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CONSTRUCTED WETLANDS FOR WATER QUALITY IMPROVEMENT, RECYCLING AND REUSE

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Abstract: Natural wetland systems have often been described as the "earth's kidneys" because they filter pollutants from water that flows through on its way to receiving lakes, streams and oceans. Constructed wetlands are primarily biological filters that are very effective in removing BOD, COD, TSS and organic nitrogen; nitrates are almost totally removed. When comparing performance of wetlands, the comparison should be based on the performance of complete systems remembering that wetlands are only one part of a multi-part system. Wetlands can be subjected to wastewater discharges from municipal, industrial and agricultural sources, and can receive agricultural and surface mine runoff, irrigation return flows, urban storm water discharges, leachates, and other sources of water pollution. A pilot scale study was conducted in the SRM university campus for treating wastewaters from various types of industries. The different varieties of waste water used comprised of domestic wastewater, dairy wastewater, wastewater from petroleum industry and waste water from electroplating industry. The various species of plants that were used in the study are cattails *(Typha* spp.*)* and common reed (*Phragmites australis*).
The objective of the project was to identify cost effective wastewater treatment technique for different types of wastewaters and to identify the efficiency of wetlands for treating different types of wastewaters. The methodology focuses on both experimental and analytical. It included collection of wastewater, preparation of wetland tank model, study of soil and plant characteristics, study of treated effluent characteristics, water balance study and statistical analysis of the results. The wastewater was analysed by the use of a pilot scale prototype made using locally available materials such as gravel sand and pebbles. The design aspects and specifications were taken with respect to the standards. The wetland units developed consisted of a PVC tub of 70 x40x30 cm and the system was built with a slight slope (<1%) between inlet and outlet zones. This paper reviews the comparison of efficiency of constructed wetlands for treating various industrial effluents.

Key words: Constructed Wetlands, Typha spp, *Phragmites australis,* Industrial wastewater, Domestic wastewater.

INTRODUCTION

Introduction of anthropogenic chemicals and the massive relocation of natural materials to different environmental bodies (soils, ground water, and atmosphere), has resulted in severe pressure on the self cleansing capacity of recipient ecosystems (Susarla *et al*., 2002). Currently, it may be accepted that the necessity to control the release of contaminants was widely recognised and conceded by many countries (Schnoor *et al*., 1995). For achieving environmental sustainability or for the removal of the contaminants discharged from various industries and to include it in between the acceptable discharge limits, there are many treatment methods which are conventional. These conventional treatment methods have good removal capacities but are not cost effective methods and not biological in nature. For the achievement of a sustainable environment, implementation of biological methods which go hand in hand with the environment and its components should be adopted.

The constructed wetland systems (CWS) for wastewater treatment facility involve the use of engineered systems that are designed and constructed to utilize natural processes. These systems are designed to mimic natural wetland systems, utilizing wetland plants, soils and associated micro organisms to remove contaminants from wastewater effluents (EPA Manual, 1993). A growing number of studies have provided evidence that many wetlands systems are able to provide an effective means of improving water quality without creating problems for wildlife. While some degree of pre- or post- treatment will be required in conjunction with the wetland to treat wastewater to meet discharge standards. Various emergent macrophyte species can be used in constructed wetlands, including cattails (*Typha spp.)*, bulrushes (*Scirpus spp.)*, rushes (*Juncus spp.*), common reed (Phragmites australis) etc. The choice of plants is an important issue in CWs, as they must survive the potential toxic effects of the wastewater and its variability. (Cristina *et al*., 2007)

A pilot scale study was conducted in the SRM university campus for treating waste water from various types of industries. The different varieties of waste water used comprises of domestic wastewater, dairy wastewater, wastewater from petrochemical industry and waste water from electroplating industry. The efficiency of the constructed wetland was analysed for treating different types of wastewater and it was compared. The various species of plants that were used in the study are cattails *(Typha spp.)* and common reed (Phragmites australis). An integrated set up was also developed by planting both the species together in the wetland and the efficiency variation was analysed. The integrated setup was tried for only domestic waste water treatment. For electroplating waste water treatment the set up was tried with and without adsorbent media. The adsorbent media used was Cicer arentinum seed coat.

The objective of the project was to identify cost effective wastewater treatment technique for different types of wastewaters, to identify the efficiency of wetlands for treating different types of wastewaters and also to assess comparative treatment performance efficiency improvement and advantages of constructed wetlands using an integrated setup with different plant species like Phragmites australis and Typha.

The study hinged on the premise that engineered wetland systems are a viable and sustainable means of treating different types of wastewater. It was also hypothesised that engineered wetland systems vegetated with different types of plants would perform with different treatment efficiencies following (Mbuligwe, 2005).

MATERIALS AND METHODS

Collection of wastewater

Wastewater sampling was performed by one of the two methods, grab sampling and composite sampling. Composite sampling was the type of sampling that has been used in the collection of wastewater. Composite sampling consists of a collection of numerous individual discrete samples taken at regular intervals over a period of time, usually 24 hrs. The wastewater samples were taken using a gouge from a depth of 10cm.The samples were stored in polyethylene plastic bottles, transported to the laboratory on the same day and stored in the dark at 4°C until making the experimental procedure. (Cavusoglu *et al*., 2010)

Experimental set up

The experimental units which are called as wetland cells were located in the department of Civil Engineering, SRM University, Kattankulathur, Tamil Nadu. The experimental set up comprised the components an inlet zone, wetland cell, wetland media vegetation and an outlet zone.

The primary criterion for design of inlet structure is discharge which should be uniform along the entire width in order to prevent short circuiting. A 25 litre container was used to provide a continuous flow of wastewater through the inlet. The wetland unit was a PVC container of 70X40X 30 cm length, breadth and depth. The system was built with slight inclination of <1 between inlet and outlet zones. The wetland media consisted of a gravel bed underlain by an impermeable layer. The bed was filled to a height of 7cm with gravel of Diameter 10-30mm followed by a 7cm thick top layer of sand of 2mm diameter. The top portion of the wetland unit was filled with local sandy clay loam soil to support vegetation.

Phragmites australis and typha spp. (wetland plant species) were used in the study. The plants were collected from a nearby lake and planted in the wetland unit. They increase the residence time of water by reducing velocity, and increase sedimentation of the suspended particles. They also add oxygen and provide a physical site for microbial bioremediation. The plants have been used to remove suspended solids, nutrients, heavy metals, toxic organic compounds and bacteria. Outlet zone was designed to allow variations in the level of water discharge. (Deepak *et al.*, 2012.)

Methodology

Pot culture study was done for 2 weeks for the analysis of suitable concentration of industrial effluent (Petrochemical and electroplating) so that vegetation can withstand toxicity and grow well in the lab prototype model of constructed wetland. Different dilutions (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%) of industrial effluent were made and used for irrigating the units having the plants on which the physical symptom of toxicity was studied.

The methodology included setting up of the wetland prototype or the experimental setup as discussed earlier with different components like inlet zone, wetland cell, wetland media, vegetation and outlet zone. The plant was placed in the wetland cell and was allowed to grow in the media. Initial analysis of wastewater was carried out and various parameters like pH, BOD, COD, N, P, TSS and heavy metals (for industrial effluent alone) were analysed. After the analysis of the characteristics the wastewater was collected and was poured into the inlet zone of the wetland media and at regular intervals. The collection of water from the outlet was done at regular interval as per the HRT of 1 day, 2 days and 3 days. The different parameters were analysed for the treated water and the comparison of each parameter was carried out for industrial and domestic waste waters. The laboratory analysis for all parameters was done according to the standard methods as per APHA which are used for the examination of water and wastewater. For highly toxic effluents adsorbent media was also used. For electroplating waste water treatment the set up was tried with and without adsorbent media. The adsorbent media used was Cicer arentinum seed coat.

RESULTS AND DISCUSSION

The overall wetland system performance was high and stable during the observation period. Fig. 1, 2, 3 and 4 describe the system efficiency for treating domestic and industrial wastewaters.

From Fig. 1 it is evident that the effluent concentrations from the wetland units at 1st, 2nd and 3rd days showed reasonable variations. From the figure it is clear that the constructed wetland is working more effectively in the treatment of domestic wastewater. Domestic wastewater after treatment showed desired removal efficiencies of 64% for BOD, 55% for COD, 60% for TSS, 57% for TDS, 21 % for N and 42% for P. We also conducted experiments for integrated setup and the removal efficiencies were almost similar.

Fig. 2 shows the dairy wastewater characteristics and the bar chart clearly indicates the reduction in the parameters and it implies that the efficiency of filter media used in constructed wetland is able to minimise the BOD, COD content from the dairy wastewater. The parameters like Ammoniacal Nitrogen and phosphorous (P) present in the dairy wastewater also reduces considerably. Industrial wastewater from the dairy industry after treatment showed a reduction rate of 64.4% for BOD, 25.3% for COD, 79.3% for TSS, 72.4% for TDS, 37.3% for Ammoniacal nitrogen and 42.5% for phosphorous.

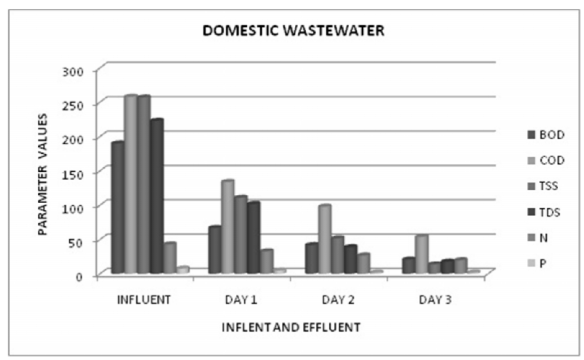

Fig. 1. The variation of various parameters in untreated influent and effluent at 1st, 2nd and 3rd days (Domestic wastewater)

From electroplating effluent analysis it was clear that mainly hard chromeplating is done in this process shop. The result also reveals that there is stock piling of the industrial effluent due to which the concentration of certain heavy metals is many times more than the usual discharge limits. As the concentration of heavy metals is too high, it is advisable to treat the industrial effluent along with the domestic wastewater. For this electroplating wastewater and sewage water were mixed in 1:2 ratios and

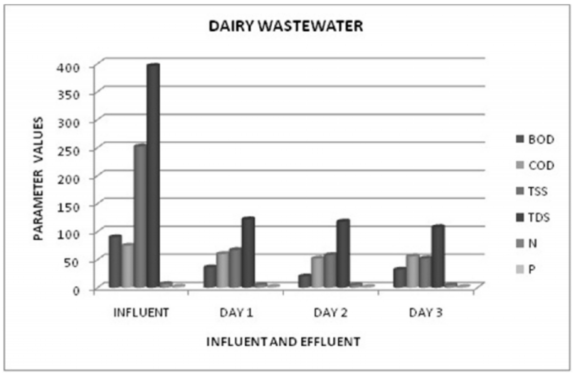

Fig. 2. The variation of various parameters in untreated influent and effluent at 1st, 2nd and 3rd days (Dairy wastewater)

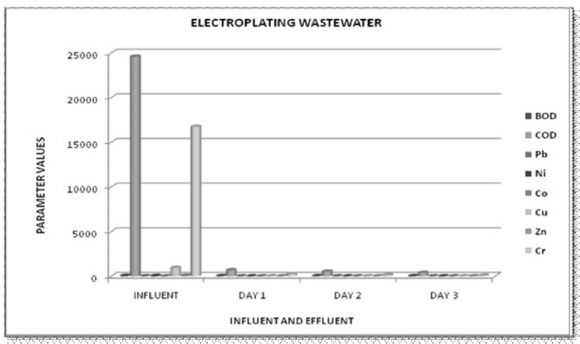

Fig. 3. The variation of various parameters in untreated influent and effluent at 1st, 2nd and 3rd days (Electroplating wastewater).

then it was used for irrigation in the constructed wetland. Considering electroplating industrial effluent for normal setup with Phragmites plantations the reduction efficiencies at the 3rd day were 10.80% for TDS, 97.78% for COD, 60% for BOD, 99.63% for Pb, 99.74% for Ni, 99.41% for Co, 99.70% for Ag, 98.95% for Cu, 91.19% for Zn, 99.14% for Cr. The reduction of contaminants after using an adsorbent media were 98.89% for COD, 37.93% for BOD,99.45% for Ni, 98.20% for Co, 99.93% for Cu, 92.34% for Zn, 99.95% for Cr respectively.

For petroleum waste water the reductions are 98.90% for TSS, 31.58% for ammoniacal nitrogen as N, 76.36% for sulphide, 89.39% for BOD, 93.81% for COD, 18.76% for phosphorous with Typha plants. Based on the analysis, we can observe that Typha spp showed greater efficiency in removal of parameters such as COD, BOD, and sulphides than Phragmites

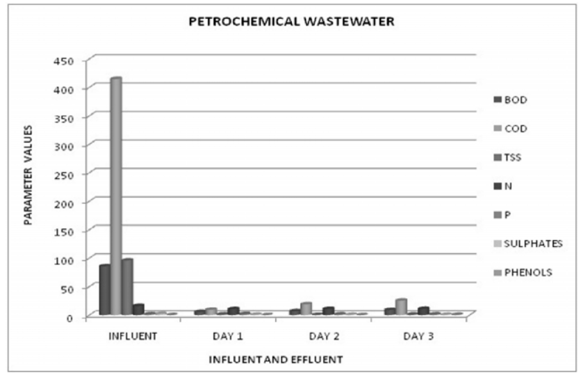

Fig .4. The variation of various parameters in untreated influent and effluent at 1st, 2nd and 3rd days (Petrochemical wastewater)

spp. The physical characteristics such as length, new shoots, nitrogen uptake was observed more in Typha species.

CONCLUSIONS

Hence, based on the analysis after treatment of wastewater in horizontal sub surface flow constructed wetland by batch process it can be said that wetland vegetated with both Phragmites spp. and Typha spp. is working well in degradation of high concentration of wastes in Indian climatic conditions. As we have applied the wastewater treatment system on the SRM university campus it has created awareness on environmental consciousness to the students and staff and other residents of the township. Constructed wetlands act like primarily biological filters and are very effective in removing BOD, COD, TSS and organic nitrogen. When comparing performance of wetlands, the comparison should be based on the performance of complete systems remembering that wetlands are only one part of a multi-part system.

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