Commercial demonstration and performance validation, Hassi Messaoud, Algeria

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1. Contents

REGEN: TECHNICAL PERFORMANCE VALIDATION

1. Executive Summary

REGEN Wastewater Technology Inc. has developed a containerized wastewater treatment system for decentralized or off grid locations. The system fits inside a 40' ISO shipping container and can be easily shipped to and installed in remote locations. The system combines improved fixed film technology, and energy efficient processes to significantly reduce the operation and maintenance costs of the system. The advanced technology allows the system to self-correct and sends warning messages to operators when actions are required.

REGEN staff traveled to Algeria to install the treatment system in March 2017. The local staff were trained in the operation of the system, which does not require skilled wastewater technicians. After 6 weeks of operation the system achieved 80% removal of BOD and the effluent met local guidelines for irrigation use.

Each piece of the system was selected to reduce complexity, increase efficiency and reduce energy requirements. The system has a very low energy requirement and requires on 1.5 kwh/m^3 of wastewater which makes it ideal for off grid location and incorporating renewable power sources.

2. Introduction

REGEN (**www.regenwater.ca**) is a Prince Edward Island, Canada based company specializing in modular, renewably powered wastewater treatment solutions. REGEN provides self-powered wastewater treatment solutions for domestic and industrial waste streams.

REGEN brings together a unique partnership of world leading expertise in microbiology, environmental engineering, power management, controls, automation, and advanced manufacturing. The primary goal is to develop low energy, self-powered, smart wastewater treatment options. REGEN customizes wastewater treatment solutions for decentralized or off grid locations.

The system was designed to treat wastewater from 300 people. The system is fully containerized and can be easily moved and installed in remote locations. The treatment system can save operators as much as 75 – 90% of the energy cost when compared to a conventional packaged MBR or MBBR treatment systems. The system does not require skilled wastewater technicians to operate the system.

The first treatment system was installed in a remote mining camp in Hassie Messaoud, Algeria. The client, RedMed Group has several remote mining camps and required a modular wastewater treatment system that had key design features that included – (1) low energy operation, (2) no use of chemicals for operation, (3) easily deployable. Another benefit to the company is the ability to use the effluent from the wastewater system for non-potable use (i.e. irrigation).

3. Process Description

Preliminary Process Flow Diagram of the wastewater system can be seen in Figure 1. If required more than one treatment container can be added after the Primary Tank / Holding Tank.

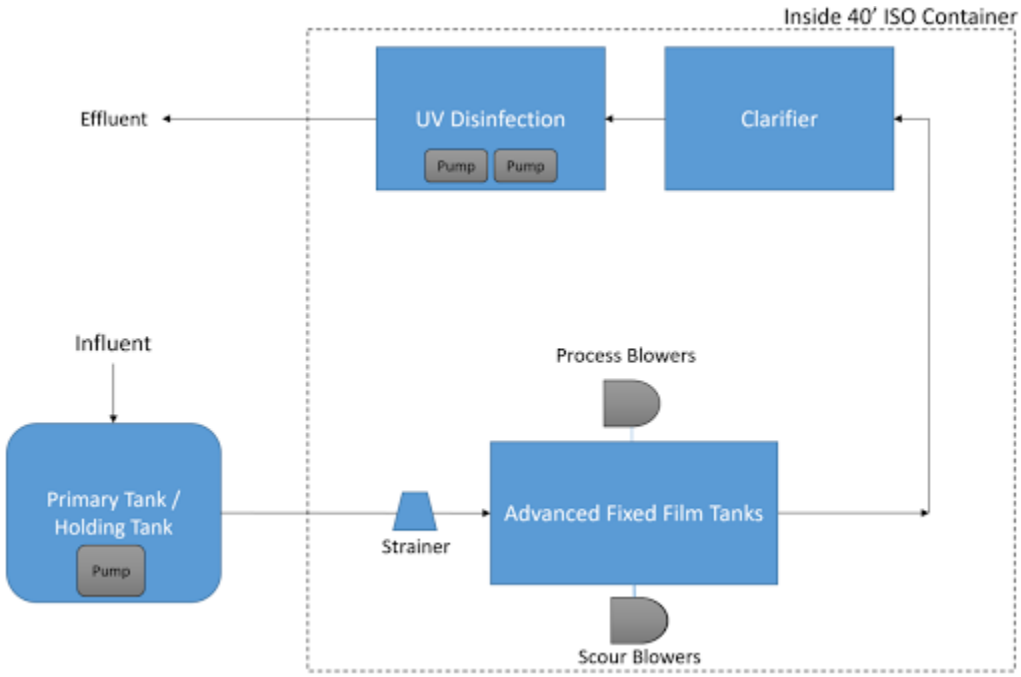


FIGURE 1 PRELIMINARY PROCESS REVIEW

Wastewater progresses through the upfront primary treatment and equalization. Wastewater is pumped by the duplex pumps through the strainer and to the 40' cargo container.

