



Pilot plant for wastewater treatment with Ydro-Process® technology Short report – at the end of the experiment

For the pilot application, part of the teaching and research waste water treatment plant was used as a large-scale test facility with the following system specifications:

- 1 round aerated sand collector
- Rectangular primary tank, ($V = 60 \text{ m}^3$, $A = 35 \text{ m}^2$)
- Centrifugal pump maximum $15 \text{ m}^3/\text{h}$ for feeding the oxidation ditch
- 1 aeration tank / oxidation ditch with surface aeration (total volume 114 m^3 , intermittent aeration, O_2 measurement)
- 1 final sedimentation tank, funnel tank ($V = 24 \text{ m}^3$, $A = 12 \text{ m}^2$)
- Screw pump for return sludge (volume flow adjustable)
- 1 eccentric screw pump (secondary excess sludge removal), controlled by timer
- 2 automatic samplers, refrigerated
- 1 continuous oxygen measurement device

Process monitoring is executed with analyzes of substances in water as follow:

- 3 samples per week at 3 measuring points (biology inlet / effluent, inlet primary tank (see table for list of parameters))
- 24h mixed sample
- Sludge analyzes (amount of excess sludge, MLSS in the aeration tank, solids in primary and excess sludge)

In addition, the parameters inlet volume flow, O_2 content, $\text{NO}_3\text{-N}$ and $\text{NO}_2\text{-N}$ in the oxidation trench were measured and recorded online using sensors.

The measurement of the following analysis parameters was planned:

| Parameter | Unit | Inflow Primary Tank | Inflow Biology | Effluent Final Sedimentation Tank | Sludge Aeration Tank, Secondary Excess, Primary |
|---------------------|------|---------------------|----------------|-----------------------------------|---|
| COD | mg/L | x | x | X | |
| COD mF | mg/L | x | x | X | |
| Ntot | mg/L | x | x | x | |
| NH4-N | mg/L | x | x | x | |
| NO3-N | mg/L | | | x | |
| Ptot | mg/L | x | x | x | |
| PO4-P | mg/L | | x | x | |
| DM | g/L | | | | x |
| VSS | % | | | | x |
| Organic Acids (Hac) | | | x | | x |
| Filtrable Solids | mg/L | x | x | x | |
| Turbidity | NTU | | | online | |

The Ydro-Process® technology was used to operate the plant (developed by the company HYDROTECH ENVIRONMENTAL). The company EDIAS provided support with recommendations for the operational parameters.

The system was filled with sludge from the LFKW from October 9, 2023. After filling, the sludge was circulated and aerated and continuously fed with a partial stream of wastewater from the Bünsau waste water treatment plant inlet. Operating records start on October 21, 2023.

Operating results

The test plant was operated in parallel and fed with inlet wastewater from the LFKW (inlet sand collector unit) into the circular sand collector. The inlet volume flow was set to approx. 7 m³/h and the sludge recirculation was initially set to the same value.

The chronological sequence can be seen in the following figure.

