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TAYA– Intensive Wetland Technology facilitates the treatment of high loads of organic pollutants and ammonia

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Abstract: Constructed wetlands are seen as a mechanically, simple treatment alternative in many Mediterranean countries. However, as a primary goal of wastewater treatment programs is to produce an effluent suitable for agricultural reuse in water-scarce regions, water loss through evapotranspiration in the wetland (and associated salinity increases) is undesirable.In Israel, this had lead to an interest in intensified wetland systems that occupy smaller areas and minimize this water loss effect. This is also combined with an interest to treat high loads associated with agricultural and industrial wastewaters. Over the last years, a new type of *intensified wetlands* involving fill-and-drain principles has been developed, and a variety of full-scale applications are now in design.

Keywords: TAYA, fill-and-drain wetland, tidal flow wetland, piggery wastewater, pickling wastewater

INTRODUCTION

Constructed wetlands are evolving from being a passive technology suitable for effluent polishing to becoming a modern technology applied in engineered installations where the parameters can be controlled and monitored. Engineered wetlands have developed further to become the technology presented in this article which we refer to as *Intensive Wetlands*.

This name may seem counter-intuitive, but engineers and regulators regard wetlands as an alternative to electro-mechanical systems which are generally considered as intensive systems. The treatment wetlands presented in this paper are intensive from the process and biochemistry aspects but extensive when it comes to their operation and maintenance.

The TAYA method has been implemented successfully in industrial pilots trating agricultural and industrial wastewater systems with a proven ability in the treatment of wastewater with high loads of organic matter and ammonia. The system, which uses simple means, replaces heavy electro-mechanical systems to reach the same effluent qualities.

THE TAYA WETLAND TECHNOLOGY

The TAYA wetlands model is based on the filling and draining of pairs of subsurface flow constructed wetland basins. The fluids are pumped from one side to the other at a calculated flow rate which facilitates particularly low energy consumption. Aspects of the pumping design are proprietary and will not be discussed in detail as patent filings are underway.

The design of this wetland system includes calculations of the oxygen transfer quantity, retention times and pollutant loadings (similarly to the calculations done for activated sludge systems). By fixing the number of cycles for circulating the water from one side to the other the mass transfer of oxygen may be controlled. The depth of the water surface remaining within the system determines the extent of the anoxic capacity while the feeding mode allows control over the de-nitrification processes.

Treatment Systems for High Loads

The integration of anaerobic pretreatment systems together with full treatment in the wetlands provide a winning combination when it comes to economics and process considerations, as well as being very simple to maintain and operate. The reduction of a high load in anaerobic systems is applied using a number of methods in line with the client's needs.

Anaerobic stage.

- Sealed earth basins (open or covered) with long retention times that facilitate the breakdown of 70-90% of the organic load in the fluids and the long-term breakdown in the accumulated sludge layer.
- Low rate anaerobic reactors enable the breakdown of 90% of the fats or the suspended solids' load.
- High rate anaerobic reactors are suitable for industrial wastewater which does not contain oils and TSS or has undergone appropriate preliminary treatment.

Wetland stage. The effluent from the anaerobic stage is fed into one or more pairs of wetland basins. The calculation of the wetlands' size and the number of pairs is based on the organic load and the nitrogen compounds on the one hand and the required water quality demands on the other hand. Fill-and-drain wetlands are susceptible to clogging if not dimensioned properly (Behrends, Bailey et al. 2006; Austin, Maciolek et al. 2007), but have also proven to be effective for the removal of organic matter and nitrogen compounds (Behrends 2000; Austin, Wolf et al. 2006; Sun and Austin 2006)

Filling and draining of the paired wetland basins is used as a means of energy-efficient oxygen transfer particularly well suited to warm-climate applications. As the water temperature increases, the saturation level of dissolved oxygen decreases (Snoeyink and Jenkins 1980), and fill-and-drain wetlands start to become more energy efficient than using compressed air (Austin and Nivala 2009; Kadlec and Wallace 2009).

CASE STUDIES

The TAYA wetland process has been tested in pilot- over the last five years. This paper presents two representative case studies, both dealing with high-strength wastewater.

