RESEARCH ARTICLE

Changes in Physico-Chemical Characteristics of the Sewage Effluent under Constructed Wetland Technology Treatment

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ABSTRACT

In India, the per capita freshwater availability has been reducing since 1951 from 5177 m^3 to 1588 m^3 in 2010 due to over-population and indiscriminate utilization of water resources. Currently, fresh water resources are polluted by anthropogenic means, so it is necessary to treat the wastewater to overcome water scarce in future decades. Constructed wetland technology seems to be a promising technology with simple construction and low maintenance where the aquatic plants and medium used for filtration plays an active role in removing the pollutants in wastewater. An attempt has been made to assess the phyto-remediation potential of locally available aquatic plants to treat the sewage effluent collected after primary treatment from Tamil Nadu Agricultural University (TNAU) STP utilizing the constructed wetland technology. The results of the experiment revealed that the pH, EC, TSS, TDS of the sewage water was significantly reduced by the aquatic plants throughout the retention time from D_1 to D_7. Among them significant reduction of pollutants was noted at 7th day of retention time and the plants *Canna indica, Xanthosoma sagittifolium* and *Typha angustifolia* performed better than other plants.

Keywords: *Constructed wetlands, Aquatic plants, Sewage effluent, Pollutant.*

INTRODUCTION

The availability of water is expected to decrease in many regions. In the mean time future global agricultural water consumption alone is estimated to increase by ~20% by 2050 and will be even greater in the absence of any technological progress or policy insinuation. India supports more than 16% of the world's population with only 4% of the world's fresh water resources (Kaur *et al.,* 2012). In India, per capita domestic water demand is likely to increase from the estimated 31 m^{-3}.person^{-1} .year^{1} in 2000 to about 46 and 62 m^{-3}.person^{-1} .year^{1} by 2025 and 2050, recpectively. A substantial water supply coverage is increasing for both urban and rural areas due to increase in per capita demand of domestic water (Amarasinghe *et al.,* 2008). Hence, waste water recycling and enhanced water use efficiency are the urgent need for efficient water resource management.

The limitation of water resources and sustainable use of alternative water sources demands for the development of improved technologies. There are many technologies like Activated Sludge Process (ASP), Rotating Biological Contactor (RBC), Stabilization ponds, oxidation ditch, Trickling Filter (TF) etc., used for the waste water treatment (Tanner & Sukias, 2003); (Sayadi *et al.*, 2012). Similarly, there is a natural wastewater treatment process which is known to be constructed wetland technology.

During the last four decades of 20th century, constructed wetlands are the most widely used ecological wastewater treatment systems. The constructed wetlands are several types which could be distinguished according to distinct criteria such as presence/absence of free water surface, macrophytes used or direction of flow (Vymazal, 2010). Constructed wetland is environmental friendly, natural process and eco-friendly with simple construction and low maintenance which makes it as one of the interested technique when compared to other mentioned conventional technologies (Vymazal, 2010); (Madera-Parra *et al.,* 2015); (Shelef *et al.,* 2013).

In this technology, plants plays a main role in the wetlands by creating attachment sites for microorganisms and to release oxygen. The effectiveness of the desired treatment will increase based on the selection of suitable plant species (Jethwa & Bajpai, 2016)decrease wind speed and avoid re-suspension of nutrient and sludge, supply Surface for periphyton and bacteria and help in providing the required conditions for various

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biological, physicochemical processes within a constructed wetland for effective treatment of wastewater. Most commonly used plants are Typha angustifolia, Phragmites australis, different types of grass, and bulrush. This review paper studies plant types, including emergent herbaceous plants, and plant characteristics used for constructed wetlands, their phytology, plant nourishment and growth cycles, factors to selection in plant selection. Wetlands are transitional areas encompasses between land and water also known as wet soils, having plants that adapt well to wet soils. Land and water can merge in many ways; there is no appropriate single correct definition to suit all purposes. Dominant plants, wetlands can be classified into three groups: salt and freshwater swamps, marshes, and bogs. Swamps are flooded areas created by water-resistant ligneous plant and trees, marshes are created by soft-stemmed plants and bogs are created by ferns and acid-loving plants. Constructed wetlands (CWs. aquatic plants acquire nutrients from the sediment as well as directly from the water itself (Schulz *et al.*, 2004 and Shelef *et al.*, 2013).