The Aerated Fixed Film Tanks are essentially considered an advanced fixed film biological process. Aeration comes from the membrane fibers, but aeration is done not through bubble generation, but by air diffusion through the fixed film. Biology grows directly on the fixed film, facilitating in the oxygen transfer. Oxygen transfer efficiencies can reach the range of 50 - 80%. The oxygen is consumed at this interface, and as such, no dissolved oxygen reaches the bulk wastewater.

During this step, BOD is consumed, while nitrification and denitrification also take place, due to the dissolved oxygen concentration being negligible. Process air is added in this step on a continuous basis. Larger scour blowers are included to help provide enough vigorous aeration to remove excessive biofilm growth on the fibers and provide intermittent mixing. This helps prevent any limit in the oxygen transfer due to biofilm thickness.

The system is designed to reduce process complexity, and to provide additional functionality in each process piece, enabling a reduction in overall tankage. This was accomplished by re-evaluating each step with the attempt to achieve more removal per tank. The result is a streamlined single-pass

wastewater treatment design. Complexity, such as moving parts, is removed when possible to keep operator maintenance and energy costs to a minimum.

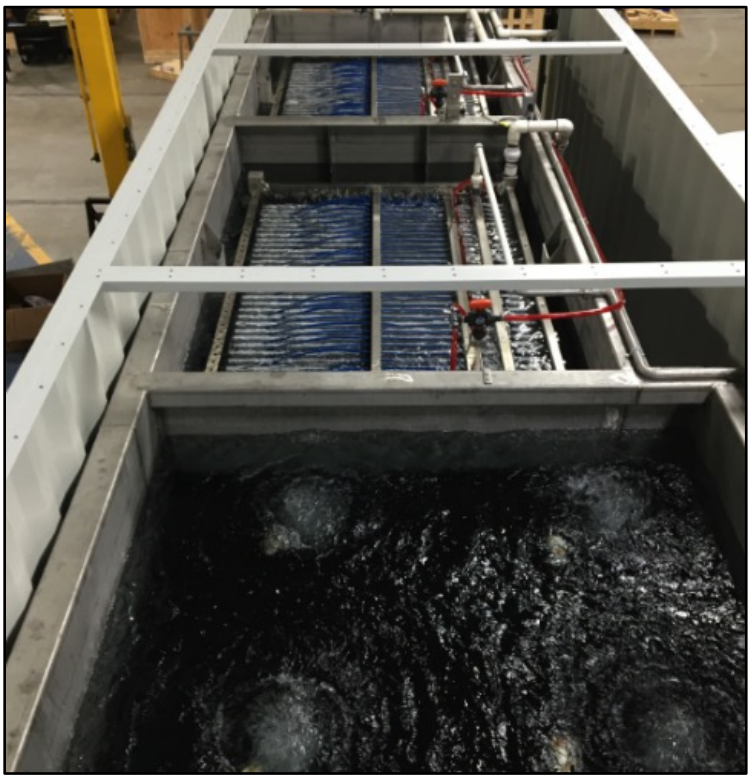


FIGURE 2 SINGLE PASS ENHANCED FIXED FILM PROCESS

a. Introduction to Advanced Fixed Film Technology

REGEN's advanced fixed film technology is an optimized fixed film process, with a specific aeration application. The advanced fixed film material is designed to reduce the operational costs of wastewater treatment. Aeration is the key component of biological wastewater treatment and traditional aeration technologies can be energy intensive processes. This advanced fixed film maximizes the efficiency of oxygen transfer.

FIGURE 3 EXAMPLE OF ENHANCED FIXED FILM MATERIAL

This aeration technology utilizes **diffusive silicone fixed film surface area** to supply the oxygen required for aerobic bacteria to treat wastewater. Biological treatment is accomplished through an attached growth system supported by an array of fixed film. The advanced fixed film creates an ideal environment to support a robust biofilm which absorbs and consumes carbon based pollutants.

