

## Case Study

### **Activated Sludge Bioaugmentation with Bioclean™ at the Biological Wastewater Treatment Plant Treating the Wastewater of a Paper Mill and a City**

$Q=100,000-110,000 \text{ m}^3/\text{day}$



**Author:** Malatech Water, Ltd.

**The Wastewater Treatment Plant** receives both municipal and industrial sewage, a combined flow of 100,000-110,000 m<sup>3</sup>/day. Municipal wastewater, providing only 20% of the influent is originated mainly from a nearby town, while the industrial fraction is the pretreated liquid waste from pulp and paper mill.

**The goal of bioaugmentation was multiple:**

**1. Improving the stability of the treatment plant**

- stabilization of effluent COD and BOD parameters
- improving activated sludge characteristics, SVI
- improving resistance to shock loadings, inhibitory and toxic effects

**2. Reduction economical costs**

- decreasing excess sludge production
- reducing energy consumption
- odor control – reduction of malodor originated from aeration basins

A continuous dosing of the product **Bioclean TM** has been used to alter the bacterial composition of the activated sludge to allow us the desired changes in the operation of the WWTP. These changes included the regulation of excess sludge removal rate, altering DO-values in aeration basins and the modification of nutrient dosing.

The bioaugmentation process started on *24th September 2012*.

**Application used:**

Reduction of excess sludge production

A **large portion of the operational costs** at a wastewater treatment plant is associated with **sludge handling**. Polyelectrolyte used for sludge dewatering and shipping and disposal of the dewatered sludge are factors that make the operator interested in **reducing the quantity** of the sludge produced. The use of **our biotechnological products** makes it possible through complex, sophisticated mechanisms to **significantly reduce excess sludge production**. The activated sludge is inoculated with bacteria strains, which have a lower yield, compared to the originally occurring bacteria in the activated sludge. The composition of the activated

sludge is normally determined by the fact, that whichever species are capable of the largest growth under the given circumstances will outgrow the less competitive bacteria. This means that an activated sludge formed without external aids will always have the largest sludge production. The presence of **bacteria**, which have a lower yield but have several **beneficial properties** can be ensured **by continuous dosage**, therefore we provide an efficient substrate-competitor for the original species of the activated sludge. The bacteria in our products have a **high organic matter breakdown rate and a low yield**, therefore the consumed substrate will be converted to more carbon-dioxide and less new cellular matter, and less substrate will be available for the growth of the original bacteria. Thus the **production of excess sludge is reduced**. The improvement of the floc structure makes it possible to operate at **higher MLSS concentrations**, and to reach higher sludge age. Increased SRT leads to a more extensive **hydrolysis of particulate organic matter and decaying cellular matter** further decreasing the quantity of sludge produced. Certain strains in our products are responsible for the increased production of exocellular enzymes enhancing the hydrolytic processes. The overall attainable **reduction of sludge production is a result of several complex and interconnected processes**, and depending on the technology and loading of the particular WWTP it can reach **8-60%**.

#### Reduction of energy consumption

The consumption of electric energy is another **significant cost component** of operation. A major part of the energy is used by the machinery responsible for **aeration** (blowers, surface aerators). If the automatic **control** of the aeration machinery is possible based on the dissolved oxygen levels measured in the aerobic reactors, **bioaugmentation treatment provides a way to moderate their energy consumption**. Just like in the case of sludge production the reduction of oxygen requirement is accomplished via the **combined effect of several factors**. Due to the **increased biodegradation rate** the **oxygen requirement is much faster decreased** towards the end of the reactor. DO probes are usually located at the end of the reactors, where it will be possible to reach the set level with a smaller airflow, therefore the control system is able to intervene and **lower the frequency**. As mentioned before the **bacteria strains used in our bioaugmentation process are**

**able to take up the necessary amount of oxygen even at lower dissolved oxygen concentrations because diffusion through the cell membrane is easier.** This allows the bacteria to speed up their metabolic processes at the influent end of the reactors where high substrate concentrations and low DO concentrations are typical, and **DO levels can be set lower**, too. The attainable reduction of energy consumption is largely dependent on the design and trouble-free operation of the control system.

## Results

### Reduction of excess sludge production and optimizing SVI

It is one of the main goal to reduce sludge production with the application of Bioclean TM. A comparison of excess sludge production is made for this bioaugmentation process period, between „Before treatment” (01.01.2011-23.09.2012) and „During treatment” (24.09.2012-31.07.2014). For this period can be regarded representative of the safely attainable sludge reduction, especially taking into consideration the removed COD. A comparison of results and average values is provided below.

The results show clearly that the sludge production is lower throughout the whole period of the treatment than in the preceding years. It can be achieved **a decrease of 416 kg/day in the average value of excess sludge dry weight**. Rate of decrease is even more and more representative considering that COD removal significantly improved due to the treatment (3485 kg/day higher value for COD removal during the treatment with Bioclean TM compared to the period before treatment).