Piggery Wastewater

The original system at the piggery consisted of three 4000 m^3, anaerobic earth basins, three vertical subsurface flow wetland basins of 800 m^2 each and four horizontal subsurface flow wetland basins of 1200 m^2 each. This system was not successful in meeting treatment goals and needed to be upgraded. The industrial pilot application of the TAYA wetland was applied as the upgrade of the original system but only required two of the original 7 wetland basins. The new Piggery wastewater treatment plant is designed to treat 300 m^3 per day which enters the system with typical concentrations of 20,000 mg/l COD, 12,000 mg/l BOD, 1,100 mg/l TKN and 3,000 mg/l TSS. The upgraded system is designed to yield quality levels of 20/30/50 mg/l for BOD/TSS/NH_4 respectively. At this initial stage, a pilot for only the *first phase was completed* *that is designed to produce effluents quality levels of 40/100/50 mg/l of BOD/TSS/NH_4 respectively*. In the second phase intermittent sand filters are proposed to meet the final effluent quality. This second phase has currently been evaluated.

Results. At the industrial pilot system the anaerobic basins effluent is treated in two out of the 3 open earth basins working in series, which operate as passive settling, anaerobic basins. These basins allow the reduction of COD, BOD and TSS between 80-90%; followed by the treatment stage in one pair of wetlands to complement the treatment and attain values of 30/80/30 mg/l BOD/TSS/NH_4 respectively.

Due the anaerobic pretreatment basins. BOD decreased from values of about 10,000 to 12,000 mg/l at the inlet 500 mg/l; values for TSS decreased from about 15,000 mg/l to approximately 750 mg/l. The values for ammonia entering the system were about 1,500 mg/l as TKN, and at the outlet from the pretreatment the concentrations were about 900-1,200 mg/l. This represents the influent to the TAYA wetland system. Recent performance of the wetland system for BOD, TSS and NH_4-N are summarized in Figures 1, 2 and 3, respectively.