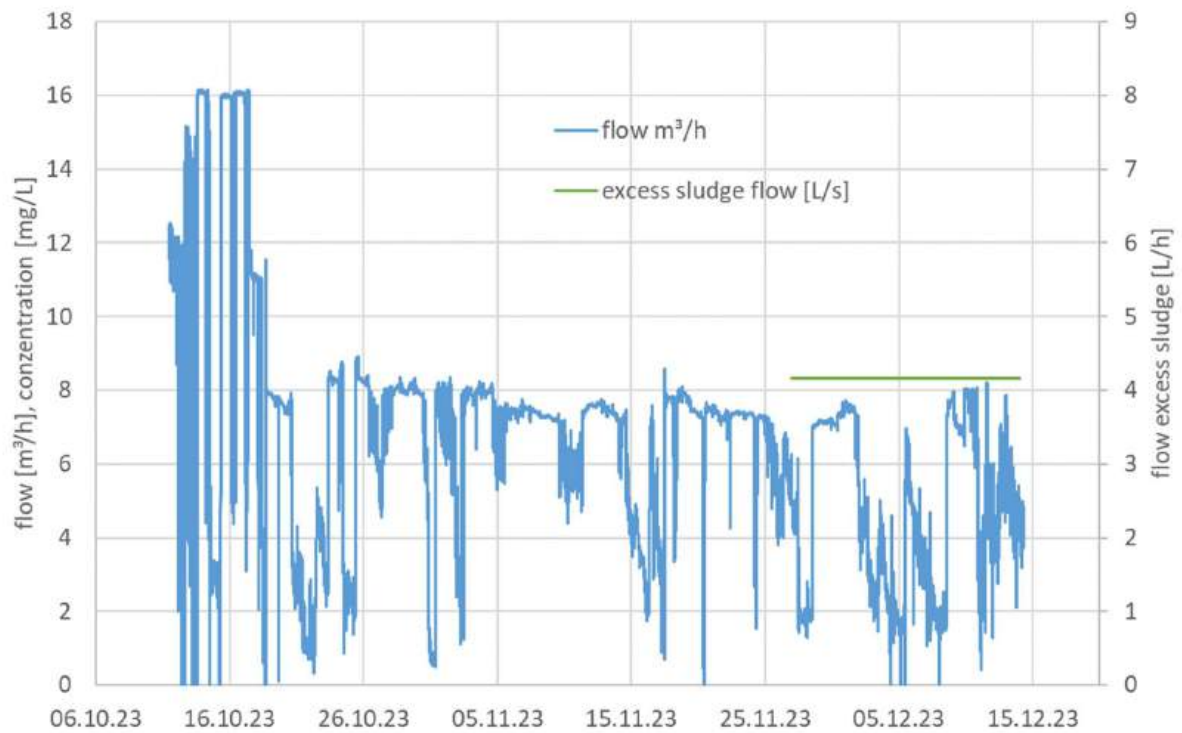


Figure 1: Volume stream of the test plant

The dissolved oxygen concentration in the oxidation ditch as well as the concentrations for $\text{NO}_3\text{-N}$ and $\text{NO}_2\text{-N}$ were continuously measured. The following figure shows the results of the data recording.