By calculating the most representative value, the specific excess sludge production (in kg dry weight / kg COD removal) the results show **a decrease from 0.274 to 0.242 kg dry weight / kg COD removal in average (etc. 12% reduction in average)**, which is important to reduce the economical costs, as well as environmental fees.

The results also show, that **the SVI (Sludge Volume Index) value is lower**, it has been decreased to a value of 150 ml/g, and stabilized there, which was fluctuating in a bigger range and at higher levels before the treatment. Due to the better sludge structure, the better settling also helps the operator to prevent sludge washouts, and lower the effluent COD, BOD, TSS values.

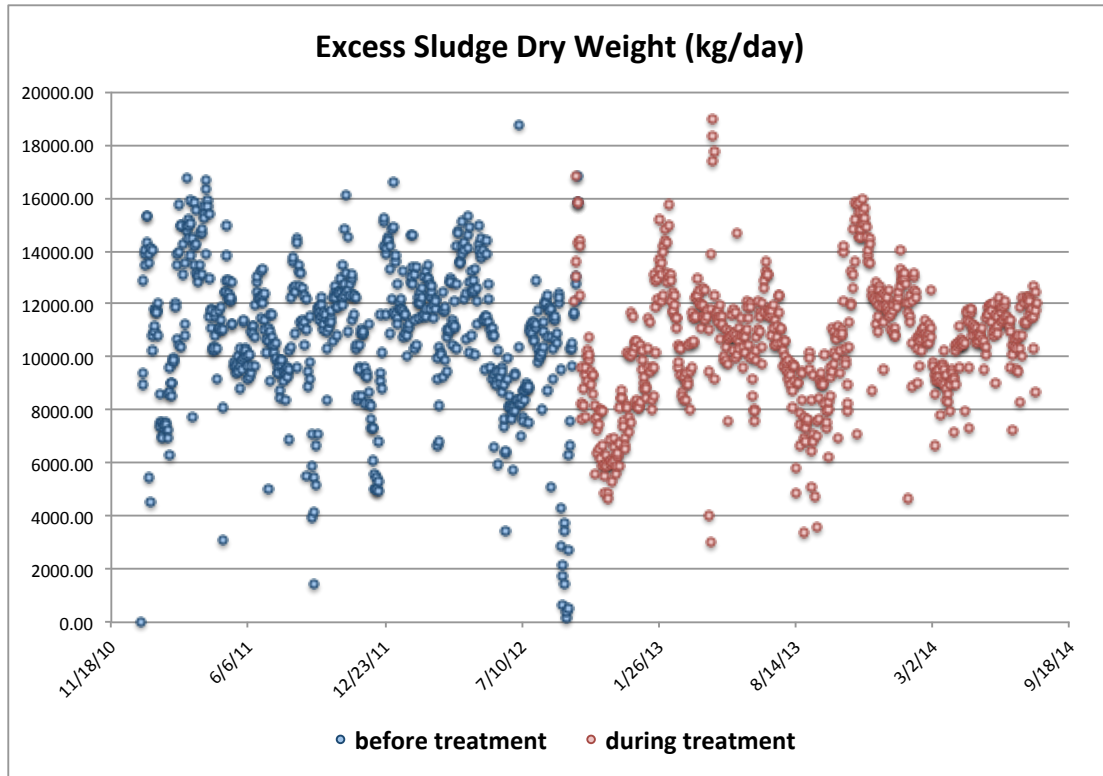


Figure 1 – Excess sludge dry weight in kilograms

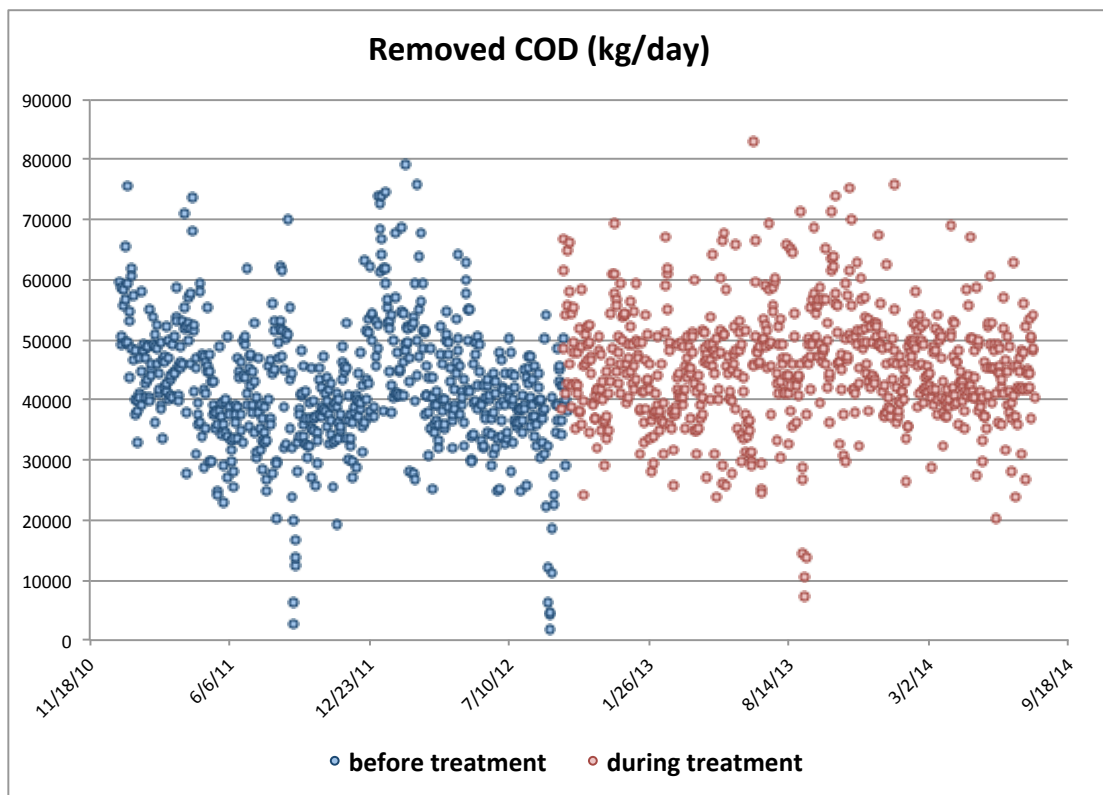


Figure 2 – Removed COD in kilograms

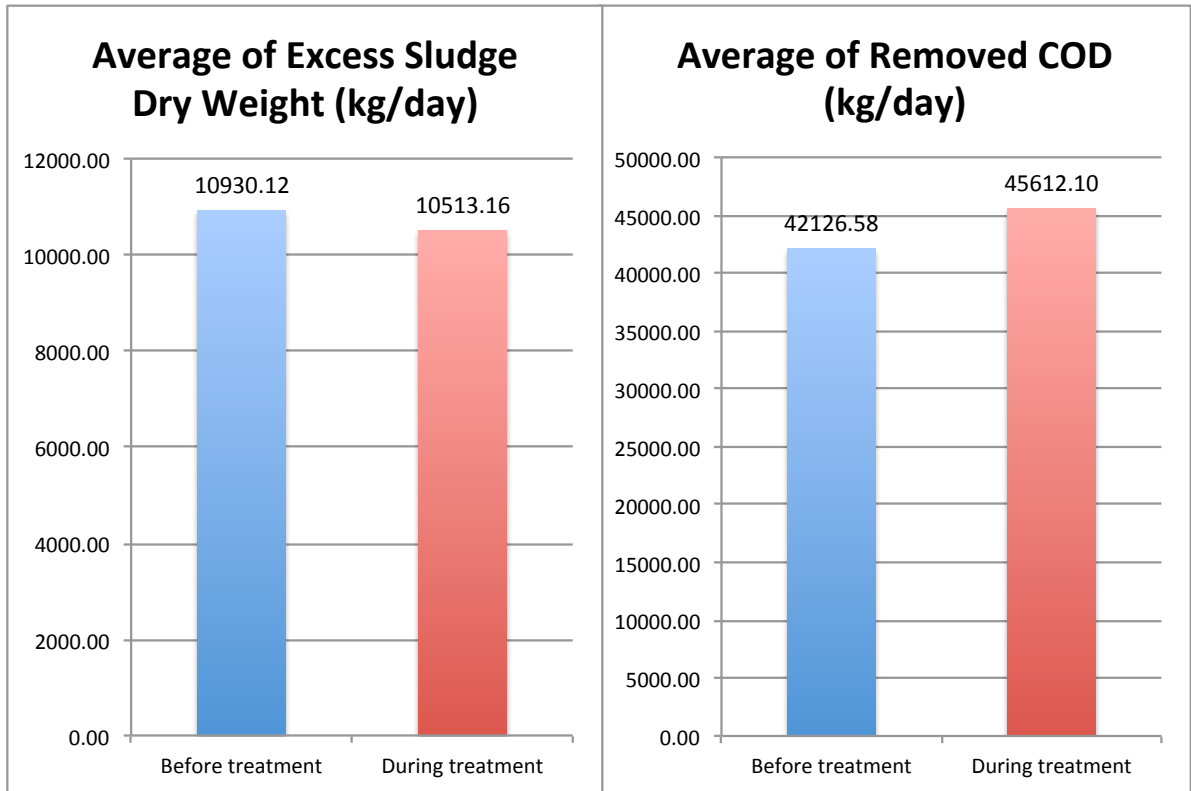


Figure 3 – Average values of excess sludge dry weight and removed COD

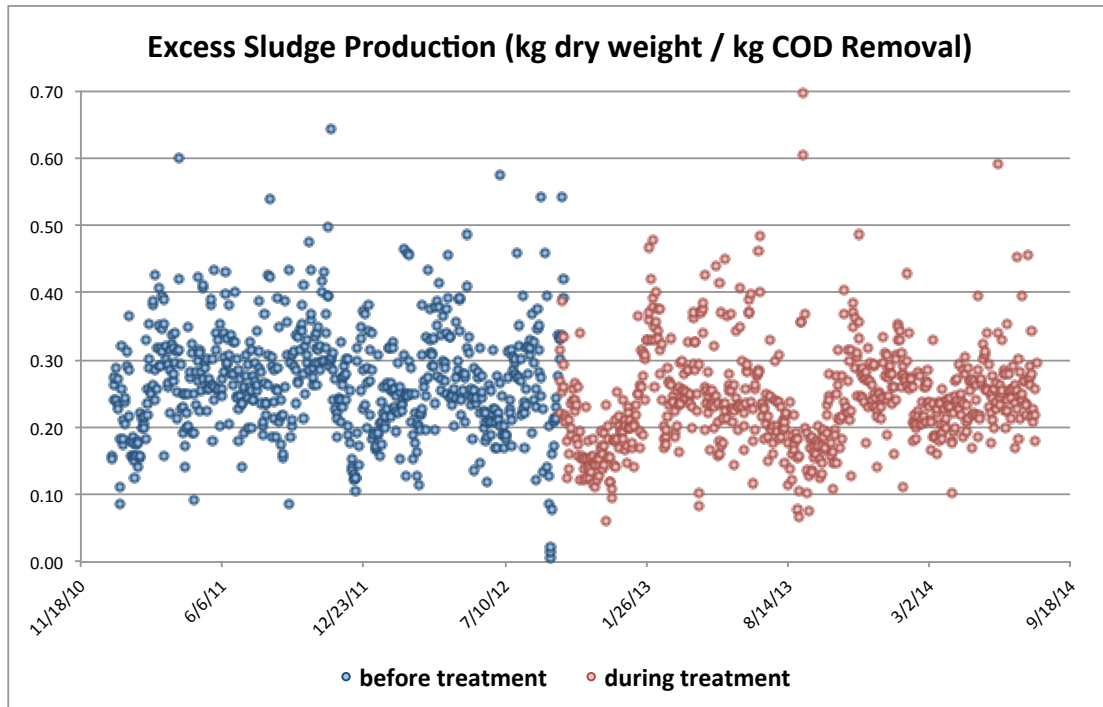


