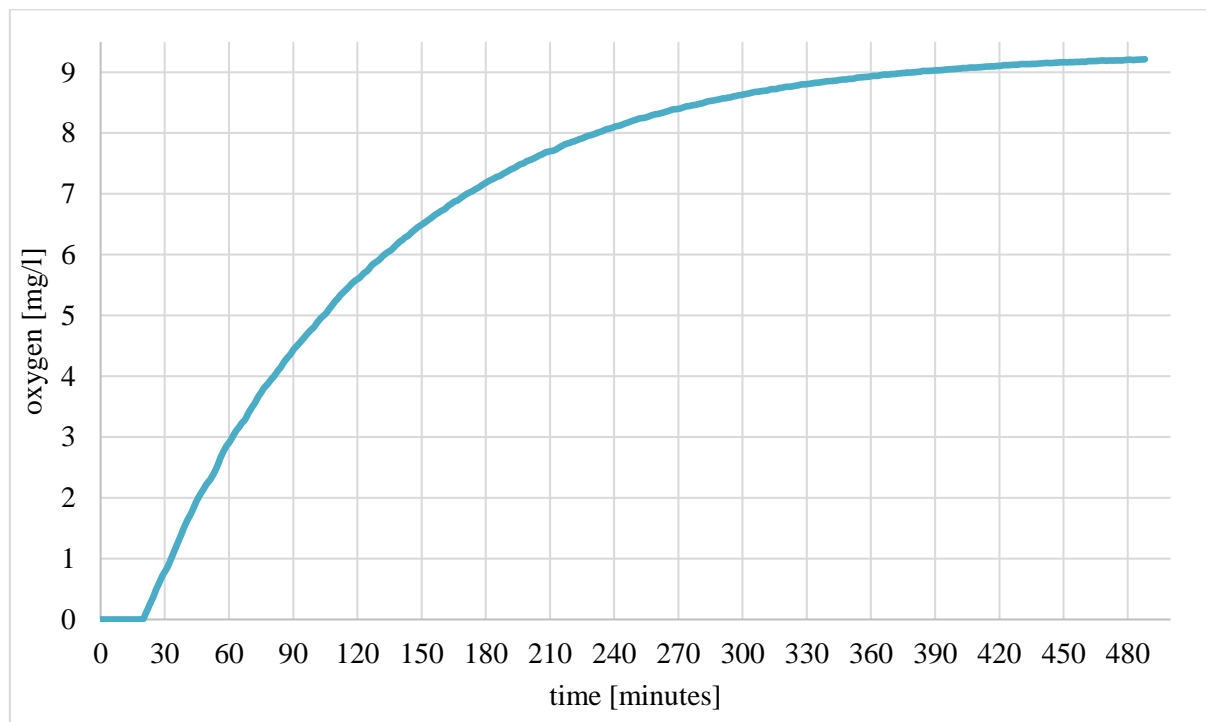
### 3.2. Increase in oxygen over time

After reaching zero values at the probes measuring dissolved oxygen, the aeration system was activated. The combined system therefore mixed and aerated at the same time. The initial zero value persists for some time due to the surplus of chemicals in the water. The measurement was always conducted until the saturation concentration was reached because the values of dissolved oxygen concentrations did not stabilize. The saturation value for this temperature (listed in table 1 and table 2) is around 9 mg/l [2], which was achieved after ca. seven hours of aerating. Water temperature greatly affects the transfer of oxygen and this also affects the determination of coefficients that are important in determining oxygenation capacity [5].

Both graphs (figure 7 and figure 8) show an increase in dissolved oxygen. The graph is steeper at the beginning of the aeration and then it becomes more gradual. For the sake of clarity, the graph showing the first measurement (figure 7) is completed in the fortieth minute of aeration and contains records from all five probes. The graph from the second measurement (figure 8) shows the entire course of the measurement and, for the sake of clarity, it only contains values from probe no. 1.



**Figure 7.** Increase in dissolved oxygen concentration during the first measurement for the five probes.



**Figure 8.** Increase in dissolved oxygen concentration for probe 1 during the second measurement.

#### 4. Conclusions

Over 2,100 values of dissolved oxygen concentrations are recorded from one measurement. The measurement was taking place until the oxygen level increased to the saturation concentration value for the given temperature, which took about 7 hours. An important finding was the fact that the system can increase the concentration of dissolved oxygen above 9 mg/l, although over a longer period of time.

The aim of the article is to determine the rate of oxygen transfer in pure water during aeration and mixing by a combined system. The value of 2 mg/ l was reached in both measurements approximately 30 minutes after the start of the dissolved oxygen increasing. This value is crucial for the treatment processes, as it is usually the maximum at which the activation reactors are aerated. However, it should be added that this value would be reached in a different time interval in waste activated sludge.

The measurement results will be further processed in order to determine the oxygenation capacity of the combined system and its more detailed characteristics.

#### Acknowledgements

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#### References

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