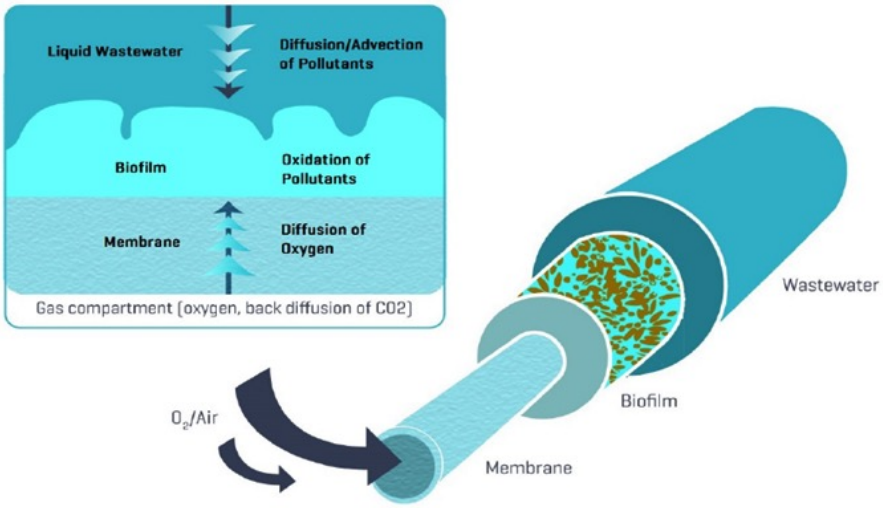


FIGURE 4 HOW FIXED FILM BIOLOGY REMOVES CONTAMINANTS

This increased oxygen efficiency allows additional oxygen to transfer directly to the biofilm and does not enter the wastewater bulk solution. This allows the wastewater to remain anoxic while aerobic processes continue to take place within the biofilm. In addition, because the process is biofilm-based, there is no requirement for sludge recycling.

Fixed Film Deployment

The improved fixed film is incorporated into a submersible modular cage unit.

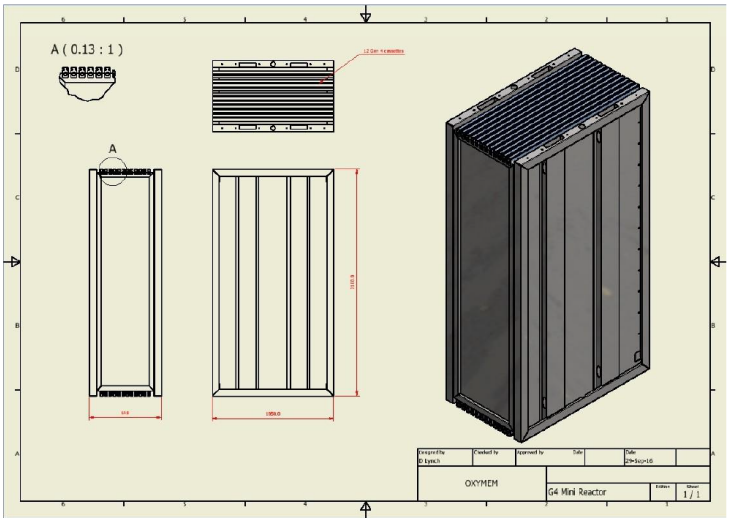
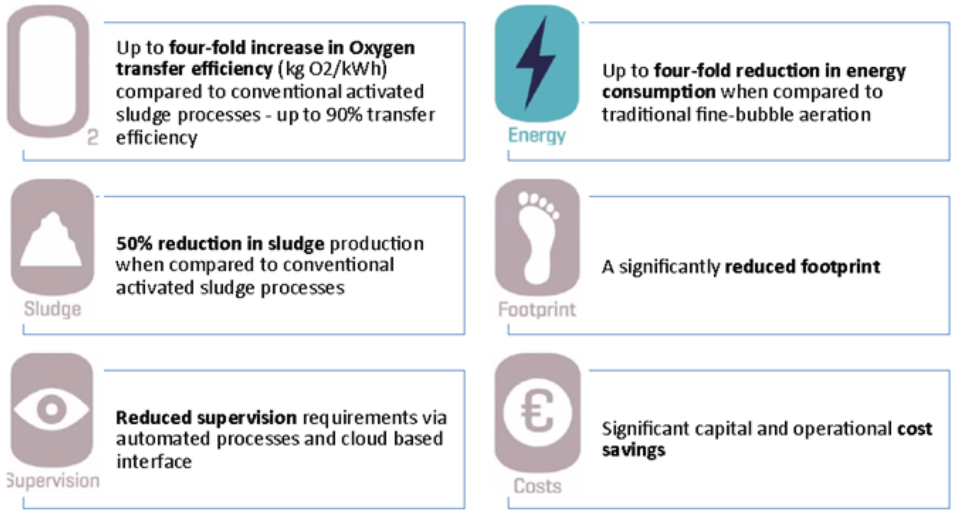