Figure 4 – Excess sludge production

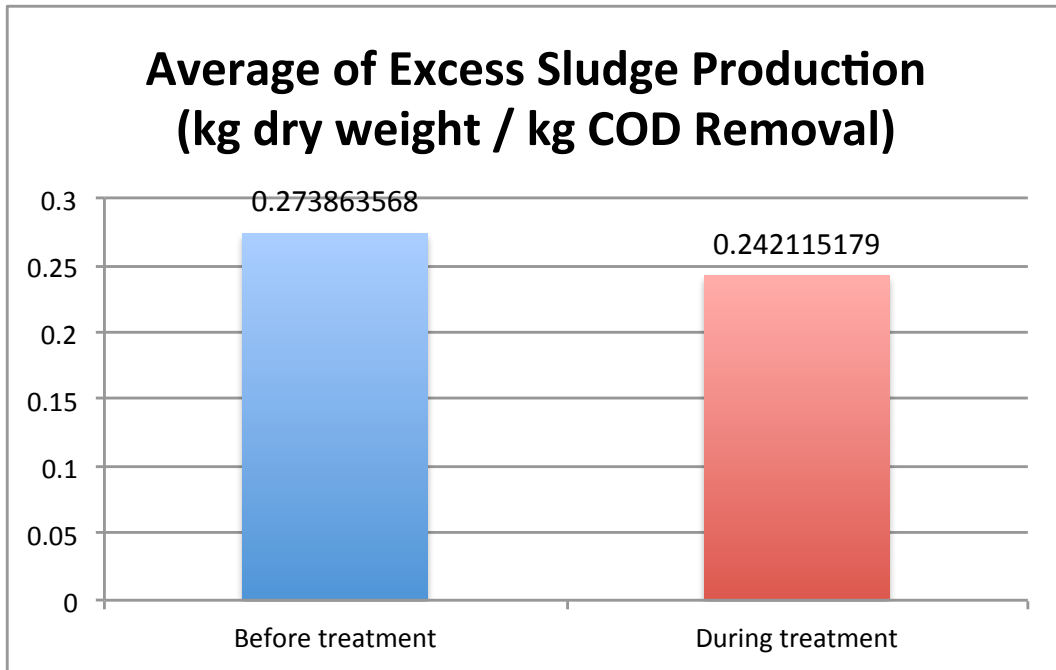


Figure 5 – Average values of specific excess sludge production

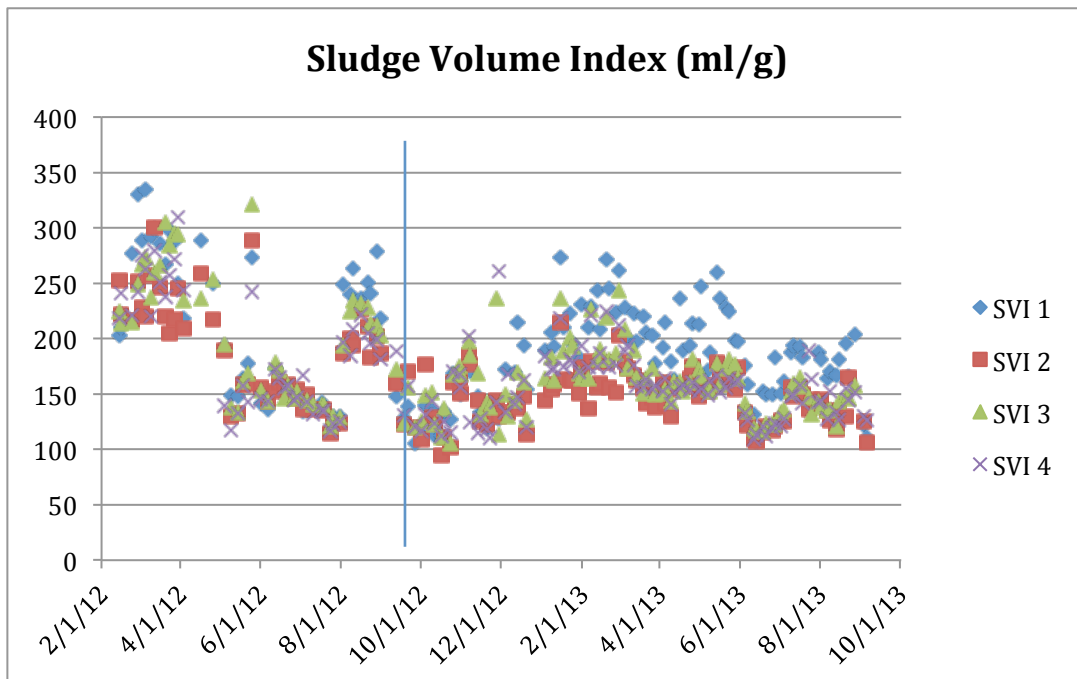


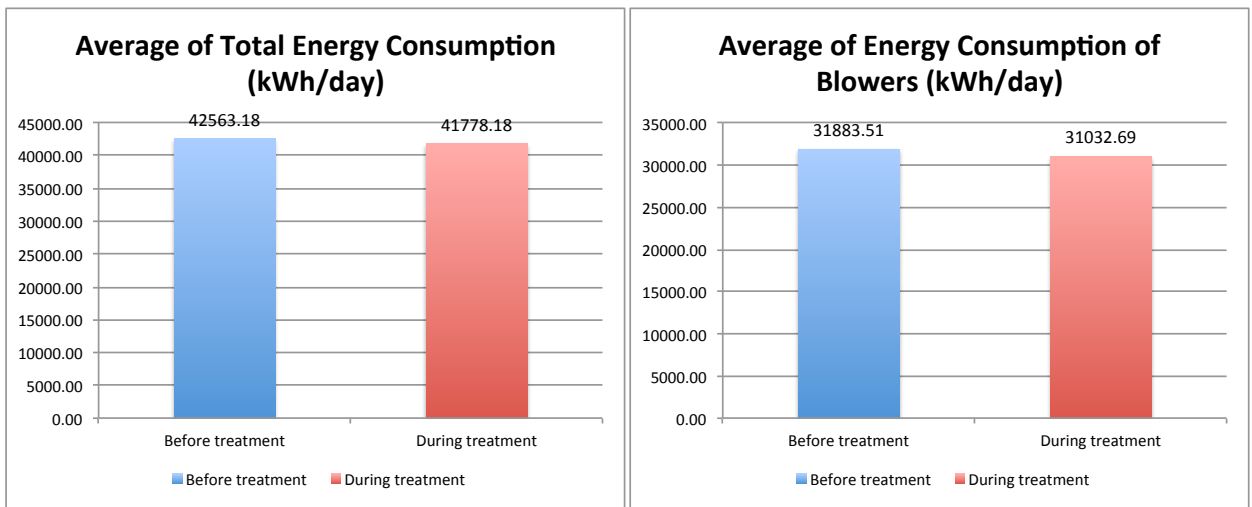
Figure 5 – SVI values

**Energy consumption reduction**

When comparing energy consumption data from various periods the use of specific values is strongly recommended as well. The actual oxygen requirement of the activated sludge is determined by the removed organic matter, which can be expressed as kilogramm Chemical Oxygen Demand. Removed organic matter can be expressed as follows:

$$\text{Removed COD (kg/day)} = (\text{influent COD (kg/m}^3\text{)} - \text{effluent COD (kg/m}^3\text{)}) * \text{Influent wastewater flow (m}^3\text{/day)}$$

Dividing the daily energy consumption by the amount of removed COD gives the specific value, which is the most representative for evaluation of the effects of Bioclean TM on energy consumption. A comparison of results and average values is provided below.