Figure 1. BOD reduction in the piggery wetland treatment system

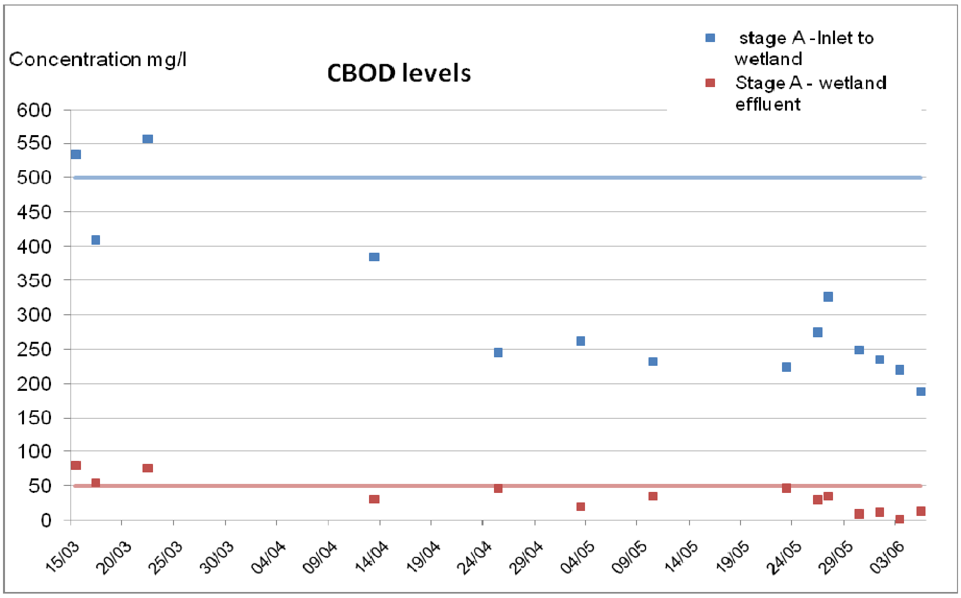


Figure 2. TSS reduction in the piggery wetland treatment system

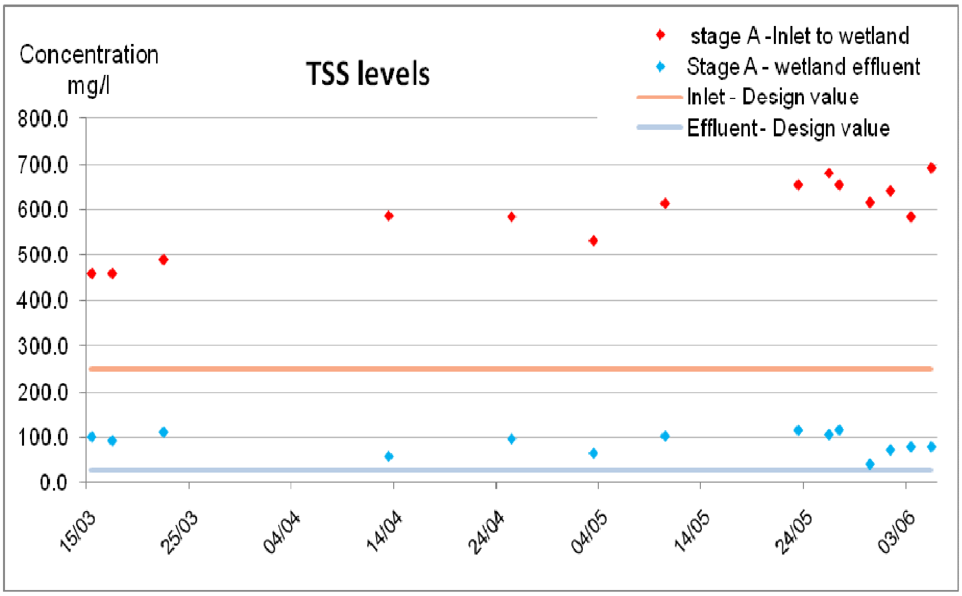
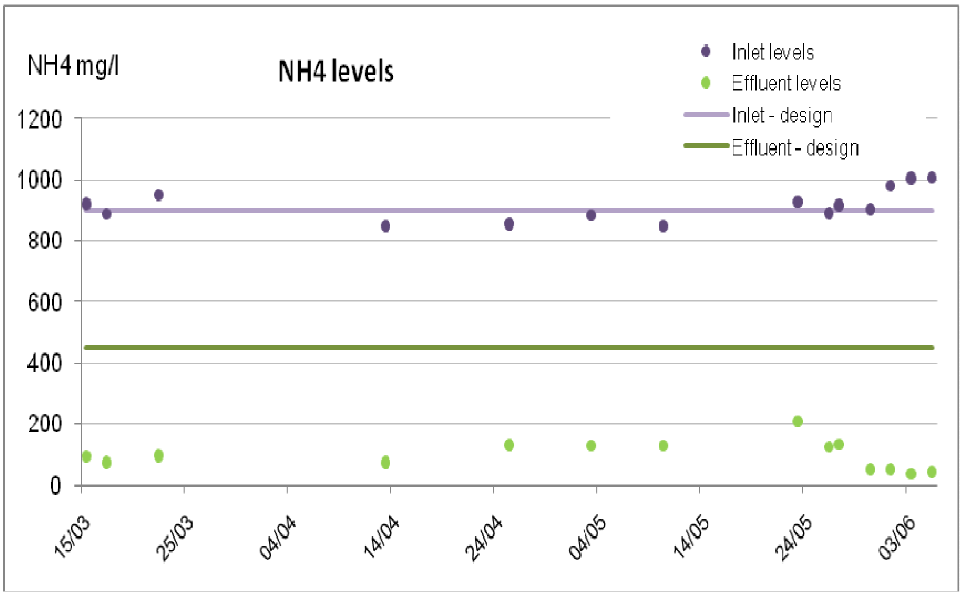


