Water Treatment and Remediation using a Bioreactor

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Objectives:

1. *Investigate if bacteria cultures of a constructed wetland can remediate pharmaceutical compounds in waste water.*
2. *Investigate the best treatment sequence for pharmaceutical removal.*
3. *Investigate a treatment sequence for the removal and degradation of pharmaceutical, chemical, and organic compounds in various waste water types.*

Golf courses require an average of 48.2 acre feet to 386.2 acre feet of water for irrigation purposes annually, depending on location and regional availability. Water used for irrigation purposes might come in the future from: (i) storm runoff from impervious surfaces captured in retention ponds, (ii) high flow (flood) water diversion into storage ponds, (iii) secondary or tertiary effluent from a waste water treatment plant (WWTP), (iv) grey water, and (v) treated or raw water from a local public water supply distribution system. All of the above WW types might contain chemical and pharmaceutical compounds that can have a dramatic and disconcerting effect on humans and local wildlife, while placing a huge burden on the entity for effective water treatment.

Subsurface Bioreactors (S2BR) operated under a gravity feed drain system could provide the solution to treat the used waste water (WW) and provide a functional design, natural appearance, low cost in operation and maintenance, and can be operated year round in any US climate. S2BR operated under an advance dynamic fill and drain cycle could allow the removal of carbon, nitrogen, phosphorous and pharmaceuticals and personal care products (PPCPs) that have been discharged into the environment unchecked for many years. It is expected that applying S2BR technology to a golf course's infrastructure and operation requirements will allow treating any WW for irrigation purposes, as well as runoff water from golf courses that is discharged into environmentally critical water sheds.

Figure 1: Laboratory S2BR bioreactors could provide a natural, low cost method to treat waste water and provide.

Laboratory Installation:

The experimental S2BR laboratory cell 1 and cell 2 were designed out of a 55 gallon plastic drum split in half. Each cell's dimensions were 0.52 m x 0.86 m x 0.25 m with a surface area of 0.44 m² and 52 l of water holding capacity after the media was installed (Figure 1). Gravel media from an existing constructed wetland (CW) (Figure 2) at CERF was used to mimic the bacteria consortium, porosity, particle size, and sludge composition. The media was taken from the beginning, the middle, and the end of the CW and placed accordingly into the laboratory cells.

As a WW feed tank, a 1000 l industrial bulk container tank (IBC) was used. A metering pump was used to transfer the WW from the 1000 l IBC feed tank to cell 1,

Figure 2: CERF Constructed Wetland

and from cell 1 to cell 2. The treated WW was discharged from cell 2 into a large pan by opening a 3/4"valve. The S2BR system was installed in a barn at the CERF facility where the temperature was maintained at 70°C.

Laboratory Tests:

To determine the functionality of the laboratory S2BR, the ammonia (NH3) concentrations of the influent and effluent WW were measured immediately after the samples were collected with a Hach DR/2000 Spectrophotometer. The NH3 concentration can be directly related to BOD and COD removal of the WW. The system was considered functional if the ammonia effluent concentrations were found at a level below 4.5 mg/l. The influent NH3 level in the WW tested between 15.42 mg/l and 18.58 mg/l with a pH between 6.52 and 7.24 and temperature of 16.2 and 17.1 °C.

For the laboratory tests, the pharmaceuticals ibuprofen and naproxen were chosen because they are two of the most commonly used pharmaceuticals and can be found in the wastewater available at concentrations of 7.51 µg/l to 40.32 µg/ depending on the week day.

To test the pharmaceutical removal rate, a total system hydraulic retention rate (HRR) of 2 days, 1 days and 0.5 day was tested. The HRR is the time the WW needs to pass through the S2BR system.

Tests were conducted using U.S. EPA established standard methods (Methods 1694, U.S. EPA 2007), used for the measurement of more than 70 pharmaceuticals and personal care products (Methods 1694, U.S. EPA 2007). Tests were conducted using a HPLC-MS/MS.

All samples were tested in triplicate and the average was calculated.

Evaluation of the Experimental Laboratory S2BR

The S2BR laboratory evaluation had various influent levels of pharmaceuticals with a range of 7.51 µg/l to 40.32 µg/l, depending on the day of the week. Figure 3 shows the Ibuprofen and Naproxen remediation rate. Ibuprofen remediation was found to be 40.76%, 26.17, and 38.79% for the 2 day, 1 day and 0.5 day HRR respectively. Naproxen remediation was found to be 30.26%, 26.42, and 83.13% for the 2day, 1 day and 0.5 day HRR respectively. The variation in removal efficiency can be related to the different influent levels of pharmaceutical compounds in the waste water as well as effects of sorption and microbial degradation during the testing phase.

Discussion of Results:

Laboratory S2BR as used for this research can be used to evaluate WW removal functionality and pharmaceutical removal efficacy. The established bacteria consortium in the laboratory S2BR will remediate various influent levels of pharmaceutical compounds. At lower pharmaceutical influent levels a higher removal rate can be achieved. Due to a daily change in influent levels it cannot be determined which operation sequence will be best. For pharmaceutical influent levels of up to 25 µg/l a HRR of 0.5 day seems to be sufficient. Whereas for pharmaceutical influent levels of up to 40 µg/l a HRR of 1 day is not sufficient. However, pharmaceutical removal rate seems to be linked to the volume and surface area of the media of the S2BR where better pharmaceutical removal rates can be achieved if the influent level is

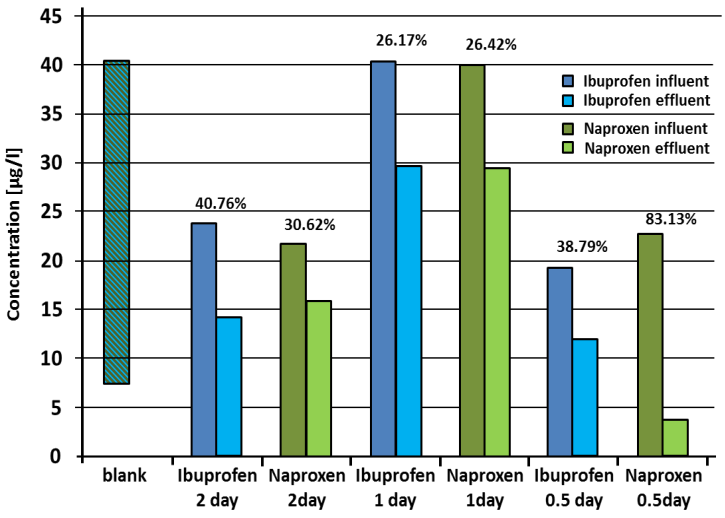

Figure 3: Ibuprofen and Naproxen Removal from

lower. This leads to the conclusion that a S2BR with greater media surface area will have a higher removal rate due to its larger internal surface area available to host the remediating bacteria consortium.

Next Steps:

- Build a portable 1000 gal S2BR pilot unit and perform initial tests at the Minoa Cleanwater Educational Research Facility and later dispatched the S2BR unit for testing at a golf course site.
- Selection of a suitable Golf Course for installation by USGA.
- Installation and testing of water remediation performance at the selected golf course site.

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