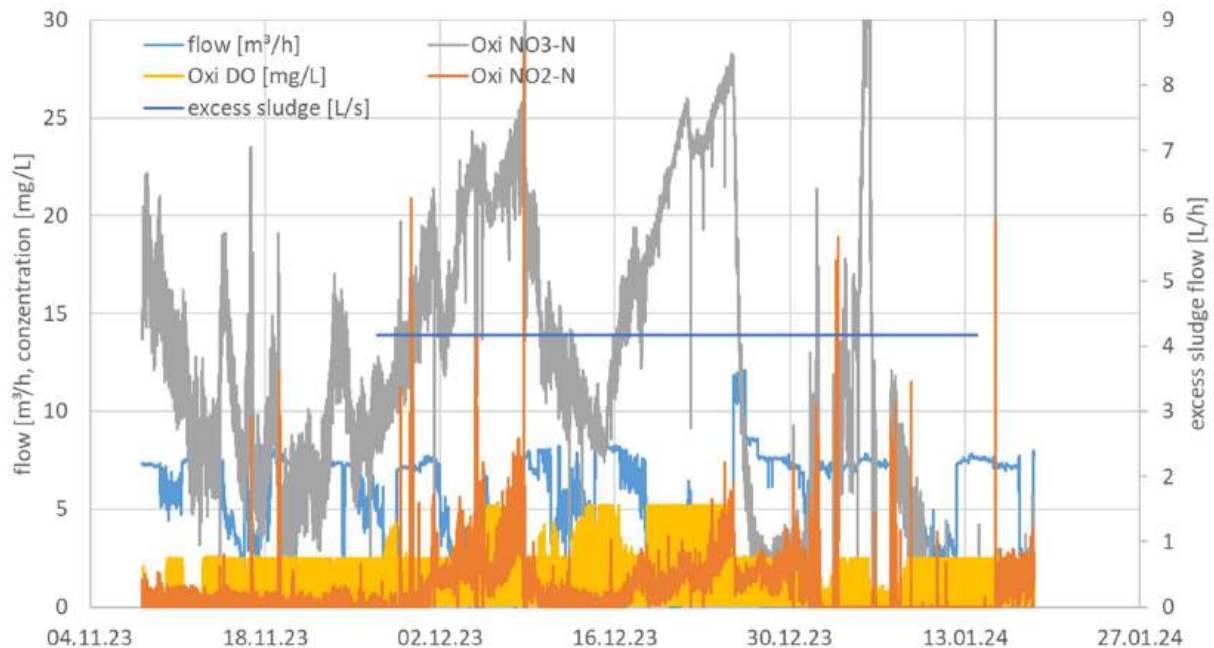


Figure 2: Measurement values oxidation ditch

The online measurements were recorded from November 8th, 2023. The oxidation ditch was intermittently aerated. That's why the measured values fluctuate between 0 mg/L and the load-dependent maximum value. If the load decreases because, for example, a blockage occurred in the inlet channel (from December 2nd, 2023) or rainfall diluted the wastewater (December 10th to December 16th, 2023), then the maximum O₂ concentration achieved increases with the same length of aeration time.

The NO₃ measurements are very high at the beginning of the recording and then decrease until November 18th to below 10 mg/L. The cause is the increase in sludge recirculation and the associated increase in the solids content (MLSS) in the aeration tank. Basically, the NO₃ concentration runs in the opposite direction to the load. Therefore, the NO₃ concentration increases again from December due to the low inflow volume and decreases from December 10th again because the aeration time was then shortened by 15 minutes and the denitrification time was extended by 15 minutes.

The period at the beginning of December 2023 is therefore shown in a smaller day scale in the following figure.