Figure 3. NH_4-N reduction in the piggery wetland treatment system



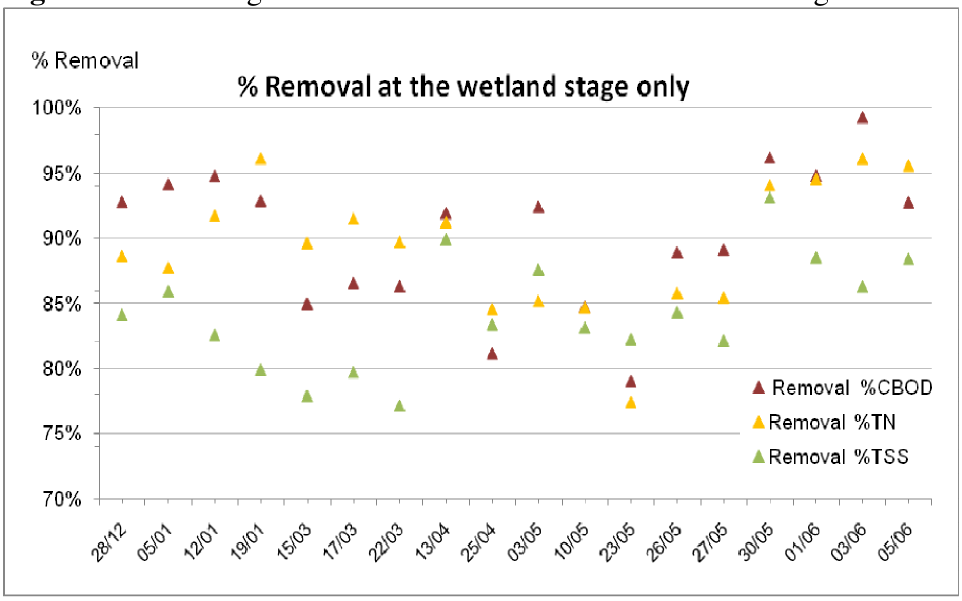
The reduction of BOD at the wetland stage allowed reaching effluent quality of 40-30 mg/l. The TSS was treated in the wetlands to a level of 60-80 mg/l. The particle size of the remaining suspended solids in the effluents was less than 10 microns and at some future date these could be removed in a sand filter. The ammonia was treated in the wetland to concentrations as low as 30 mg/l.

Electricity consumption. The system consumes about 1 kw of energy per m^3 which is much lower compared with energy consumption of conventional activated sludge treatment for similar loads of BOD and ammonia.

Land requirements. The designed land area required for the piggery TAYA wetlands system is about 2,500 m^2. The original wetland system used seven basins with a net area of about 7,500 m^2. This earlier system was designed to treat effluent qualities of only 70/90 mg/l BOD/TSS and no nitrification, could not comply with those standards. The TAYA pilot system is producing 30 mg/l BOD, 70mg/l TSS and NH_4-N at a level of 30 mg/l.

The designed TAYA wetland system utilizes ⅓ of the original basin area and attains much higher water quality levels. The pilot demonstrates a powerful tool (especially for nitrification) reducing concentrations from 1200 mg/l to 30 mg/l in one stage, as can be seen in Figure 3. The overall treatment efficiency of the reconfigured system can also be expressed on a percent removal basis (Figure 4).

Figure 4 - Percentages of removal with the TAYA wetland configuration.



Factory for Pickles and Other Preserves Using Vinegar and Salt

An additional system for a high load was a year-long pilot project for the treatment of wastewater from a factory producing pickled vegetables (where in addition to the high organic load, high concentrations of salts were also present, reaching a level of 40,000 mg/l TDS). This system consisted of two pretreatment stages (anaerobic and anoxic) followed by two TAYA wetland treatment stages arranged in series. Treatment performance for this system is summarized in Figures 5 through 8.

Figure 5. BOD concentrations of raw wastewater, after anaerobic pretreatment and after anoxic pretreatment

