FLOATING TREATMENT WETLANDS FOR STAGNATED WATER TREATMENT

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Abstract- Floating Treatment Wetlands (FTWs) are an innovative alternative of the more traditional constructed wetland and pond technologies that offer great potential for the treatment of the polluted water stagnated areas. This study is aimed at designing a New Combined Treatment Wetland (NCTW) and assess the treatment efficiency by treating stagnated water in lab scale and pilot scale studies in tropical climate of Sri Lanka. Two types of floating macrophyts, Typha angustifolia and Canna irridiflora, and submerged macrophyt, Hydrilla verticillata were investigated in a lab scale study in batch experiments, using two Surface Treatment Wetlands and a Submerged Treatment Wetland (STW). Biological Oxygen Demand (BOD_5) and total nitrogen removal efficiencies were measured at different depths of water; 0.0 m, 0.6 m, and 1.2 m from the water surface in 5 day intervals. The experimental results revealed both Typha angustifolia and Canna iridiflora can be used effectively for removing carbonaceous and nitrogenous compounds from surface water. The maximum treatment efficiencies of two Surface Treatment Wetlands were recorded at surface level. Canna iridiflora was found to perform well at maturity and Typha angustifolia perform well at the beginning. But none of them were capable of treating water at a depth greater than 60 cm. Considering the aesthetic appearance and treatment efficiency, Canna iridiflora was selected as the best vegetation for treating surface water in stagnant water bodies. On the other hand, wetland planted with Hydrilla verticillata at a depth of 60 cm in the third tank proved that it was capable of removing carbonaceous and nitrogenous compounds from polluted water even below a depth of 60 cm. Surface Treatment Wetland planted with Canna irridiflora and STW planted with Hydrilla verticillata were combined together and a NCTW was designed and its treatment efficiency was investigated in lab scale and pilot scale. The results revealed that the NCTWs show an enhanced pollutant removal efficiency as they could cover the treatment in a depth –wise basis. It could be concluded that the NCTWs ensure a more efficient removal rate of pollutants from stagnated water in comparison with individual FTWs.

Keywords- Floating Treatment Wetlands, New Combined Treatment Wetlands, Submerged Treatment Wetlands, Treatment Efficiency

I. INTRODUCTION

Treatment of wastewater plays a vital role on human health; furthermore, the limitation of water resources and sustainable use of alternative water sources have led to the demand for the development of treating methods [1], [2], [3]. Different conventional methods for wastewater treatment such as Active Sludge Process (ASP), Rotating Biological Contactor (RBC), Stabilization Ponds, Oxidation Ditch, Trickling Filter (TF), Sequence Batch Reactors (SBR), Lagoons and Up Flow Anaerobic Sludge Blanket (UASB), Micro-algae Techniques etc. are used world-wide. These methods are blended with limitations such as energy, economic, need for large land, complex construction and operation, sensitive to temperature and excessive sludge [4], [8], [6]. Devices have been increasingly integrated into water sensitive urban design practices for the past two decades. This growing popularity has been largely due to the fact that pond and wetland based systems offer the advantages of providing a relatively passive, low-maintenance and operationally simple treatment solution whilst potentially enhancing habitat and aesthetic values within the urban landscape [7]. However, a number of limitations have emerged with the application of wetland systems for storm water treatment. Floating Treatment Wetlands (FTWs) are a relatively novel alternative of treatment wetland and pond technology that offer great potential for treatment of storm water and other contaminated waters. They have the key advantage, in terms of storm water management, of being able to accommodate at variable water depths. Further work is required to assess the performance and process dynamics of full-scale systems and to develop robust sizing and system design approaches to optimise the desired treatment processes and reliably achieve water quality objectives [8], [9], [10]. However, no research has been carried out to investigate the effect of combined system of submerged and floating plants on pollutant removal in floating treatment wetlands which caters the treatment process depth-wise. The contribution of the surface runoff and other improper waste disposal to the lakes and ponds are studied in this study through the introduction of a new floating wetland unit combining submerged and floating plants. The potential of using New Floating Treatment Wetland as a cheaper and effective alternative method for treating polluted water stagnant areas in tropical environmental was investigated in this study.

II. AIM AND OBJECTIVES

A. Aim

To evaluate the performance of a “New Floating

Treatment Wetland" as an effective water treatment technology in natural way for polluted stagnated water reclamation in tropical climate.

B. Objectives

- To select the most suitable vegetation cover for the Floating Treatment Wetland (FTW)
- To design a New Combined Treatment Wetland using locally available material.
- Apply the New Combined Treatment Wetland to the polluted pond in OUSL Kandy Regional Centre, Sri Lanka.

III. METHODOLOGY

Potential of the NCTWs for treating of wastewater was evaluated using lab-scale and pilot-scale batch experiments. Premises in Polgolla (Kandy Regional Centre, Faculty of Engineering Technology, Open University of Sri Lanka, Sri Lanka) was selected to establish the experimental setup. Four identical plastic tanks (0.375 m radius x 1.20 m depth; operational water volume 500 ml) set up under a clear plastic covered shelter were used to conduct a series of lab scale experiments. The pilot scale experiments were conducted in a polluted pond (4.5 m radius x 2 m depth) in the Open University of Sri Lanka, Kandy, Sri Lanka.