FIGURE 5 MODULAR FIXED FILM CASSETTES

The modular cage unit is designed to house a large amount of improved fixed film. The unit incorporates an in-built scouring and mix system for system optimization. In-built process connections for process, scour and mix air ensure ease of installation.

Advanced Fixed Film Benefits



The efficiency of any aeration process depends on the amount of surface contact between the air and the wastewater. **Traditional aeration technologies rely on bubbles** to supply the air to wastewater. Typically, less than 30% of oxygen supplied by diffusers is transferred to the wastewater resulting in a large amount of energy wastage.

The advanced fixed film technology enables the oxygen to be transferred directly to the bacteria thereby achieving oxygen transfer efficiencies of up to 90%. As a result, system air requirements are significantly reduced leading to dramatically reduced operating costs and **a more energy efficient treatment process.**

The biomass is attached directly to the fixed film surface. This results in a lower concentration of suspended solids in the bulk liquid. As a consequence, the advanced fixed film system produces approximately **50% less sludge** at the end of the treatment process when compared to conventional activated sludge processes.

With typical alkalinity concentrations, **wastewater can be processed without any additional chemicals added to the process, greatly reducing operational and logistical issues.**

The clarifier is an up-flow chamber that used gravity to feed the water into and out of the chamber.

The UV system is designed to receive wastewater at 50% UVT or higher. Typically, <30 mg/L TSS / BOD produces a UVT of 60%+. As such a UV dosage of 30-40 mJ / cm^2 is typical for the system.

4. Installation and Operation

The installation of took place in RedMed's main camp, located in Hassi Messaoud. REGEN team members were onsite to oversee the installation, train local RedMed employees, and assist in any trouble-shooting and maintenance for the first 6 weeks of operation. System installation was successful with minimal trouble-shooting and the trained staff have successfully been running the unit since. The installation is shown in Figure 6.

FIGURE 6: INSTALLED IN REDMED REMOTE MINING CAMP

5. Testing Procedure

On Aril 26, 2017 influent and effluent samples were taken from the treatment system. The influent samples were taken before the wastewater entered the screen vault and the effluent samples were taken after the wastewater exited the UV units. The samples were kept on ice and sent to a local third-party wastewater testing facility for analysis. The influent and effluent samples are shown in Figure 7.