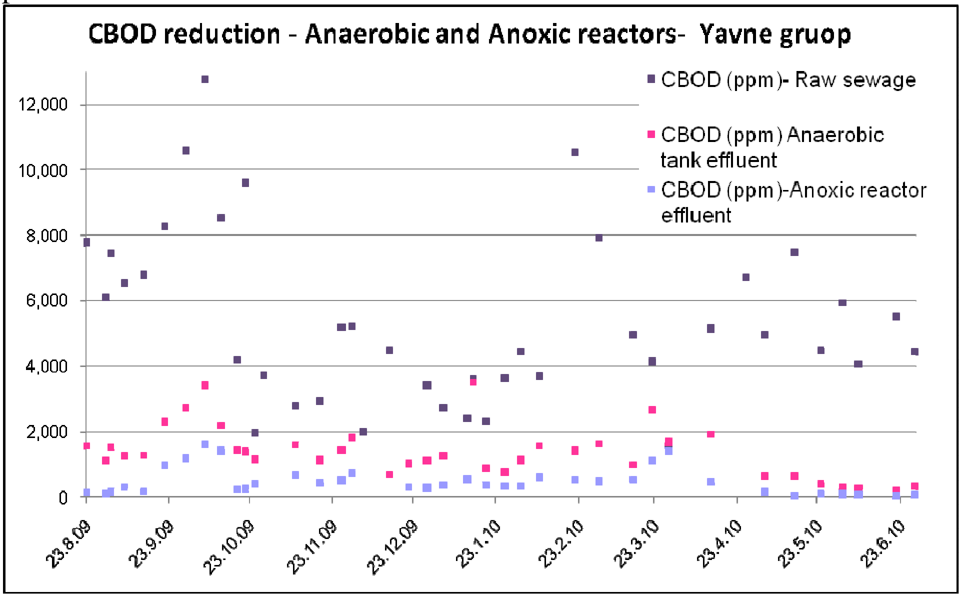
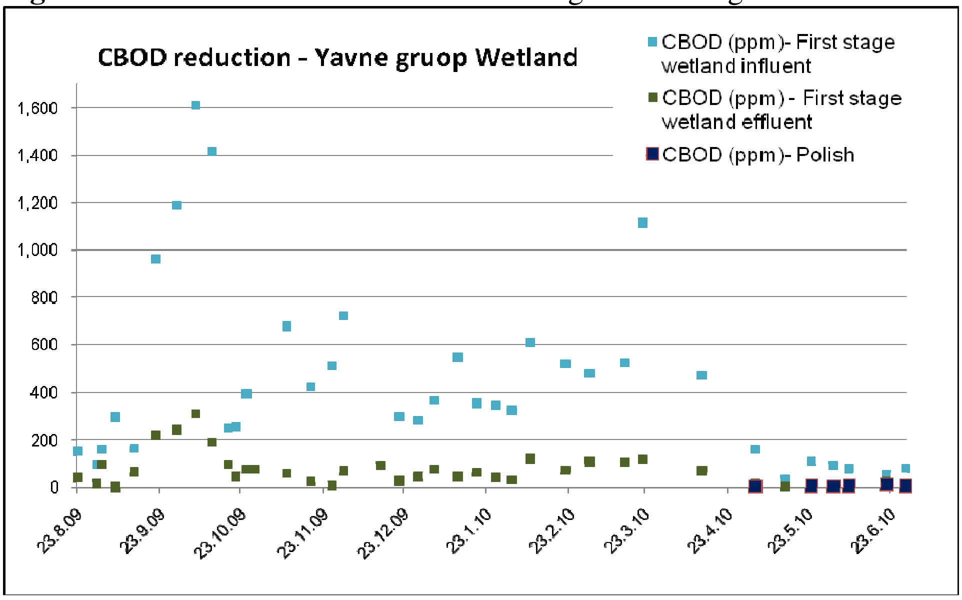


Figure 6. BOD concentrations after both Stage A and Stage B of TAYA wetland treatment



The BOD values decreased in the anaerobic system from levels of about 4,000 - 10,000 mg/l to values of about 300 – 2,600 mg/l. The final effluent quality reached values of less than 100 mg/l after Stage A, and to about 3-10 mg/l after Stage B.

Figure 7. TSS concentrations of raw wastewater, after anaerobic pretreatment and after anoxic pretreatment

