Effects of Hydrology on Constructed Wetland Vegetation in Tropic Region

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Abstract

Toddy distillery units produce a colour effluent which is rich in organic material. This effluent is one of the most environmentally unfriendly industrial product in the Jaffna district of Sri Lanka. Therefore, effluent from distillery unit has to be treated before being discharged into the environment. In this study, experiments were conducted to find out optimum dilution factor of effluent for wetland treatment to remove the organic loads from the effluent in constructed wetlands by using aquatic plants *Eichhormia* sp, *Lemna* sp *Lemna minor* and *Pistia* sp, The experiments were conducted by different process like aeration, dilution, adjusting the pH by using lime and hydraulic retention time using aquatic plants to reduce the various parameters in effluent. Important chemical properties such as pH, dissolved oxygen, EC and TSS of fresh effluent were measured to identify the problematic parameter and to determine the dilution factor It was found that the dilution of 1, 2, 3, and 4 was not effective due to the lower pH and dissolved oxygen value. The aquatic plants, *Eichhormia* sp, *Lemna* sp, and *Lemna minor* were successfully survived in dilution factor of five after aeration and pH adjustment. *Pistia* sp failed to survive in five dilution. Removal efficiency of phosphate and nitrate were significantly differ in *Lemna minor*, *Lemna* and *Eicchormia* compared from control. Maximum phosphorus removal was in the range of 50-54% and nitrate by 32 to 35% was observed with six days hydraulic retention time. These highest reductions of PO_4^{3-} and NO_3^- were achieved by *Lemna minor* in the dilution factor of five.

Key words: Constructed wetland, Dilution factor, Distillery effluent

Introduction

A large and increasing volume of wastewater is produced globally by the winery and distillery industries. Considerable amount of effluent is coming from the distillery units which are situated in Jaffna at Navally and Thikkam. In the Northern part of Sri Lanka, especially in the Jaffna peninsula the distilleries are using, naturally fermented palmyrah and coconut sap called 'palmyrah toddy' and 'coconut toddy' respectively to obtain ethanol. Amara *et al.*, (1990) stated that distillery unit generates 1.3 million liters of effluent annually and the principle waste is locally referred as "Coda". Direct discharge of effluent from the toddy distillation units into the environment is causing significant environmental pollution in Jaffna peninsula.

The fresh acidic spent wash produced from the distilleries are of high in temperature and have high Biological Oxygen Demand (BOD), and also consisting of large amount of suspended solids and high turbidity. Moreover, 88% of raw materials used in the distilleries are converted into waste and discharged into the water bodies without recommended treatments. Because of the above reasons, distillery industries have become a major source for the water pollution (Farid *et al.*, 2010). The disposal of large quantities of biodegradable waste into the water bodies without adequate treatment has been banded through the Environmental laws.

Distillery industries have become a major source of pollution, because levels of constituents of distillery waste are often above the permissible standards specified by the Central Environmental Authority. Also discharge of untreated acidic spent wash can destroy There are no any sound management techniques proposed until now to overwhelm liquid waste

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management problem which is the major deadlock for producers. Recent study focused new strategy to manage this problem through the construction of wetlands to treat the nutritive effluent and reuse it for agriculture as an alternative for chemical fertilizer and irrigate the crop land (Sathish *et al.*, 2013). Moreover, constructed wetlands can also be a cost effective and technically feasible approach for treating wastewater. Wetlands are often less expensive to build than traditional wastewater treatment unit and have low operating and maintenance expenses and can handle fluctuating water levels. Additionally, they are aesthetically pleasing and can reduce or eliminate odors associated with wastewater. However, the concentration of the distillery wastewater is too much for the direct application of the wetland treatment process .Therefore, this research is planned to find out the best dilution factor for wetland treatment.

Materials and Methods

Fresh effluent samples were collected directly from the outlet unit without accumulating in aerobic tank from Thikkam distillery in Jaffna into 20 liter plastic containers. The following aquatic plants, *Eichhormia* sp, *Lemna* sp, *Pistia* sp and *Lemna minor* were selected for this study because of their fast growing habit in fresh water and high nutrient feeding. According to the study of Amara *et al.*,. (1992) *Eichhormia* sp, *Lemna* sp *Lemna minor* and *Pistia* sp were used for biological treatment of distillery waste and stated that these plants were well survived to grow in effluent. Important chemical properties such as pH, dissolved oxygen, EC and TSS of fresh effluent were measured to identify the problematic parameter and to determine the dilution factor. For the experiments, the aquatic plants, which maintained in the plastic tanks were collected, cleaned and introduced in the constructed wetland. Approximately, 100 g of aquatic plants were used in each constructed wetland for this study. These experimental tanks were filled with effluent of 1000 ml. Triplicate of each experimental setup was maintained. The experimental setup were examined for a period of 7 days by 2 day intervals by using aquatic plants and conducted the study with various dilution factor (1, 2 ,5 ,10, 20). The dilution factor was used such that one part of effluent with various numbers of part of well water, thus, the ratio of 1, 2, 5, 10 and 20 represents these parts of well water mixed with raw effluent. The pH was adjusted by using lime. The concentrations of the various parameters in effluent before and after treatment with different aquatic plants were determined as per the standard procedure stipulated. The percent of removals of various parameters by aquatic plants were calculated.

Results and discussion

The pH value of the fresh spent wash was an acidic nature varying from 3.2 to 3.4. Dissolved oxygen value of spent wash was less than 1 mg/l. EC values of the effluent ranged from 1.08 - 4.02 mS/cm. Complete death of aquatic plants were observed in the dilution factor of 5, 4, 3, 2, and 1 times with groundwater due to the lower pH and dissolved oxygen value. In the series of dilution, plants survived in dilution factor of 20, because of effluent was adjusted the pH of 7 by adding water. But 20 L of groundwater was used to dilute one L effluent. This dilution factor is not economical one in large industrial scale.

Further the facts were used to improve the pH and increase the DO level. Even though effluent was aerated using air compressor for one hour, the system remains in an anaerobic condition with the DO level of less than one mg/l. The pH value of the effluent was adjusted to 6 by adding lime to the effluent. Lime was selected for neutralizing the effluent because of it is more effective and low cost than KOH or NaOH. Then this effluent was diluted with ground water in 1, 2, 5, and 10 times. Aquatic plants survived in 10 times of dilution with water. Again dilution factor was further reduced to 5

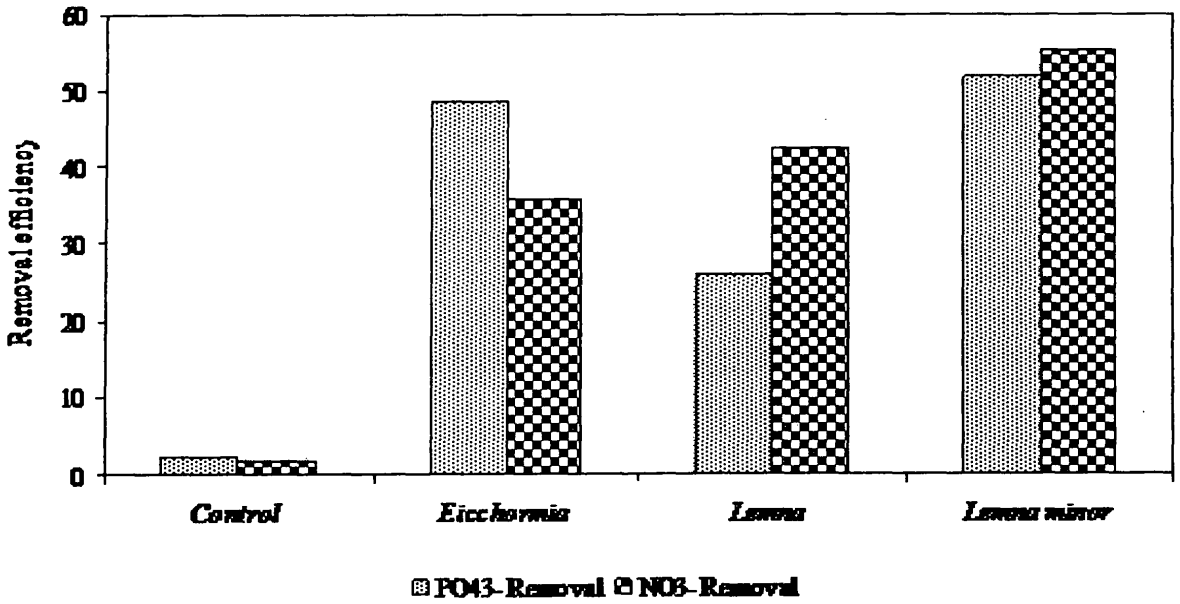

Figure 1. Removal efficiency of effluent after two days for PO_4^{3-} and NO_3^-

times in large scale treatment. Even further it could be reduced in contracted wetland while flowing water.

Figure 1 shows the removal efficiency of the effluent with various type of plant. It was found that, *Lemna minor* shows higher removal efficiency compared to others. The removal rates of PO_4^{3-} in constructed wetland were 2.35%, 48.24%, 25.88%, and 51.76%, respectively for control, *Eichhormia* sp, *Lemna* sp and *Lemna minor*. It was observed *Eichhormia* sp, *Lemna* sp and *Lemna minor* produced the greatest reduction in NO_3^-. The high removal rate of NO_3^- was found in *Lemna minor* as 55.17% of NO_3^- within two days. *Eichhormia* sp removes higher PO_4^{3-} than NO_3^- whereas *Lemna* and *Lemna minor* remove higher NO_3^- than PO_4^{3-}. The electrical conductivity value was 1.869 mS/cm after dilution with water. It was reduced to 1.856 mS/cm, 1.797 mS/cm, 1.592 mS/cm and 1.593 mS/cm for control, *Eichhormia* sp, *Lemna* sp and *Lemna minor*, respectively. The pH reduced from 7.05 to 6.45 due to the absorption of minerals by plants.

During the process of constructed wet land treatment, the problem was availability of water for dilution and disposal of wastewater from wetland. Particular amount of water was discharged from the outlet of distillery as waste during the processing time. Also normally the processing was during the months of April to August. Hence *Yala* rain water harvesting water could be used during the peak season of distillation. The large volume of wastewater could be used for producing valuable liquid fertilizer that reduces environmental hazards.

Initial parameters of raw effluent were high in temperature (80-85°C) large amount of suspended solids (1900 mg/l), high pH(3.23-3.3), EC(4.02-4.05Ms/cm), total phosphorus(37.6 mg) and nitrate(166.6 mg/l) were reported. The values of constituents of distillery waste and even diluted by 5 times were often above the permissible standards specified by the Central Environmental Authority for the discharge of industrial effluents into land.

The dilution of 1, 2, 3, 4 and 5 was not effective due to the lower pH and dissolved oxygen value. The selected plants were successfully grown in further dilution

series of 5 after the reduction of pH and aeration in lab scale. And only one aquatic plant species was survived in the dilution factor of four. Aeration and pH adjustment were influenced on reduction of the dilution. But further reduction of the dilution could be obtained in field flowing constructed wetland. The aquatic plants, *Eichhormia* sp, *Lemna* sp, and *Lemna minor* were successfully survived in dilution factor of five. *Pistia* sp was failed to survive in five dilution. *Lemna* sp were well survived even in the dilution of four.

Removal efficiency of phosphate and nitrate were significantly differ in *Lemna minor*, *Lemna* and *Eicchormia* compared from control. Maximum phosphorus removal was in the range of 50-54% and nitrate by 32 to 35% with six days hydraulic retention time. These highest reductions of PO_4^{3-} and NO_3^- were achieved by *Lemna minor*.

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