Passive Onsite Disinfection Using Gravel Conveyance System

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Introduction

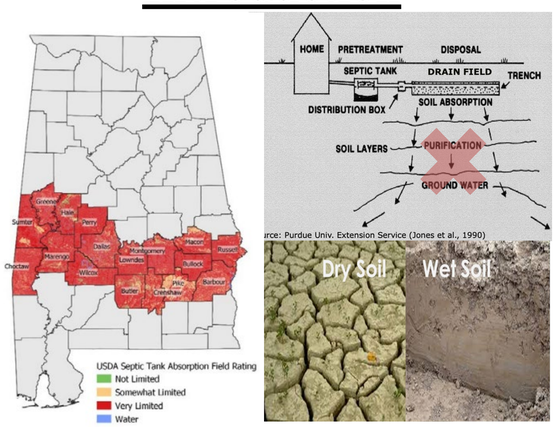

Fig. 1 Alabama Black Belt Region

Alabama Black Belt Region

- Typically defined as 17 counties in central Alabama and named for the dark fertile **clay** soil historically used for cotton production in the region (Fig 1)
- The region has a high poverty rate and only half of the people living in the Black Belt have access to sewers (Fig 1 & 2)
- As septic tank drainfields don't work, many households release raw sewage straight on to the ground, leading to severe public health concerns (Fig 2)

Fig. 2 straight pipes in the Black Belt Region of Alabama

On-site treatment solution

- Aerated treatment systems with post-UV disinfection is currently being used to treat septic tank effluent (Fig. 3 & 4)

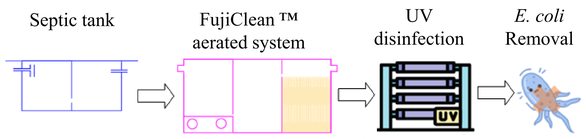

Fig. 3 On-site treatment solution

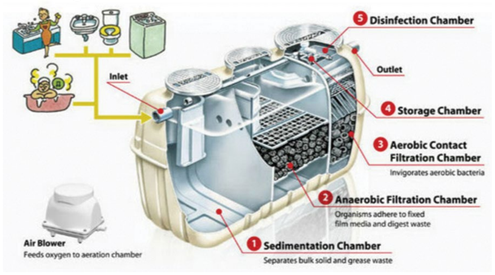

Fig. 4 FujiClean™ aerated treatment system

- When in operation, the combination of aerated treatment with post UV disinfection has shown to remove >90% of Total Nitrogen, Phosphorus, Biochemical Oxygen Demand and *E. Coli*.
- However, *E. coli* removal was inconsistent primarily due to periodic failures in the UV disinfection system, and frequent maintenance is cost-prohibitive for the residents.

Overall Objective

- Develop and test a gravel conveyance system as a cost-effective (and passive) alternative to the current UV system for *E. coli* removal

Specific Objective

- Determine the optimal Hydraulic Retention Time (HRT) for the gravel conveyance system to achieve the required level of *E. coli* removal