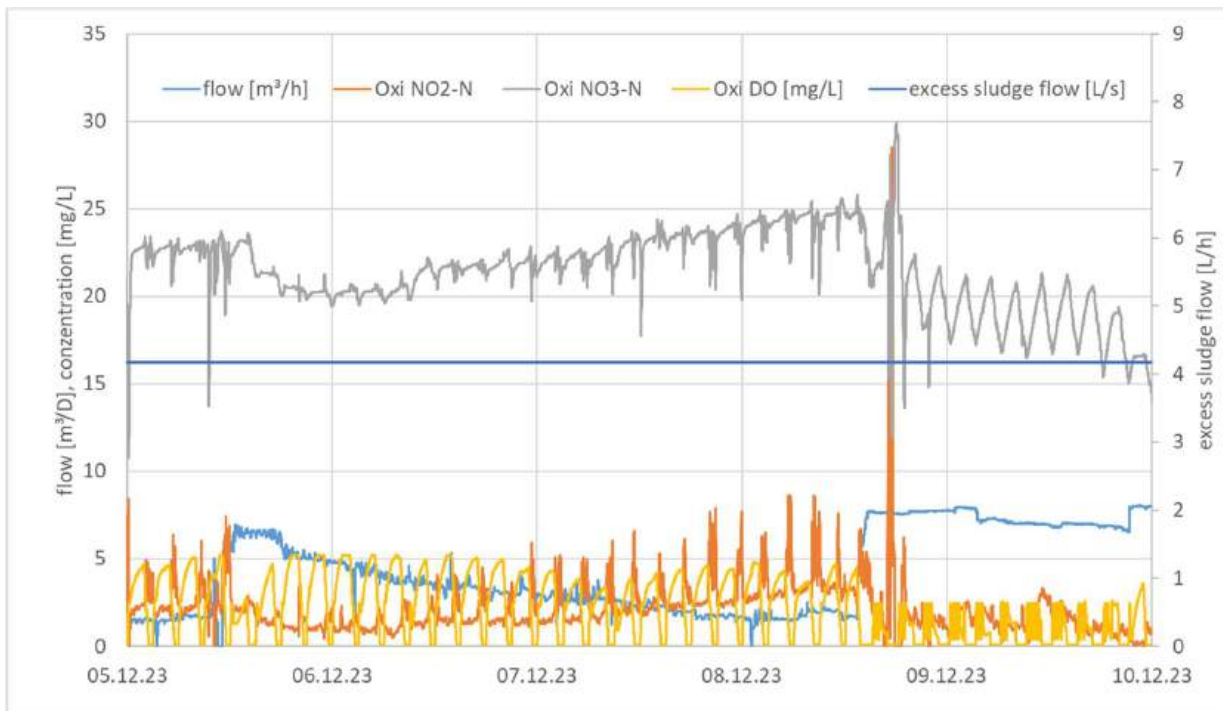


Figure 3: online measurements beginning December 2023

On December 5th, 2023 the blockage in the inlet was solved. As a result, the load increases and O₂ and NO₃ measurements decrease. Due to the gradual decline in the inflow, O₂ and NO₃ rise again until flushing takes place again on December 8th, 2023, aeration is suspended and the denitrification time is also extended. Since the inflow quantity remains high from December 9th, 2023 and less air is introduced with a longer denitrification time, O₂, NO₃ and NO₂ concentrations decrease.

Parameters in the inflow and outflow of the systems were measured in accordance with the wastewater regulations. The following figure shows the measured values for at the drain measuring point. The samples were measured in the inlet and outlet from daily mixed samples averaged over time.

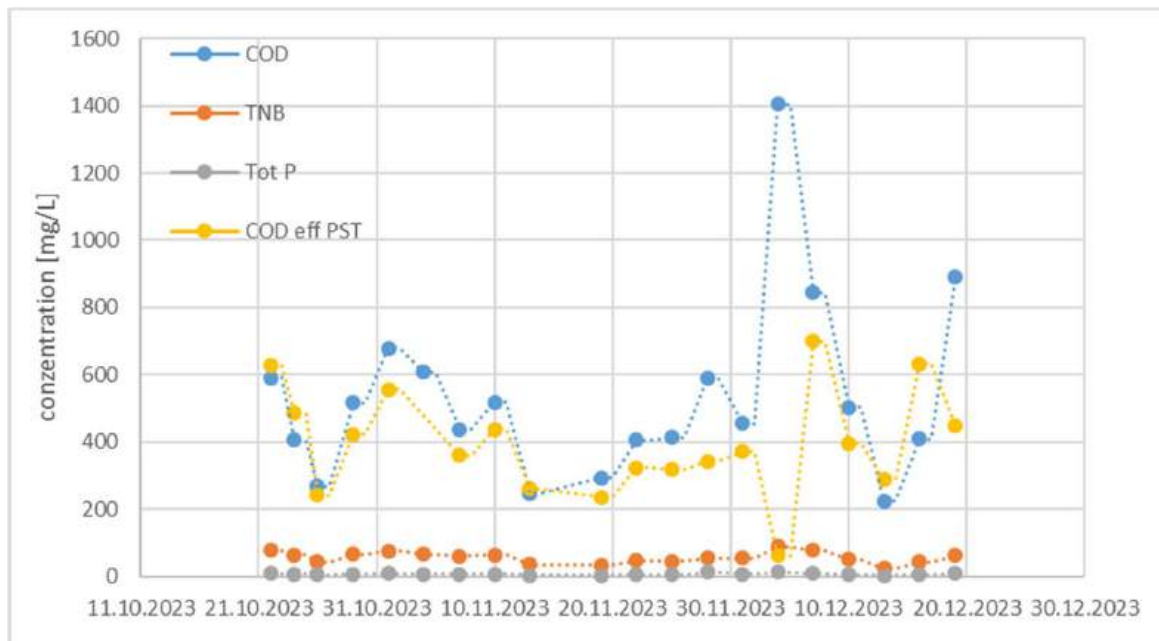


Figure 4: Results of inflow concentration measurements

The COD concentrations in the inflow fluctuate between 200 mg/L for mixed water inflow and 900 mg/L in dry weather conditions. The very high COD value on December 5th is due to flushing activities in the sewer system network.