A. Design of Floating Wetlands

Two Surface Treatment Wetland models (each of 0.45 m x 0.3 5m) were constructed with a floater and a frame for keeping the vegetation and the media for growth of vegetation (coconut coir pith, mosquito net and GI mesh). STW unit was designed without a floater and media for vegetation and additionally added four floating balls for buoyance to keep the wetland unit at 0.6 m submerged depth. Typha angustifolia and Canna iridiflora as floating macrophytes and Hydrilla verticillata as a submerged macrophyt were selected for the experiment since these three types of macrophytes were available and sustainable at the environment in Kandy, Sri Lanka. Macrophytes approximately of 0.2 m shoot height were chosen carefully and planted in the wetland units with a plant density of 30 number of plants/m^2.

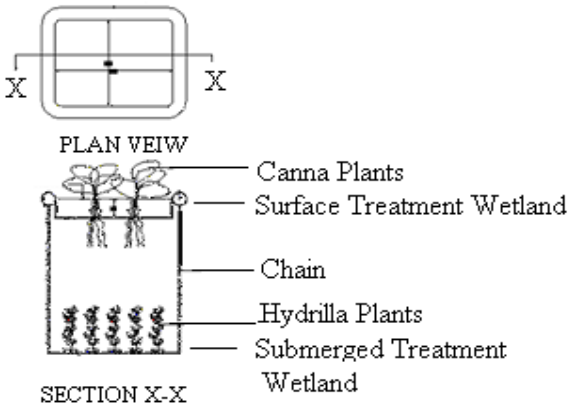


Fig.1 Schematic diagram of the New Combined Treatment Wetland

Surface treatment wetland unit with Canna iridiflora and STW unit were combined together by 0.6 m long four chains to produce NCTWs for lab scale experiments (Fig.1). Sixteen numbers of NCTWs (each size 1.35 m x 1.05 m) were constructed for the pilot scale experiments with a plant density of 10 no of plants/m^2.

B. Experimental procedure

Batch reactor method was selected to test all the Floating Wetlands with 30-35 days as hydraulic retention time. After running in tap water for a period of one week to acclimatize the systems, wetland units were placed in tanks and filled with wastewater coming from the canteen at the Open University of Sri Lanka, Kandy Regional Centre, Polgolla to stream water (proportion 1:8). Lab scale experiments were conducted for two Surface Treatment Wetland units and a STW. According to the initial stage results a NCTW was created and lab scale and pilot scale experiments were conducted.

Effluent samples were taken at different depth of water body 0.0 m, 0.6 m, and 1.2 m from the water surface at 5 days interval. Each sample was tested for BOD_5, NH_4^+–N and NO_3^--N at the Provincial Laboratory, Central Environmental Authority, Kandy, Sri Lanka.

IV. RESULTS AND DISCUSSION

A. Evaluation of treatment efficiencies of FTWs

BOD_5 removal efficiency of the two Surface Treatment Wetlands was found to be slightly decreased with time and varied significantly with depth. The highest BOD_5 removal efficiency of two Surface Treatment Wetlands was observed at the surface level and T. angustifolia performs well in removal of BOD_5 than that of C .iridiflora at this level. In Submerged Treatment Wetland unit, the maximum BOD_5 was observed at submerged level of 0.6 m depth (Fig 2). Ammonium (NH_4^+ -N) removal capabilities of FTWs were slightly decreased and Nitrate NO_3^-–N removal efficiency varied significantly with depth. The maximum total nitrogen removal efficiencies, in STWs were observed at level of 0.6 m depth and in Surface Treatment Wetlands at the surface level (Fig.3 and Fig.4).

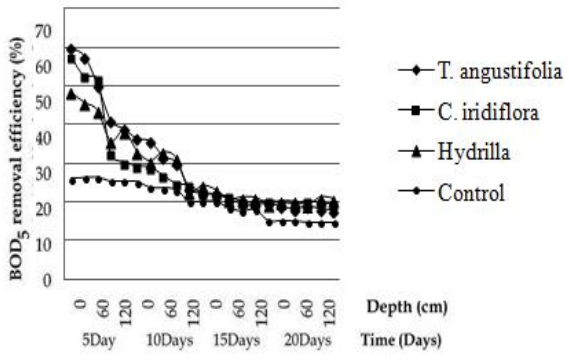


Fig.2 Depth-wise variation of BOD_5 removal efficiency of two Surface Treatment Wetlands and the STW with time