Method

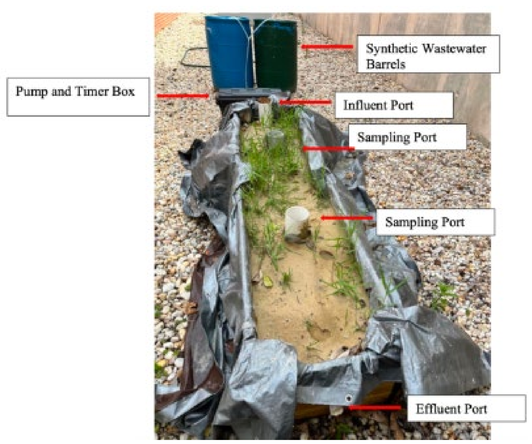

Fig. 5 Pilot- scale Gravel conveyance

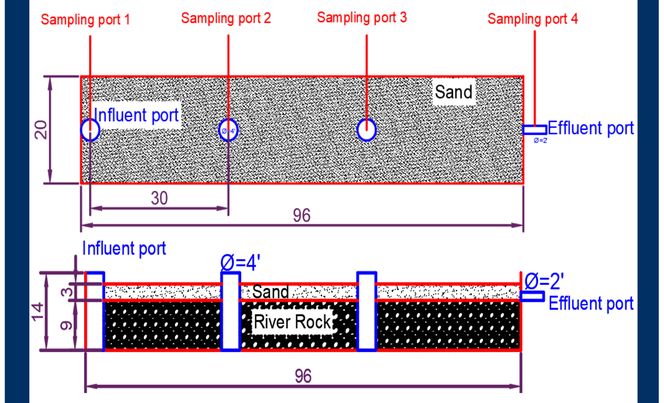

Fig. 6 Plan and profile of Pilot-scale Gravel conveyance

- A pilot-scale Gravel conveyance system was constructed with dimensions of 96" x 20" x 12" (LxWxH) (Fig 5 & 6)
- Out of a total height of 12", 9" was filled by #57 river rock, and the top 3" filled with sand
- Three 4' diameter PVC pipes (Sampling port 1, 2 & 3) were placed within the system and a 2' diameter effluent port served as Sampling port 4 (Fig. 6)
- Water spiked with *E. coli* was used to simulate the effluent wastewater coming out of the FujiClean ™ aerated treatment system
- Hydraulic retention time (HRT) of the system was varied via influent flow rate control
- Water was pumped from a 50-gallon tank at a flow rate of 50, 35, 30, and 25 gallons per day (gpd) was used to provide an HRT of 0.57 day, 0.81 day, 0.95 day, and 1.1 days, respectively
- One gallon of concentrated *E. coli* spike dose was poured into the influent port (also Sampling port 1) at the beginning of each HRT test
- Triplicate Samples were collected from 4 ports at three different times (0, 24, and 48 hrs) and analysed using CompactDry™ *E. coli* (EC) and Coliforms for colony counting kit
- All tests were repeated three times, approximately three months apart, to assess the impact of external environmental exposure on removal efficiency

Results

- Fig. 7, 8, 9, and 10, show the mean value of the 3 different days, with the triplicate sample at each port, a total of 9 sets (n=9) with flow rates of 25, 30, 35, and 50 gpd respectively
- **No** *E. coli* was measured in the gravel conveyance effluent port at 0, 24, and 48 hrs for HRTs of 0.95 and 1.1 days (Fig 7 & 8)
- For HRTs of 0.81 and 0.57 days, traces of *E. coli* traces were seen in the water samples after 24 and after 48 hours (Fig 9 & 10)
- Based on the optimum HRT of 0.95 days, the dimensions of the gravel conveyance system required for a three-bedroom house must be 22' x 7' x 1.25' (LxWxH)
- Out of a total height of 1.25', 1' must be filled by #57 river rock, and the top 0.25' must be filled with sand

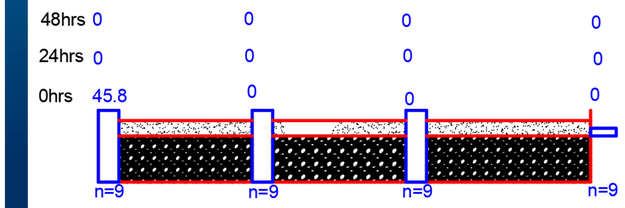

Fig. 7 Hydraulic Retention Time of 1.1 days (results in cfu/ml)

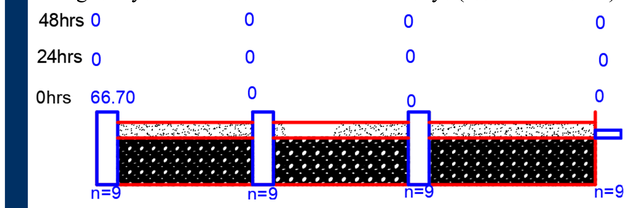

Fig. 8 Hydraulic Retention Time of 0.95 days (results in cfu/ml)

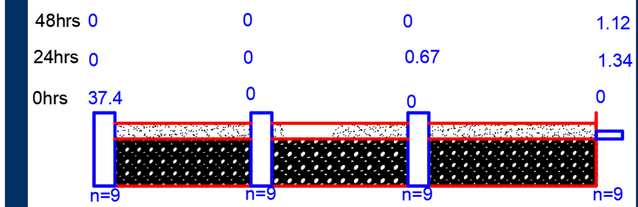

Fig. 9 Hydraulic Retention Time of 0.81 days (results in cfu/ml)

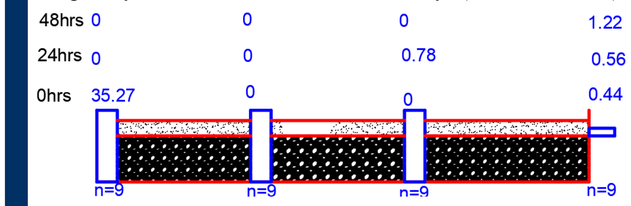

Fig. 10 Hydraulic Retention Time of 0.57 days (results in cfu/ml)

Conclusion and Future Work

- The pilot-scale study results demonstrated effective *E. coli* removal at HRTs of 0.95 or 1.1 days
- However, the current flow rate or Hydraulic Retention Time (HRT) smaller than that expected from a household, thus full-scale testing is needed
- In future work, the team plans to test the addition of biochar to the media, aiming to enhance *E. coli* removal efficiency at lower HRTs, thereby reducing the system's overall size

Acknowledgment and Disclaimer

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Reference will be provided upon request