Wastewater Management in Rural Pakistan

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ABSTRACT

Water contamination is a major issue in rural Pakistan. Poor wastewater management practices are the leading cause of contamination and human disease. In many villages, wastewater from houses flows freely in open channels and unlined ditches before draining directly into crop fields for irrigation [1].

Water hyacinths are an invasive, aquatic plant that is abundant in Pakistan. They have been tested before on treatment of industrial wastewater, providing promising results, but were not yet tested on human wastewater [2]. Testing was performed using human wastewater, to determine remediation rates and overall reductions of wastewater parameters. The hyacinths provided major reductions, making them a simple and available form of treatment for rural villages. The proposed solution has two methods of reducing contamination. The first subsystem is the implementation of graded 4" PVC pipes in side ditches to transport wastewater. The second subsystem is the use of phytoremediation units in the main channel, which will provide basic treatment and cover the waste. The water hyacinth was selected as a plant for phytoremediation based on its rapid growth, hyperaccumulator capabilities, widespread abundance in Pakistan and high reduction rates found through testing [3].

Critical to the success of this design are the accompanying implementation and education plans that were completed in conjunction with the project. The implementation plan includes information on materials, assembly, and maintenance and will offer an easy way for villagers to execute the proposed solutions. The education component has a brief curriculum to educate villagers on the dangers of wastewater and how this solution provides a safer alternative.

BACKGROUND

Since September of 2017, a design team of UPEI engineering students has been developing a wastewater management system for the Pakistani village Chak 232, JB. In October of 2017, the team of students traveled from Canada to Pakistan to see the village and observe the existing wastewater management state. Currently all wastewater freely flows from houses into open ditches on either side of the streets. These side street ditches flow into one larger concrete, square channel on the main street. The wastewater then flows from the main channel directly into the irrigation system for crops. A feasible solution to this problem would provide better management and basic treatment, reducing wastewater parameters, at minimal cost.

Figure 1: Existing Management State

While on the site visit, a plant called water hyacinth was discovered in the village. Water hyacinths are an invasive, aquatic plant that is found in abundance in Pakistan. Typically they are thought of as a troublesome weed, but they have been experimentally tested in the treatment of industrial wastewater in the past. They were not yet tested on human wastewater [2].

TESTING

Test plans were developed to see how water hyacinths would impact domestic wastewater. Testing was performed at the Charlottetown wastewater treatment facility, using inflow wastewater from the surrounding area. 15 liters of water was collected in three different containers, one being a control. Periodic samples were taken to test wastewater parameters and compare reductions over time.

Figure 2: Testing Setup

RESULTS AND ANALYSIS

Testing was successfully performed. Periodic samples of the wastewater were taken to the PEI Analytical Lab to measure parameters such as: fecal coliform, CBOD, BOD, Nitrogen, Ammonia and Phosphorus. All parameters except Phosphorus decreased over the 28 day period. Of the parameters, fecal coliform and CBOD had the biggest reductions. These tests were performed at 12°C. According to literature reviews, the remediation rate will increase as surrounding temperature increases [4]. The figures below show the CBOD reduction, where the plants enabled 88% reduction and the control had 54% reduction of wastewater. The final fecal coliform samples are shown on day 28. All the fecal coliform samples started at $1.6x10^6$MPN on day 0.

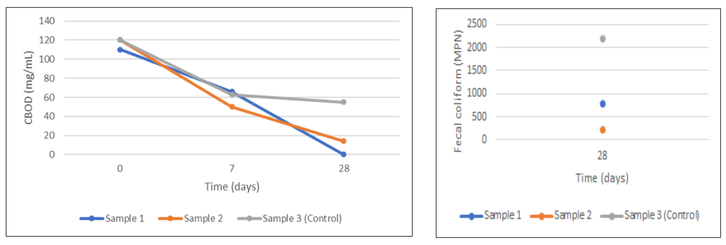

Figure 3: CBOD and Fecal Coliform Test Reductions

DESIGN

The designed solution which provides better management and basic treatment at minimal cost, has two components. The first component is the implementation of 4" graded PVC pipes in the existing side street ditches. These pipes will minimize villager contact with the wastewater and will prevent soil seepage, which causes contamination of wells.

The second component of the design is phytoremediation units, which will float in the main concrete channel. Water hyacinths will be suspended in many framed units to provide treatment to the water as it flows down the channel. The figure below shows a corner of a side street with the main street model. From left to right: existing channel and ditch, channel with grate units and ditch with PVC pipes, channel with phytoremediating plants added to grates.

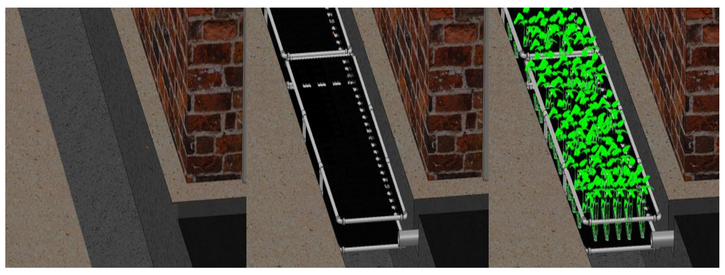

Figure 4: Corner of Side Street and Main Street CAD

IMPLEMENTATION

A prototype of the design was developed and tested at UPEI to ensure the water hyacinths would not have any negative effect on water flow. Water hyacinths were grown in grates in a simulated channel to ensure the grate did not have any impact on the plant growth. The plants were grown and observed for 3 months in the channel prototype.

For a full-scale implementation of the design in the village, the conversion of cost would be approximately $134CAD (12,000 pkr) per household.

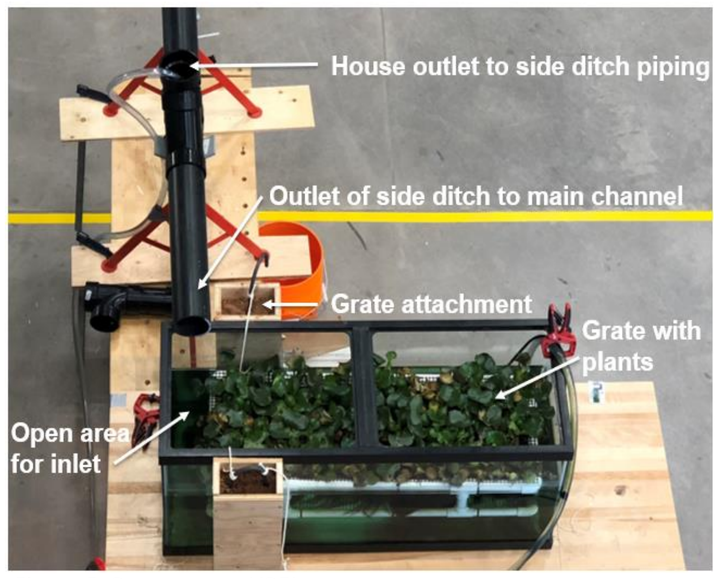

Figure 5: Prototype at UPEI

Implementing the design in the village is one of the most critical aspects of the project, as it must integrate easily into the already existing cultural patterns. A detailed guide was prepared, both in English and the native langue of the village, Urdu. This user guide shows the required materials, assembly, maintenance and explains how the design works. The plan for implementation is that it will occur in the up-coming Pakistani school year (2018-2019). Students from the University of Agriculture Faisalabad will oversee the implementation which will be performed primarily by villagers, with support from the university.

Figure 6: Discussion with Local Villagers

The second part of implementation is the educational component. A brief lesson plan has been developed to educate the villagers more on the dangers of wastewater. This information is targeted towards all villagers, but will be going directly into classroom lessons at the village school.

CONCLUSION

This project focused on the research and development of a wastewater management system for the rural Pakistani village of Chak 232, JB. A typically troublesome aquatic plant was combined with basic plumbing strategies to provide a two part solution of better management and basic treatment at a minimal cost. The planned implementation of the design is during the coming Pakistani school year, which will be led by students from the University of Agriculture Faisalabad.

REFERENCES

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