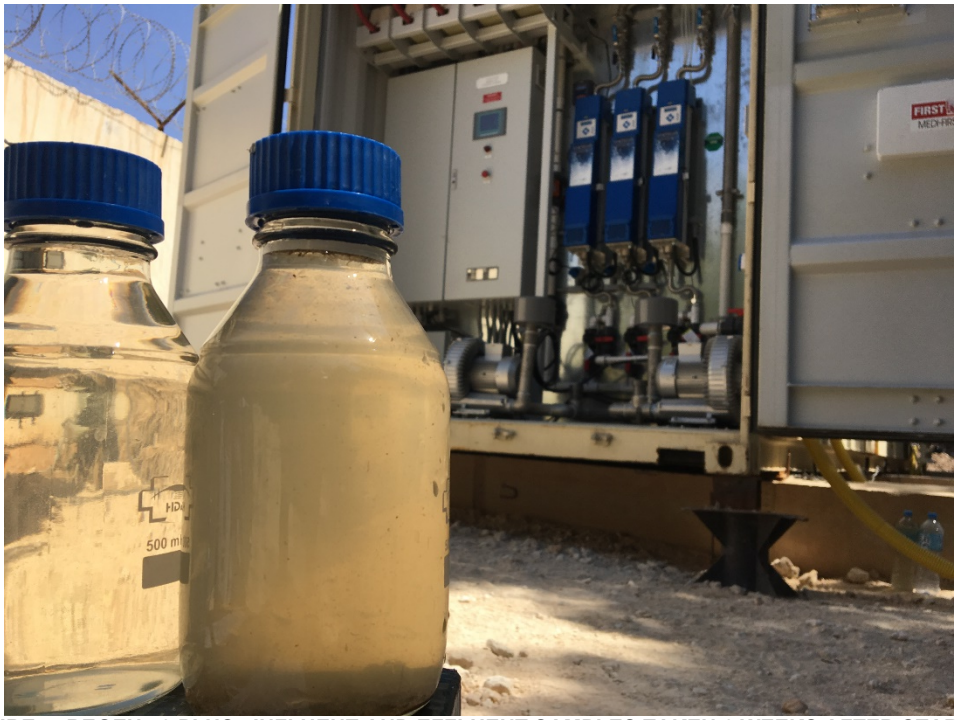


FIGURE 7: REGEN 40 PLUS+ INFLUENT AND EFFLUENT SAMPLES TAKEN 6 WEEKS AFTER STARTUP

6. Results

The results from the sampling achieved effluent results which met the local irrigation guidelines of 30 mg/L for both BOD and TSS, 90 mg/L for COD, and < 1000 CUF/100 ml for fecal coliform. The influent and effluent data is shown in Figure . The effluent fecal coliform was 70 CFU/100 ml which is well below the irrigation standards.

Each piece of equipment in the unit was chosen to have the minimal energy possible. The pumping and aeration processes are designed to minimize energy requirements while maintaining high removal efficiency and any unnecessary complexity was removed to reduce energy and maintenance costs. The treatment system achieved an energy efficiency of 1.5 kwh/m^3 of wastewater treated. The system saves 75 - 90% of operational costs over a typical MBR system.

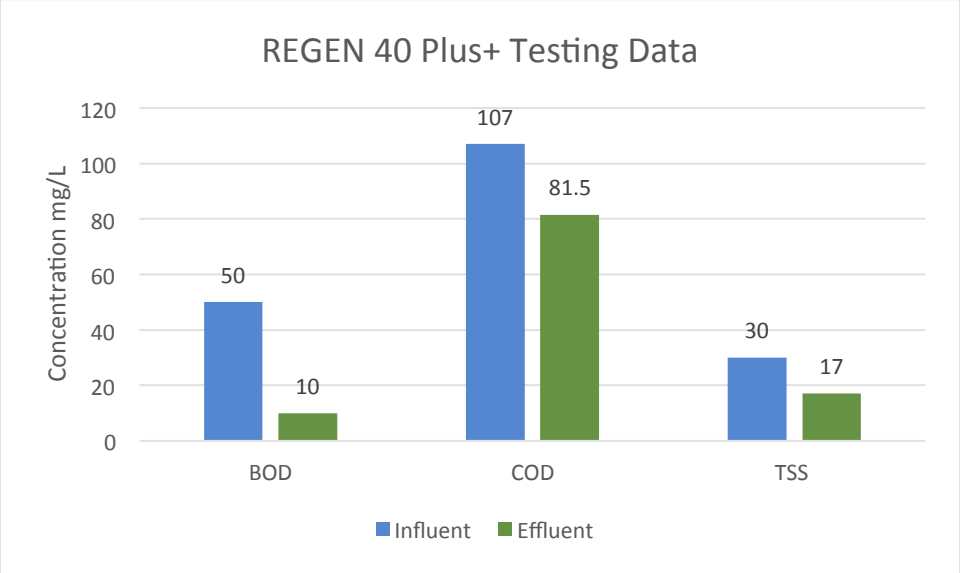


FIGURE 8: TESTING DATA RESULTS FOR INFLUENT AND EFFLUENT SAMPLES FROM THE REGEN SYSTEM

7. Conclusion

The installation of the treatment system at RedMed's remote mining camp in Hassi Messaoud, Algeria was a success. The local staff was trained to operate the system and due to the ease of operation, they have been successfully running the system since April. After only 6 weeks of operation the effluent was exceeding local guidelines for irrigation quality. RedMed was very pleased with the performance of the system and is looking to install other treatment products at remote camps across Algeria.