The COD concentrations in the primary tank are consistently lower than the influent concentrations. The average concentration of the inflow of the primary tank is 535 mg/L and in the effluent 395 mg/L. This corresponds to a COD removal of 26%. The removal is significantly lower than would be expected with primary clarification with a hydraulic retention time of more than 4 hours. According to Table 1 in DWA A131 (2026), a COD removal of 30 to 40% can be expected for a stay time of more than 2 hours. However, the reason for the higher COD values in the overflow is not a drift of particles. The reason for this appears to be the addition of the Ydro bacteria and the associated improved hydrolysis in the primary clarifier. The substances settled in the primary clarifier were hydrolyzed and discharged as dissolved organic acids.

The nitrogen and phosphorus concentrations in the inflow and outflow of the primary treatment differ only slightly.

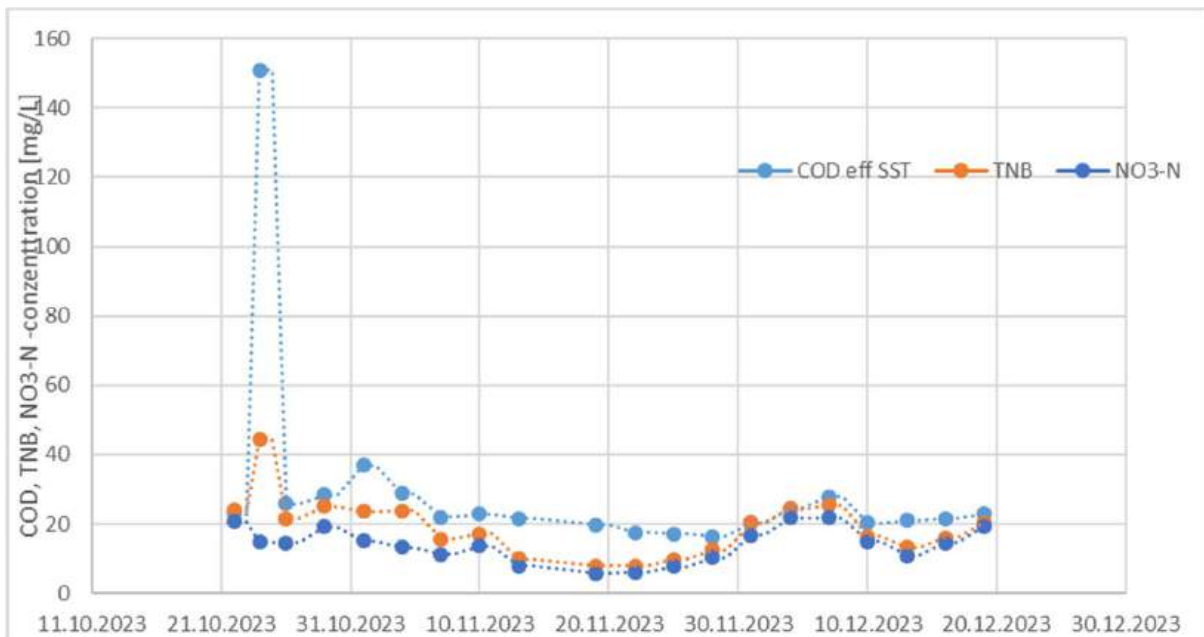


Figure 5: Results of the effluent concentration measurements CSB, Nges, NO3-N

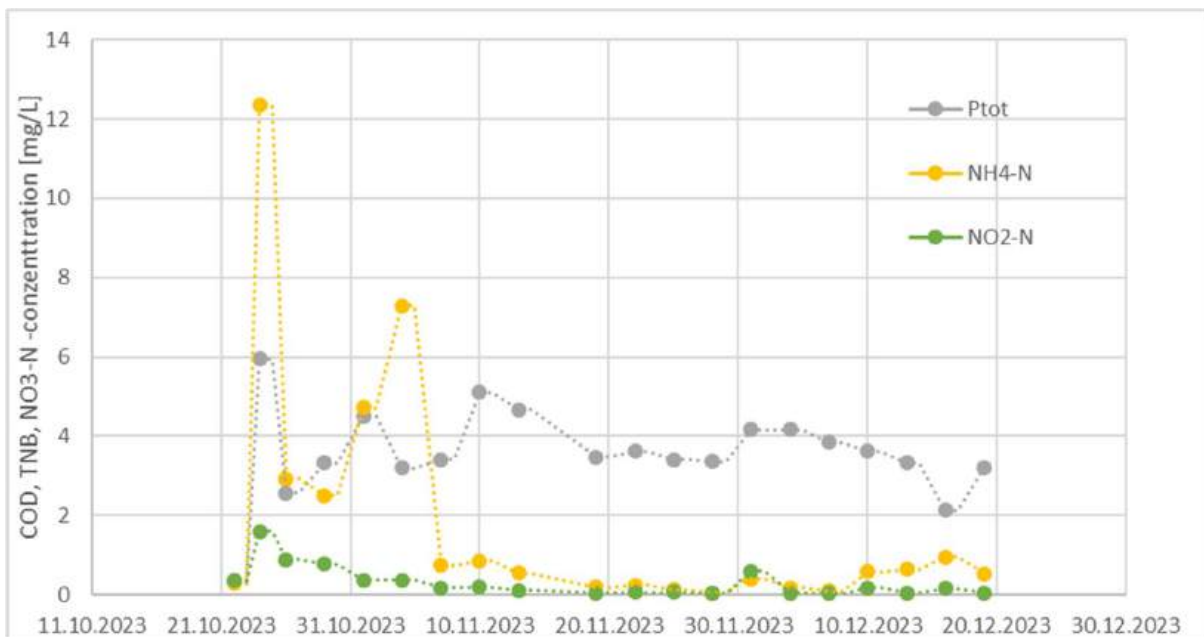


Figure 6: Results of the effluent concentration measurements Pges, NH4-N und NO2-N

The effluent concentrations are constantly low and only slightly increased at the beginning of the measurements. These higher values are due to running-in and sludge homogenization. The main reason was a blockage of the return sludge pipe and thus sludge accumulation in the final sedimentation tank, less sludge in the aeration tank and reduced nitrification.

This blockage was cleared at the beginning of November. The effluent concentrations except for PO4 then fell to COD <20 mg/L, NH4-N <1 mg/L and NO3-N fluctuating between 10 and 20 mg/L depending on the pollution status (see above).