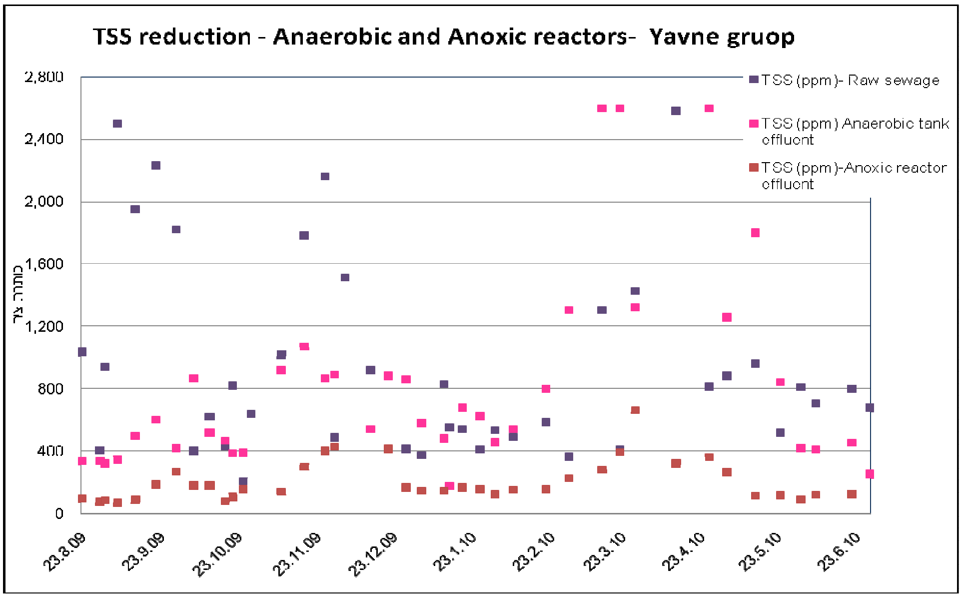
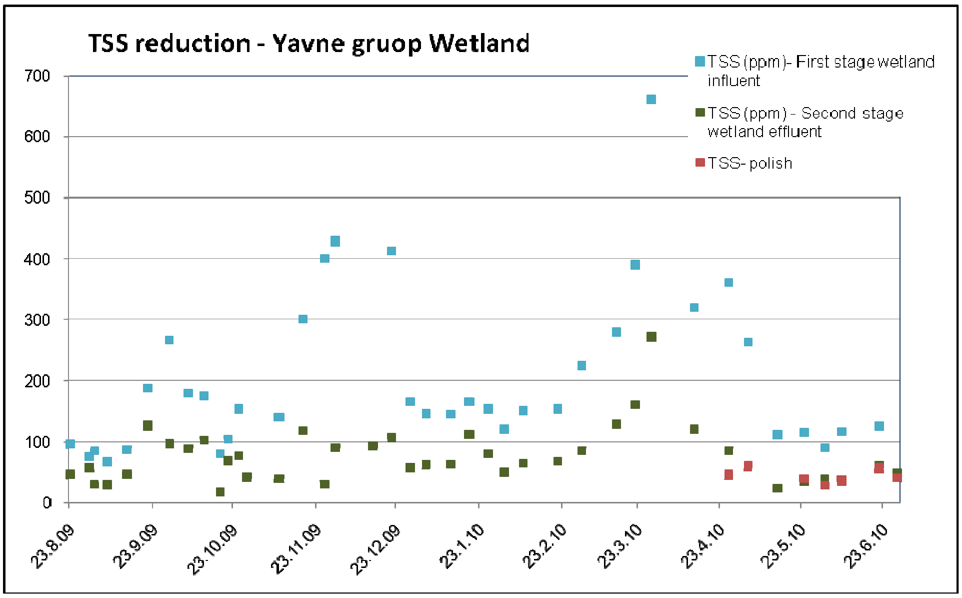


Figure 8. TSS concentrations after both Stage A and Stage B of TAYA wetland treatment



The TSS concentrations decreased in the anaerobic system from levels of about 800 – 3,500 mg/l to values of about 100 – 450 mg/l. The effluents' quality levels reached values of less than 100 mg/l after Stage A, and to about 50 mg/l after Stage B.

CONCLUSIONS

Fill-and-drain wetlands are an intensified wetland process capable of treating very heavy loads of agricultural and industrial wastewater. Due to their compact size, water loss through evapotranspiration is minimized, which makes effluents more suitable to agricultural reuse.

We have developed an effective design methodology which enables a clear calculation of the process in a similar mode to conventional systems (such as activated sludge) and it has been proven repeatedly in different industrial pilots with variable treatment objectives.

In summary, the TAYA system facilitates:

- A powerful treatment system of high organic loads and ammonia even with high TDS waste streams.
- Full treatment can be achieved with electricity consumption much lower than competing mechanical treatment technologies.
- Minimum area requirements compared to other more passive wetland technologies

The system is biochemically intensive but extensive in maintenance and electricity consumption.

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