Though there has been many studies conducted with constructed wetland with various aquatic plants, it is very much demanding to plan for a systematic study to establish cost effective and eco-friendly technology for treating the wastewater. So an attempt has been made to compare the phytoremediation potential of locally available aquatic plants to treat the sewage effluent from TNAU Sewage Treatment Plant (STP).

MATERIAL AND METHODS

This experiment was Conducted in Department of Environmental Science, TNAU, Coimbatore. Five different suitable aquatic plants *viz Canna indica* (Indian shot), *Xanthosoma sagitiifolium* (Arrow leaf elephant ear), *Arundo donax* (Giant reed), *Typha angustifolia* (cattail) and *Cyperus distans* (Slender cyperus) were collected from wetlands and lakes in and around Coimbatore. The aquatic plants were washed thoroughly and plants of uniform sizes were used for evaluating their performance in treating the sewage effluent. The effluent was collected from STP located at TNAU near to staff quarters. Pots were used for the screening experiment. A small aperture for the collection of treated sewage effluent was made manually at the bottom of the pots uniformly. Pre-sterilized media used in the experiment was gravels (20 mm), sand and soil in sandwitch manner. Subsequently, washed plants were planted with uniform height and sewage effluent was added (10 litres/pot) evenly in all the pots. The pot experiment was laid out in completely randomised block design (FCRD) replicated thrice and treatments as retention time in days (1st day to 7th day) and collected treated sewage samples were analysed through prescribed laboratory procedures to appraise the potentiality of the five different aquatic plants.

RESULTS AND DISCUSSION

Initial Characterization of primary untreated sewage effluent

The collected primary untreated sewage was assessed by analyzing its pH, Electrical conductivity (EC), Total suspended solids (TSS), Total dissolved solids (TDS), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total nitrogen (TN) and Total phosphorus (TP). The pH of the sewage effluent was 7.84 and EC was 2.40 dS m^{-1}. The TSS and TDS of the effluent were 600 and 2380 mg L^{-1}. The BOD value was 640 mg L^{-1} and COD was 2680 mg L^{-1}. The total nitrogen and total phosphorus content in the effluent were found to be respectively 0.37% and 0.31 %. The maximum amount of BOD and COD indicate the high amount of both organic and inorganic pollutants. BOD and COD values exceed the prescribed levels of 100 and 250 mg L^{-1} (CPCB) to discharge into public sewers. Hence the sewage effluent should be treated before its usage for crop irrigation (Suganya *et al.*, 2017).

pH and EC

Sewage sample collected after the treatment under constructed wetland technology in different intervals of retention time 1st, 2nd, 3rd, 4th, 5th, 6th and 7th day (24 hours interval), were analysed for pH shown in Table 1 and EC shown in Fig 1. The pH of the sewage effluent tends to get decreased from D_1 to D_7 in all the macrophytes throughout the study. Thus the pH of the water affects the solubility of many toxic chemicals and heavy metals. Release of organic acids by the aquatic plants during the experimental period could attribute to the decrease in pH with an increase in retention time. Among the plants pH and EC was in decreasing trend in different intervals of Day 1 to Day 7. *Canna indica* performs better followed by *Xanthosoma sagittifolium*, *Typha angustifolia*, *Arundo donax* and *Cyperus distans*. pH reduction by *Canna indica* significantly different from other plants used in this study and the 7th day of retention time significantly different from other treatments. Increased plant growth of *Canna indica* might be the reason for its better performance. Similar results were also proved by Suganya (2017) in a hybrid constructed wetland experiment for recycling sewage effluent with *Bracharia humidicola* and *Typha angustifolia.* The Electrical conductivity (dS m^{-1}) of the effluent decreased gradually from 1st day to 7th day of the retention time. Decreasing EC by *Canna indica* significantly different from other plants *viz.*, *Xanthosoma sagittifolium, Typha angustifolia,*