*Figure 7 – Average values of total energy consumption, total energy consumption of blowers and removed COD*

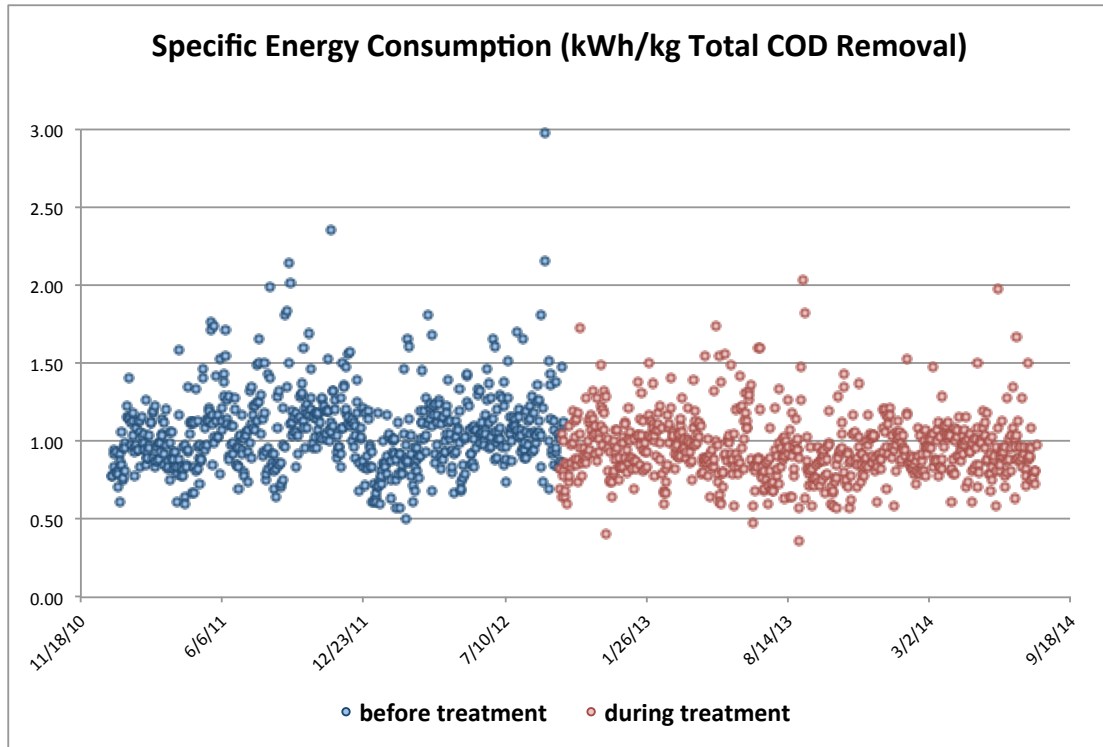


Figure 8 – Specific energy consumption

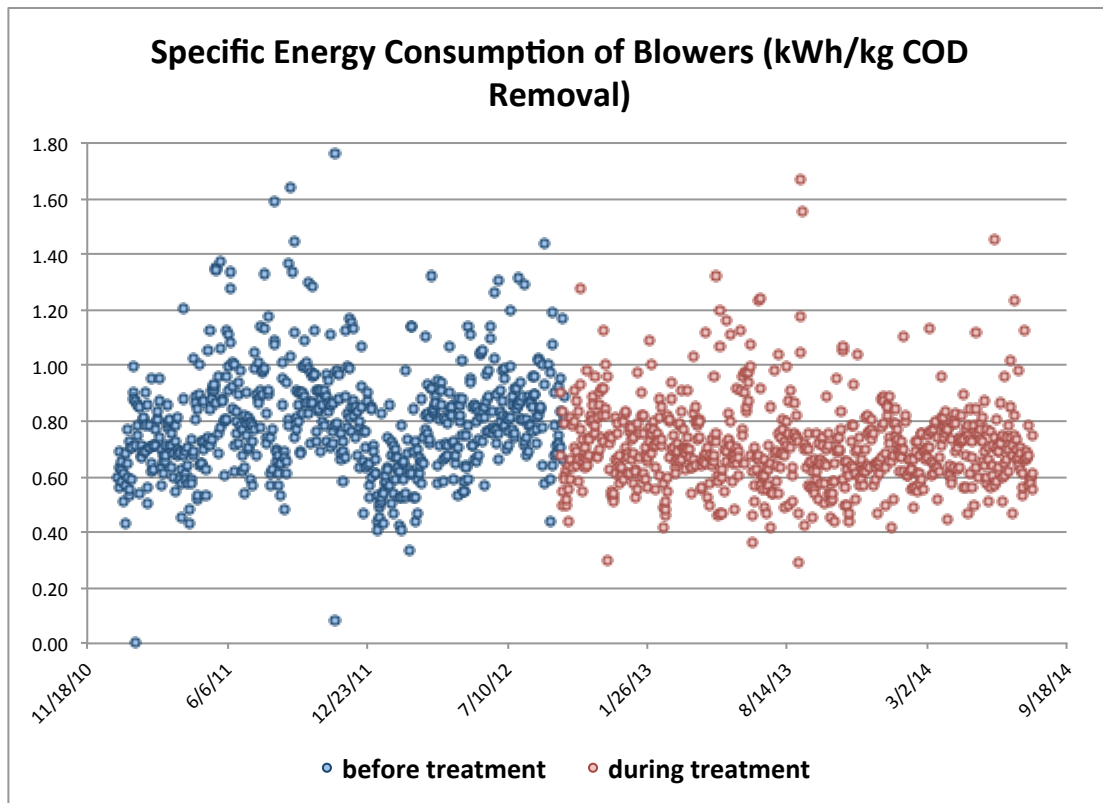


Figure 9 – Specific energy consumption of blowers

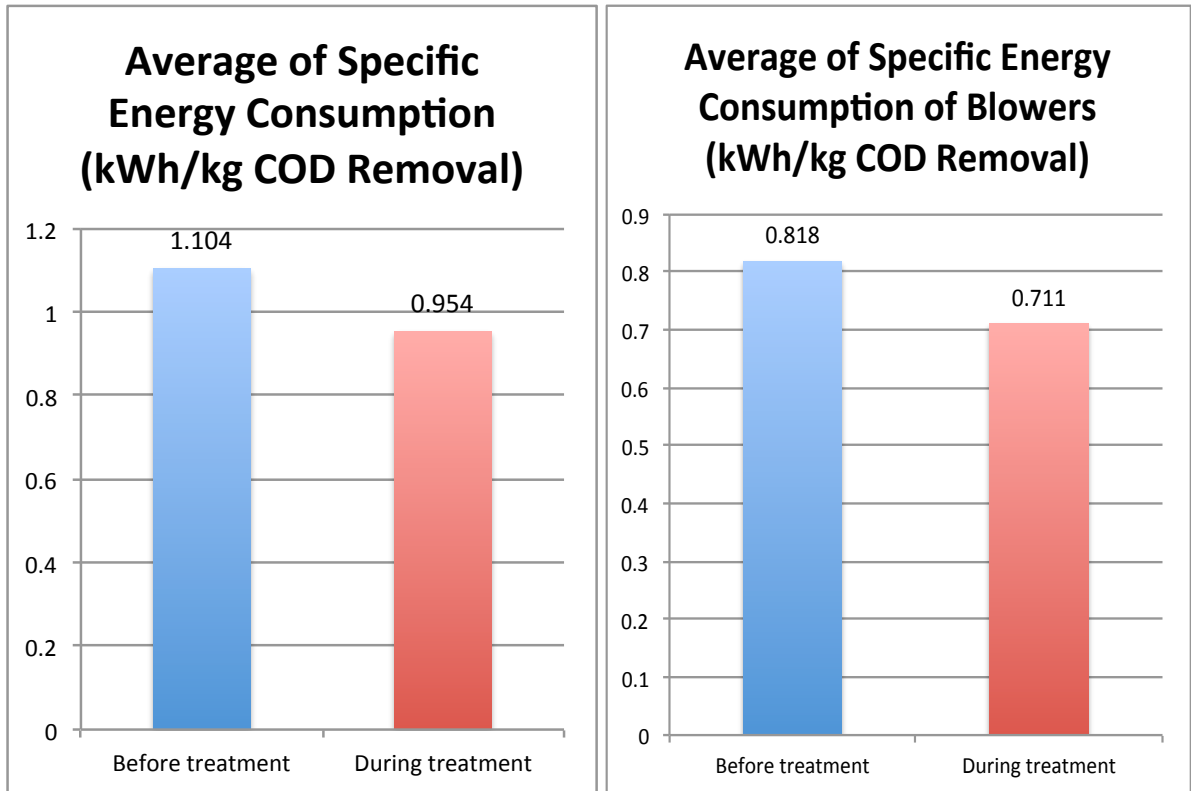


Figure 10 – Average values of specific energy consumption

It is shown that despite etc. 3500 kg more COD has been removed, the energy consumption of both the blowers and the plant has dropped. It can be clearly seen, that the average specific energy consumption and the average specific energy consumption of the blowers are obviously lower throughout the whole period of the treatment than in the preceding years. This implies that the activated sludge utilized the supplied oxygen more efficiently than before. The average values for these two periods (before and during treatment) can be compared. These yields are 1.104 and 0.954 kWh/kg COD removal for the total and 0.818 and 0.711 kWh/kg COD removal for the energy consumption of blowers. These **resulted 13.6% and 13.2% energy cost saving for the plant**, respectively.

Odor control and reduction of malodor originated from aeration basins is also an important purpose in the Wastewater Treatment Plant. The result shows that the smell index value is lower throughout the period of the treatment than before, with way lower peaks.