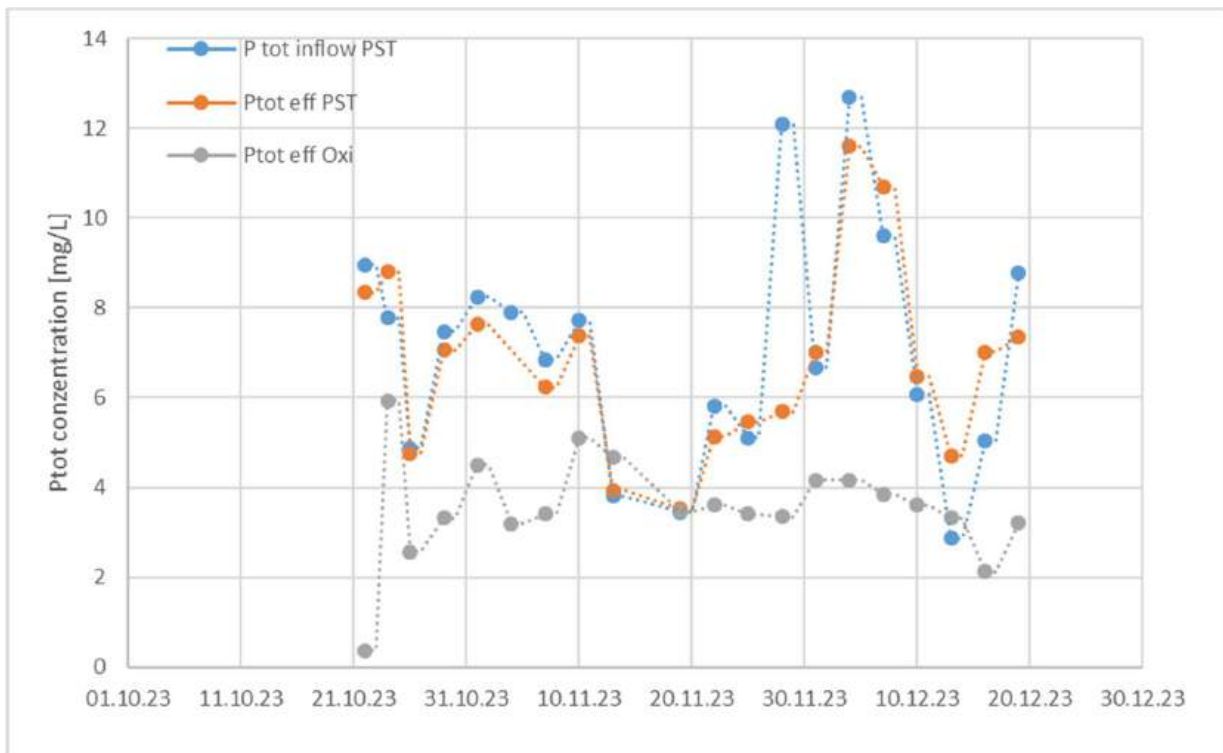


Figure 7: Inflow and effluent concentration TP

The P_{tot} concentrations of the inflow and effluent of the primary sedimentation tank (PST) are almost the same. Since particles are sedimented in the primary tank and P compounds are largely dissolved, this corresponds to expectations.

The P_{tot} effluent concentrations of the plant depends only on the P absorption into the biomass, since no chemical removal was carried out. The feed concentration fluctuates between 4 and 12 mg/L during the experimental period (depending on dilution by rainwater).

The fluctuation range in the process is between 2 and 5 mg/L. The difference was included in the biomass. This corresponds to an average P elimination of approx. 3 mg/L (approx. 50%).

The sludge volume and the solids content in the aeration tank measured every working day. Sludge concentrations and extraction volumes were determined depending on the amount. During the entire test period, 2.5 m³ of primary and secondary sludge was withdrawn for dewatering only on December 6, 2023.

The graphic representation of the measurements is shown in the following figure.