Table 1. Effect of the aquatic plants on pH of the sewage effluent

Plants	Retention time							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	Mean
Canna indica	7.55	7.32	6.92	6.84	6.63	6.42	6.32	6.86
Xanthosoma sagittifolium	7.53	7.42	7.34	6.92	6.84	6.44	6.38	6.98
Arundo donax	7.61	7.53	7.15	7.04	6.97	6.65	6.46	7.06
Typha angustifolia	7.63	7.57	7.23	6.83	6.66	6.52	6.43	6.98
Cyperus distans	7.74	7.65	7.27	6.87	6.64	6.54	6.47	7.03
Mean	7.61	7.50	7.18	6.90	6.75	6.51	6.41	

Arundo donax, *Cyperus distans* and retention time of 7th day significantly comparing from other treatments. Decrease in the EC could be due to evapotranspiration or uptake of soluble ions by plants. Jan vymazal (2011) reported that the aquatic plants *viz*., *Typha spp, Scirpus spp, Phalaris arundinacea, Arundo donax, Canna indica* has the capacity to remove soluble salts and other organic and inorganic pollutants from municipal, domestic sewage and other industrial wastewater.

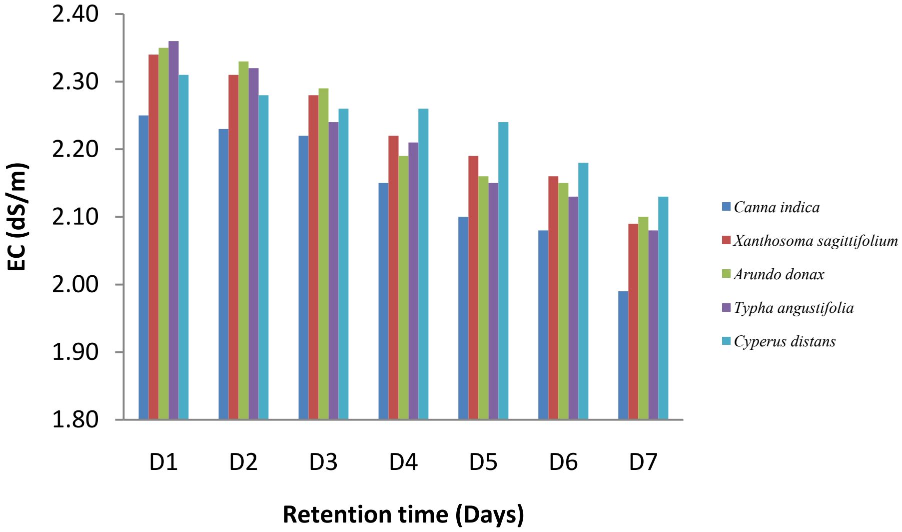

Figure 1. Effect of the aquatic plants on EC of the sewage effluent

Total suspended solids removal

The aquatic plants reduced the TSS significantly follows the order *Cana indica* > *Typha angustifolia* > *Xanthosoma sagittifolium*> *Arundo donax* and *Cyperus distans*. Reduction of TSS by *Canna indica* significantly comparing from other plants, simultaneously 7th day of retention time significantly comparing other treatments. The total suspended solids of the sewage effluent constantly decreased from D_1 to D_7 (Fig.2). This reduction might be due to the filtration and sedimentation of the medium *viz.,* gravel, pebbles, and sand used in the treatment pots. Also, the surface of macrophytes used in the study may be coated with an active layer of biofilm called Periphyton which can absorb both soluble and colloidal particles (EPA, 1999). Among the plants, *Canna indica* performed better followed by *Xanthosoma sagiitifolium* and *Typha angustifolia*. Similarly, removal of TSS in the effluent by *Canna indica* and *Typha angustifolia* was reported by Suganya (2017).

Total dissolved solids removal

With respect to the retention time of D_1 to D_7, the TDS of the sewage follows the declining trend. Increase in retention time decreases the TDS content of the effluent (Fig 3). TDS reduction follows the order *Canna indica* > *Typha angustifolia* > *Xanthosoma sagittifolium*> *Cyperus distans* and *Arundo donax* respectively. Decreasing of TDS by *Canna indica* statistically significant different from other plants and 7th day of retention time significantly different from other treatments in this study. Reduction of TDS may be due to the more contact time of the effluent with aquatic plants and different medium. This is in line with findings of Suganya and Paul Sebastian (2017).