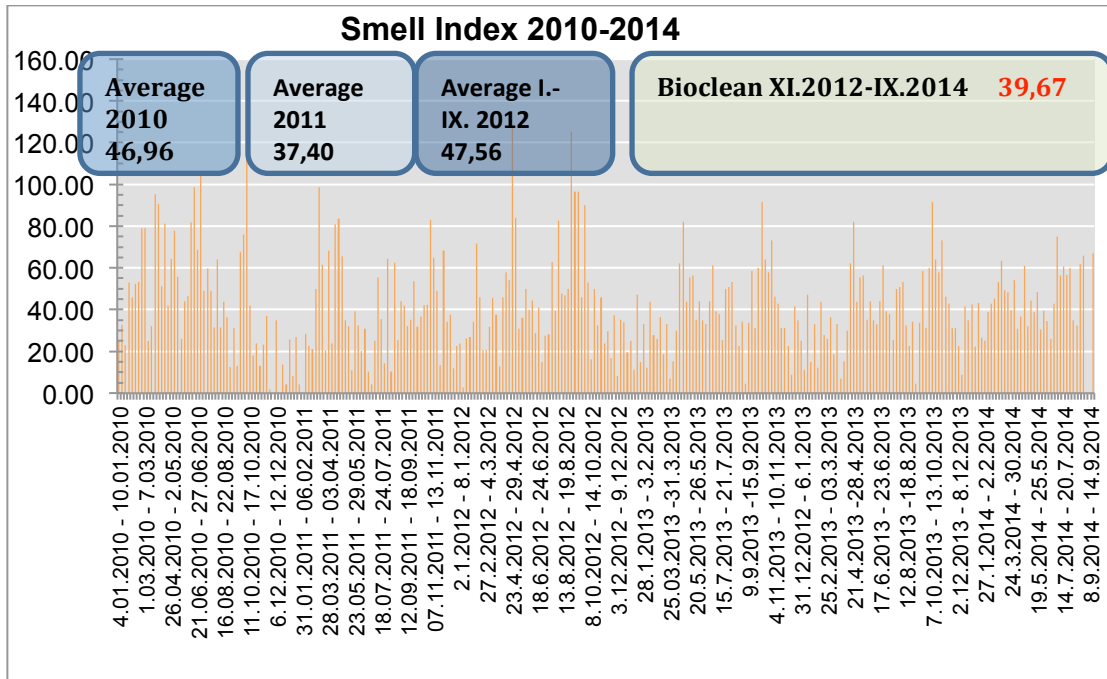


Figure 11 – Smellindex in the wastewater treatment plant

### Summary

As the operator of the plant takes 24-hour average samples from the raw influent and from the effluent every day for laboratory measurement of various parameters, including COD, it enables the operator, and us to evaluate the results very clearly on a multiple year basis before and after the start of Bioclean TM treatment. That is how the exact organic matter amount removed by the plant can be computed in kg of COD for each and every day throughout years.

This also enables the operator to calculate the specific values for energy consumption and excess sludge reduction, and evaluate the effects of Bioclean TM treatment, if no technological or other mentionable constructional/mechanical changes have been applied throughout this period. During the period evaluated above there have been no mentionable changes in the technology or in the operation.

By calculating the specific values described above, the operator can give an answer to a frequently asked, "What would be the values if Bioclean TM hadn't been applied throughout the period since September 2012?". Due to the lack of average daily

samples for influent and effluent, most operators cannot give a very exact answer to this question.

**Here all data can be calculated, what values would be for COD removal, energy consumption, and excess sludge production without the treatment,** using the specific data before the treatment with the mass and flow values of the 2nd period where treatment was applied.

**Summarizing the results in the goals of reduction of operational costs, environmental violation risk, and odor issues:**

- The effluent values, especially COD, BOD, TSS have been stabilized. Fluctuations has gone lower in effluent parameters
- The malodor of the aerobic reactors has entirely gone, which is reflected in the odor index Mondi, scp. measures.
- The resistance of the biology improved against shock loads, and inhibitory loads, more stable effluent parameters reflects this fact
- Sludge settling parameters improved significantly (SVI index), so the risk of environmental violation due to sludge washouts decreased significantly.
- The plant removes etc. 3500 kg/d more COD than before.

**Summarizing the specific values for operational cost reduction calculations, which are decreasing the monthly maintenance cost of Bioclean TM, moreover the plant saves more money than it spends on Bioclean TM.**

- Specific energy consumption of the plant has dropped from 1,104 to 0,954 kWh / kg COD removed (the drop is from 0,818 to 0,711 kWh / kg COD removed for the blowers energy consumption)
- Specific excess sludge production of the plant has dropped from 0,274 to 0,242 kg dry weight / kg COD removed
- COD removal capacity of the plant has improved by 3500 kg of COD per day.



**MalaTECH** 3.  
water  
Kereskedelmi és Szolgáltató Kft.  
1214 Budapest, Kohász u. 28.  
Adószám: 13688145-2-43  
Bsz.: 11600006-00000000-17602192

**Szabolcs Malaczko**

Head of Wastewater Department