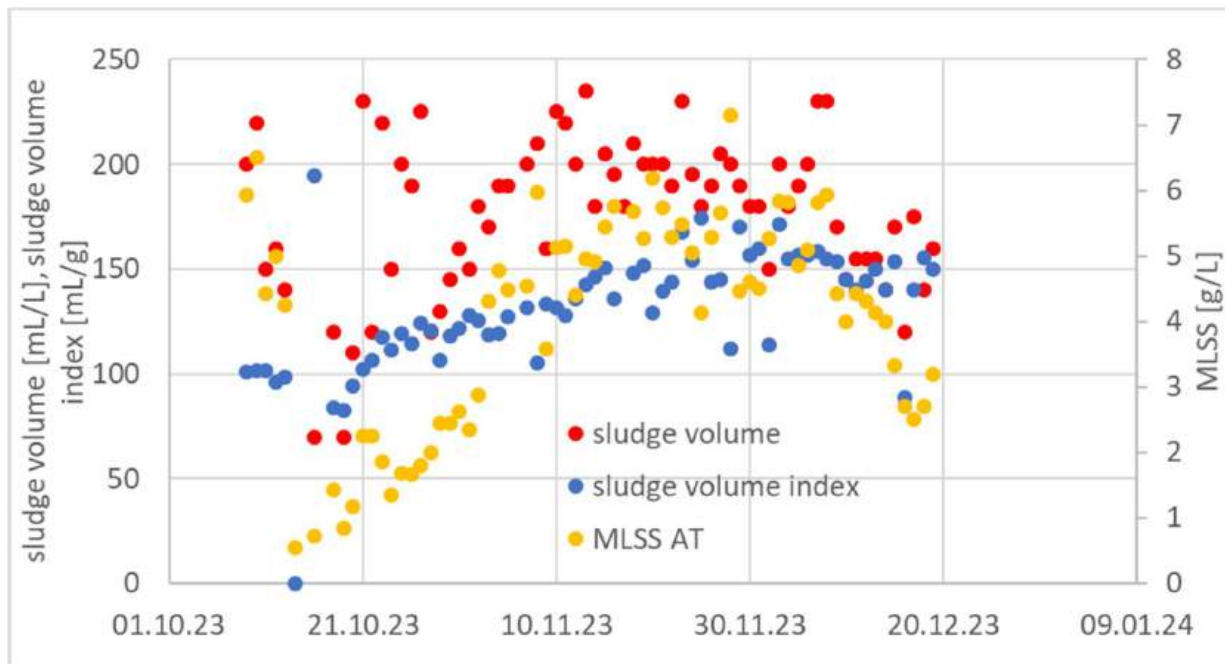


Figure 8: Results of the sludge measurements

After the system was commissioned at the beginning of October 2023, the sludge had to be distributed and evened out in the system. As a result, the measurable sludge weight was initially very low and then increased rapidly. From November onwards, a TS of more than 3 g/L was measurable in the oxidation ditch / aeration tank. The goal of maintaining a sludge weight of 4 to a maximum of 6 g/L was easily achieved.

Sludge volume shown is the actual measurement of the diluted sample. The actual sludge volume can be calculated taking the dilution factor into account. The sludge volume increases as the solids content increases and then remains largely constant. The sludge volume index is relatively high and in the range of poorly settleable sludge (ISV>130). Despite the high sludge index, good sedimentation could be observed and no floating sludge was observed. The settleability of the sludge and the concentration through the secondary clarifier is good.

Sludge balance

Approximately 100 mg/L primary sludge was sedimented daily and from November 28th. 100 L/d of excess sludge is withdrawn and introduced into the primary tank inlet.

Nevertheless, only on December 6th. 2.5 m³ of primary sludge with a TR of 4% was drawn off.

| Sludge Type | Sludge Concentration | Total per Day (Sludge * Q) | Sum in 6 weeks period |
|--|----------------------|---|-----------------------|
| Primary sludge sedimentable matters | 100 mg/L | 0,1kg/m ³ *5 m ³ /h*24=12kg/d | 540 kg DM |
| Secondary excess sludge | 8g/L | 8g/L*100L/d=800 g | 16 kg DM |
| Removal primary and secondary sludge to dewatering | 40 g/l | 40 kg/m ³ *2,5 m ³ =100 kg | |

During the test period, 540 kg of dry solids primary sludge were sedimented and 16 kg of dry solids secondary excess sludge were withdrawn (from 11/8/24) and pumped to the inlet of the primary sedimentation tank. One time 2.5 m³ of sludge was withdrawn from the primary sedimentation tank, with an equivalent of 100 kg of dry solids. The difference must either have remained in the system or been exhaled. Since the sludge level in the primary sedimentation tank has not changed (usually 20 cm below the edge of the funnel) and the solids concentration in the aeration tank has always been between 4 and 5 g/L, the sludge must have been exhaled by catabolism (metabolic pathway). This results in a sludge prevention / reduction of 82%.

Summary

The operation of a test plant with alternative sludge concepts has clearly shown that the use of Ydro-Process® technology makes it possible to operate a waste water treatment plant without significant sludge removal if the excess sludge can be hydrolyzed together with the primary sludge in the primary sedimentation tank. In comparison to a conventionally operated activated sludge plant, more than 80% sludge prevention/reduction is achievable. As a result of the hydrolysis of the sludge in the primary sedimentation tank, the concentration of organic acids in the primary tank increases.

However, this is only possible if the dissolved oxygen levels in the aerated section of the tank or during the aeration phase can be kept within a very narrow range of maximum 1.5 mg/L to 2 mg/L. This must be ensured with a very precise air entry control. An intermittent air entry control with variable air entry quantity and time/pause control can largely guarantee this. In the test operation, the concentration of dissolved oxygen increased too much, especially with mixed water operation, so that the NO₃-N values fluctuated more.

In addition, when using highly hydrolysing bacteria, care must be taken to ensure that the sludge residence time in the secondary sedimentation tank is not too long, as organic acids will then be formed again in the sludge space.

This pilot had been the second / larger scale pilot after a first pilot in spring 2021. The spring 2021 results with focus on sludge prevention / reduction has been confirmed during this second pilot.

Best regards,



Peter Maurer

Anlage: