CONSTRUCTED FLOATING WETLANDS FOR REDUCING WATERBORNE DISEASES

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ABSTRACT

Waterborne diseases pose a significant burden to national healthcare in Bangladesh. Children below five years of age are the most vulnerable to waterborne diseases. Therefore economically feasible and sustainable intervention is desirable. Constructed floating wetland for the treatment of surface water demonstrated efficient removal rates of Escherichia coli, organics and turbidity. A pilot-scale floating mat was constructed using airtight unplasticized Polyvinyl Chloride (uPVC) platform for buoyancy, and a combination of fishing net, grass straw and soil for supporting plants. The mat was allowed to float in a rectangular tank which replicated natural lake conditions, roots of the plants were allowed to grow while suspended underwater. Gulshan lake water was dosed into the tank for a period of eight weeks. Water samples from inlet and outlet of the system were tested for pH, Eh, Biochemical oxygen demand (BOD5), Escherichia coli and turbidity. Therefore, constructed floating wetlands hold the potential of becoming a cost-effective, green technology for cleaning tainted surface water and reduce waterborne diseases in Bangladesh.

Keywords: *Waterborne Diseases, Constructed Wetlands, Floating Mat, Public Health, Pollutant Removal*

1. INTRODUCTION

Almost 1.8 million out of 2.2 million people, who die every year due to diarrhoeal diseases, belong to low-income countries. Worldwide, one out of tenth principal reasons of death, in impoverished nations, happen due to waterborne diseases (Murray, & Schaller, 2010). In Bangladesh, more than half of all serious illnesses can be accredited to water, sanitation and hygiene linked issues (BRAC, 2008). Dearth of safe water sources often leads to a series of ripple effects which are debilitating to public health status. Ongoing global climate change is also gradually augmenting the spread of waterborne diseases (CCC, DOE, CDMP, DFID and, UNDP, 2008). Presence of heavy metals in surface water and their accumulation in organic life lead to severe human illnesses. Medeocre economy nations like Bangladesh are not able to contain the threats arising from these problems: often due to socioeconomic constraints. Surface water bodies in Bangladesh face unrestricted and extensive pollution from both industrial and non-industrial sources, despite a significant proportion of the population depending on them. Protecting and rescuing these water bodies may lead to a sizeable attenuation in waterborne disease rates. Constructed wetlands are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating wastewater. They are designed to take advantage of many of the processes that occur in natural wetlands, but do so within a more controlled environment (Winston et al., 2013). Constructed floating wetlands or floating treatment wetlands are an innovative and low-cost natural technology. In contrast to conventional free water surface and subsurface flow wetlands, floating treatment wetlands can be setup within a water retention structure which already exists (Stewart et al., 2008; Tanner, & Headley, 2011). Therefore floating wetlands do not require excess land area to carry out water treatment. In this study, the role of floating wetlands in improving surface water quality and reducing waterborne pathogens is explored.

2. METHODOLOGY

2.1. Study area

Gulshan Lake is the northernmost lake in a chain of water bodies in Dhaka, suffering from alarming levels of pollution. Gulshan Lake with an area of about 100 ha and is located at 23º48' N and 90º25' E of Dhaka city. Water samples were collected from three different locations at Gulshan Lake for testing and dosing purposes.

2.2. Hydraulic loading

Lake water collected from Gulshan Lake in Dhaka was dosed into the system in two phases. The 1st phase consisted of 4 weeks. For four days per week, 50 litters of water were dosed into the tank containing floating treatment wetland system. A period of 30 days water-lock was then observed before the start of the 2nd phase. In the 2nd phase, 75 litters of raw lake water were dosed directly into a tank containing floating wetland, 4 days per week for 4 weeks

2.3. Characteristics of the system

The rectangular steel tank, containing floating wetland, had length, width and height of 2.5m, 1m and 1.1m respectively. It consisted of 4 openings equipped with water valves; the upper two valves had been used for dosing and collecting samples. The floating mat consisted of uPVC pipes of 4 inch diameter, interconnected with four PVC bends and made airtight with durable plastic adhesive. The floating mat was 1.15m long and 0.85m wide. The plant bed was fabricated using fishing nets and ropes, grass straw, iron wires and soil (Figure 1). Plants used for this purpose included Dracaema Sanderiana, Lemnaceae, Phragmites, Salvinia, Hydrocotyl and Pistiastratiotes (Rahman et al., 2014).

Figure 1: Floating treatment wetland mat

2.4. Sampling, testing & data acquisition

After dosing in the wetland system, samples from influent and effluent water were collected in sterilized containers from the inlet and outlet of the steel tank. The flow of water was regulated using manual valves. The collected water samples were tested for pH, oxidation reduction potential, biochemical oxygen demand (BOD_5), *Escherichia coli* and turbidity. Dosing, subsequent sample collection and testing were conducted in two phases of 4 weeks each. A water lock with a period of 30 days was observed between week 4 and week 5.

3. RESULTS AND DISCUSSION

Data obtained from testing the samples have been represented below in their respective sub-sections and followed by explanations.

3.1. Influent and effluent pH in phase 1 and phase 2

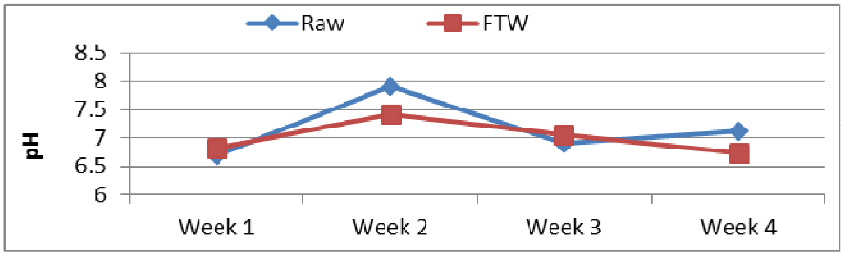

Figure 2: pH in phase 1

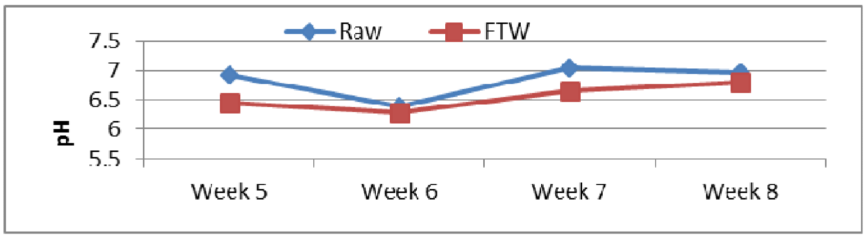

Figure 3: pH in phase 2.

In phase 1 (Figure 2), the average influent pH was 7.16 while the average effluent pH of the Floating Treatment Wetland was 7.01. In phase 2 (Figure 3), the average influent pH was recorded 6.83 and the average effluent pH was 6.55. In both the phases the floating treatment wetland seemed to have a role in negating pH deviations.

3.2. Redox potential (*Eh*) data analysis

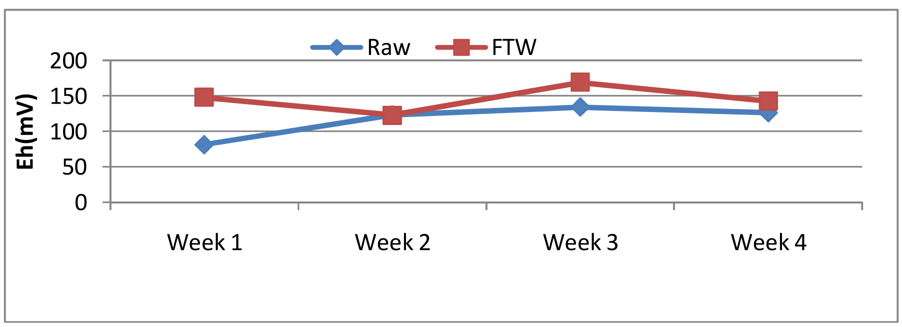

Figure 4: Eh in phase 1.

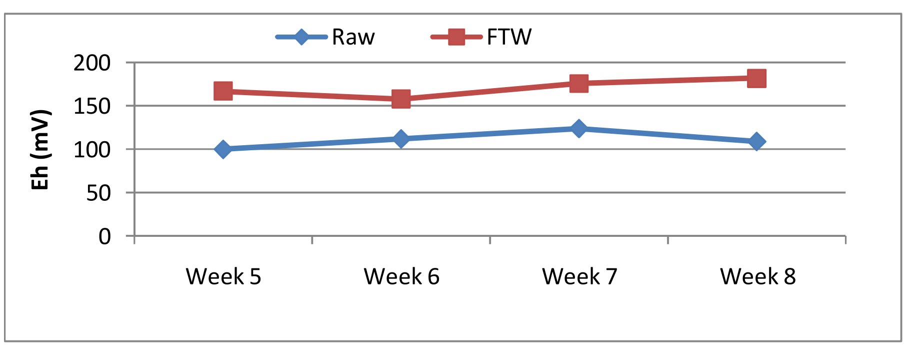

Figure 5: Eh in phase 2.

In both phases (Figure 4 & 5), the oxidation reduction potential increased significantly, meaning the existence of aerobic condition of lake water which became more aerobic after passing through the floating treatment wetland system. This aerobic condition assists in the biological treatment for removing contaminants, especially organics (Reddy, & Angelo, 1997).

3.3. Escherichia coli data analysis

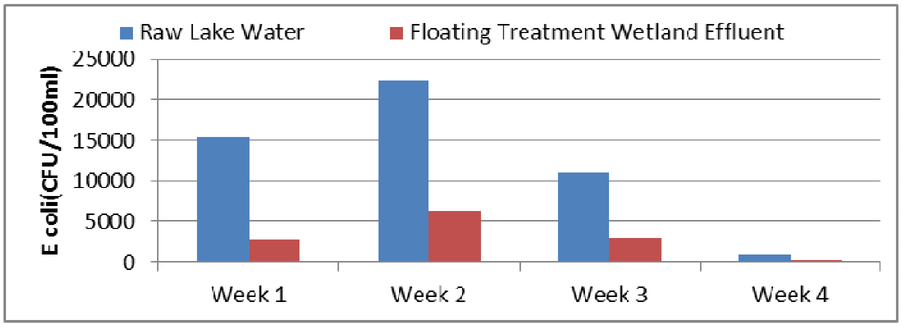

Figure 6: the status of E.coli in phase 1

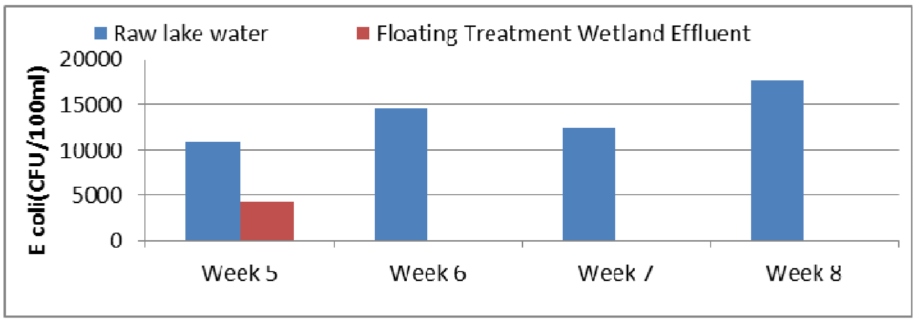

Figure 7: the status of E.coli in phase 2

After treatment in the floating wetland system, significant E.coli removal rate of 88.94% was observed. Phase 1 testing showed a removal rate of 75.66% (Figure 6), which was relatively lower compared to the removal rate in Phase 2 (Figure 7). The time difference between phases 1 & 2 allowed the plants in the floating wetland system to mature, and therefore the system performed more efficiently in the 2nd phase compared to the 1st. Removal rate in each phase improved as the week went along. There was a notable difference in terms of removal performance between weeks 4 & 5. This significant improvement in removal rate can be attributed to the water-lock condition of about one month in between these two weeks. The rainy season combined with the nutrient rich raw water contributed to the quick maturation of plants in the system. E.coli is an indicator organism; levels of removal of this organism may be taken as an indicator for removal of harmful pathogens from water (Harwood et al., 2005).

3.4. BOD data analysis

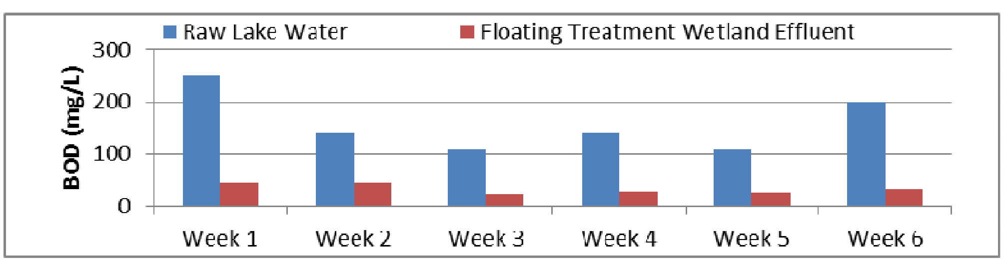

Figure 8: the status of BOD5 during testing period

The floating treatment wetland system was able to achieve impressive organic removal rates in both phases (Figure 8). The BOD_5 is a measure of the amount of biodegradable organics present in water. Organic wastes mostly originate from sewage disposal into open water bodies. These disposed organics decompose eventually. It reduces the amount of dissolved oxygen in water, leading to death of all aquatic life, rendering the water source unfit for public use.

4. CONCLUTIONS

Constructed floating wetlands achieved impressive removal rates of E.coli from lake water, showing its capability of removing harmful pathogens from water bodies. Thus floating wetlands demonstrate a promising prospect of reducing waterborne diseases contracted from surface water. Organics and turbidity removal rates by the floating wetland were also impressive; depicting its potential for significantly increasing the water quality in lakes, ponds and even rivers. Therefore, widespread application of floating wetlands in Bangladesh may help recover polluted surface water for safe usage by local population. Materials required for floating wetland mat construction are cheap and locally available in Bangladesh. Fabricating these systems is easy, and maintenance is not required. Therefore floating treatment wetlands are economically & environmentally a superior option than conventional water treatment technologies.

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