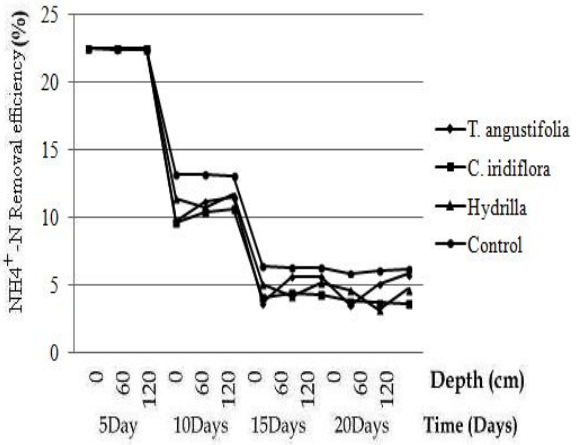


Fig .3 Depth wise variation of NH_4^+ -N removal efficiency of two Surface Treatment Wetlands and the STW with time

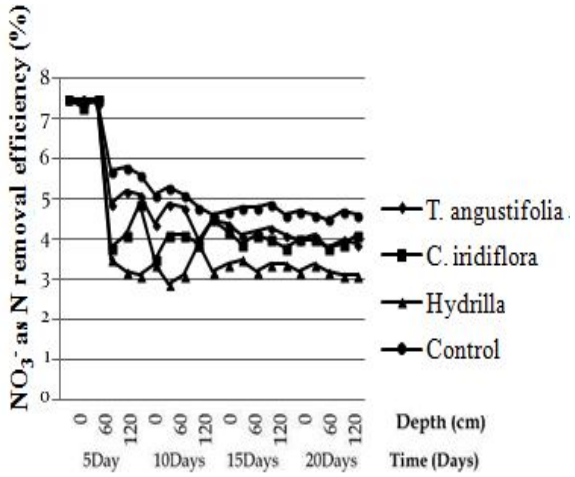


Fig.4 Depth wise variation of NO_3^- -N removal efficiency of two Surface Treatment Wetlands and the STW with time.

B. Evaluation of treatment efficiencies in FCWs

According to the results of the 20 day experimental period; over 20% of BOD and over 3% NO_3^--N removal efficiencies were observed at 0.6 m depth using the STW and over 19.5% of BOD_5 and over 4% NO_3^--N removal efficiencies were observed using the Surface Treatment Wetlands (Fig 2).

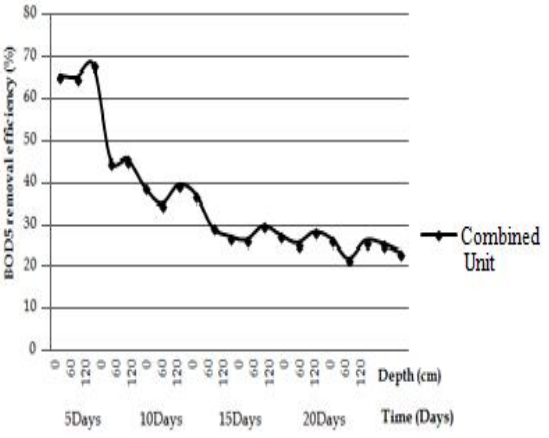


Fig.5 Depth wise variation of BOD_5 removal efficiency of NCTWs

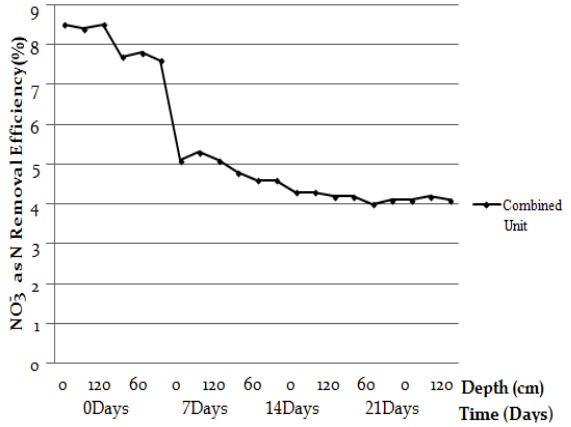


Fig.6 Depth wise variation of NO_3^- -N removal efficiency of NCTWs

After the same time period, Over 25% of BOD_5 and over 4% NO_3^--N removal efficiencies were recorded by using the NCTWs (Fig.5 and Fig.6).

CONCLUSIONS

Both Typha angustifolia and Canna iridiflora can be used effectively for removing carbonaceous and nitrogenous compounds from surface water. Canna iridiflora was found to perform well at maturity and Typha angustifolia shows better performance at the beginning of the treatment. But none of them were capable of treating water at a depth greater than 0.6 m. Considering the aesthetic appearance and the treatment efficiency, Canna iridiflora was selected as the best vegetation for treating surface water in stagnant water bodies in tropical climates.

Hydrilla verticillata is capable of removing carbonaceous and nitrogenous compounds even below a depth of 60 cm.

A NCTW was fabricated combining floating and submerged units. In the new unit Canna iridiflora was used as surface vegetation while Hydrilla verticillata was used as the submerged vegetation.

The NCTW is capable of treating stagnant water bodies both surface and depth – wise and the treatment efficiency is higher than the individual FTWs.

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