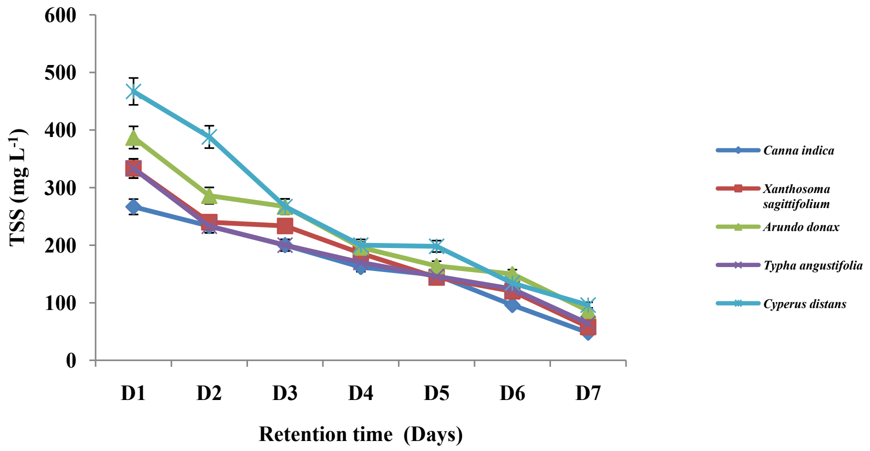

Figure 2. Effect of aquatic plants on TSS of the sewage effluent

From the above investigation the five aquatic plants selected for the study Canna indica, Xanthosoma sagittifolium and Typha angustifolia performed better. The pH and EC of the sewage water was reduced to 18.2 and 13.4 percent at 7th day of retention time. With regard to TDS and TSS, the TDS was reduced to a percentage of 13.9, 20.4, 30.8, 37.7, 42, 46 and 58.6 and TSS declined to a percentage of 40.4, 53.1, 61,

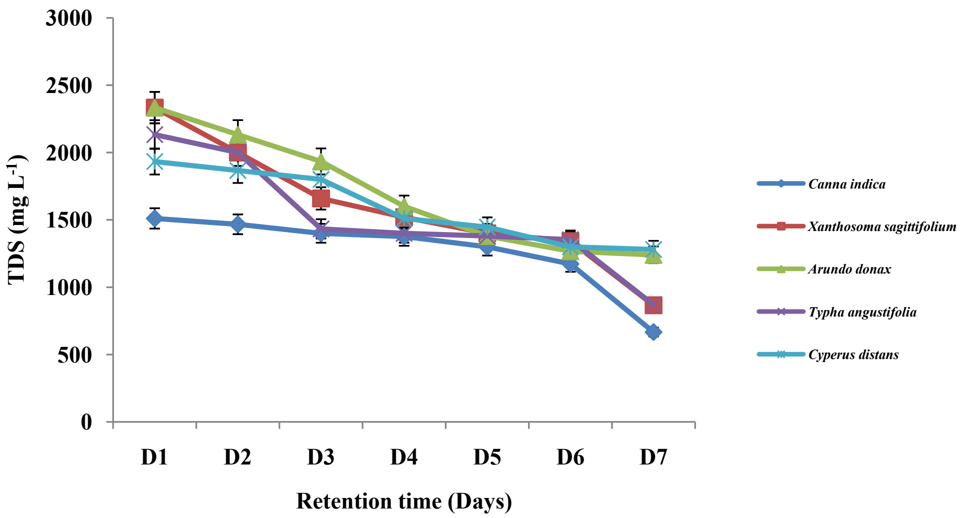

Figure 3. Effect of aquatic plants on TDS of the sewage effluent

69.5, 73.3, 79.2 and 88.2 at 1st, 2nd, 3rd, 4th, 5th, 6th and 7th day respectively. The level of the pH, EC, TSS and TDS were reduced to 6.32, 1.99 (dS m^{-1}), 48 (mg L^{-1}) and 667 (mg L^{-1}) from the Day1 to Day7 after the treatment. These values were above the permissible limits prescribed by Central Pollution Control Board (CPCB). Based on the results we can conclude that Canna indica may be the best suitable constructed wetland plant for sewage treatment.

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