# Effectiveness of *Lemna gibba L.* for Reduction of Pollutants from Textile Industry Effluent

**D. Sivakumar [*], D. Shankar [+], T. Durairai Arasu [*], V.M.Ragothaman [*]**

[*] *Department of Civil Engineering*
*Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College*
*Avadi 600 062, Chennai, Tamil Nadu, India*
*shri.sivakumar1974@gmail.com,*
[+] *Department of Pharmaceutical Chemistry,*
*K.M. College of Pharmacy, Uthangudi 625 107, Madurai, Tamil Nadu, India*

***Abstract*— Textile industry processes are among the most environmentally unfriendly industrial processes, because they produce colour wastewater that is heavily polluted the environment. Therefore, wastewater from textile industry has to be treated before being discharged into the environment. In this study, experiments were performed to remove the EC, sulphates and COD from a textile industrial wastewater in constructed wetlands by using aquatic macrophyte *Lemna gibba L.* The experiments were conducted by different process parameters like nutrient dosage, dilution ratio, pH and contact time using *Lemna gibba L.* to reduce EC, sulphates and COD in a textile industry wastewater. From the experiments, it was found that the maximum percentage reduction of various parameters in a textile industry wastewater by *Lemna gibba L.* were obtained at an optimum nutrient dosage of 50 g, dilution ratio of 10, pH of 7 and contact time of 6 days. Similarly, the validation experiment results showed that the maximum removal percentage of sulphate in a textile industry wastewater is lesser than the maximum removal of sulphate in an aqueous solution. Also, this study was extended to identify the effectiveness of *Lemna gibba L.* through sorption model. From the results of experimental and model studies, this study concluded that *Lemna gibba L.* might be used as biosorbent for removing various parameters in a textile industry wastewater.**

***Keywords*— Aquatic Macropyte, Process Parameters, Physico-Chemical Parameters, Textile Industry Wastewater**

## I. INTRODUCTION

Textile industries consume a large volume of water and chemicals for making various textile goods and as a result, large volume of wastewater discharged on land with or without treatments [1]. The quantities and characteristics of wastewater discharged vary from mill to mill, which depends on the water consumption and the average daily product. Many approaches have been taken to reduce water consumption by recycling the wastewater comes from the textile industries, else the wastewater from textile industry is contaminating soil and water environment [2]. The raw materials, particularly dyes used in the textile industry determine the volume of water required for production as well as wastewater generated [3]. The wastewater generated from the various processing units are desizing, scouring, bleaching, mercerizing, dyeing, printing, and packing required huge amount of organic chemicals of complex structure.

The main parameters identified in the textile industry are pH, electrical conductivity (EC), chloride, sulphate, phenols, total dissolved solids (TDS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and other solution substances. Therefore, wastewater from the textile industry has to be treated before being discharged to the environment.

Various methods, including aerobic and anaerobic microbial degradation, coagulation [4], chemical oxidation, precipitation, filtration, adsorption [5,6,7,8], membrane separation [9], electrochemical treatment [10], filtration, flotation, hydrogen peroxide catalysis, and reverse osmosis [11], ozonation and biological techniques [12] can be employed to remove various pollutant forms the textile industry wastewater. However, their costs are high and most of them are difficult to use under field conditions, hence such a condition there is an urgent need to study natural, simple, and cost-effective techniques for controlling pollution from industrial wastewater and treating such wastewater, such as phytoremediation [13, 14]. Phytoremediation is the utilization of plants accumulation capabilities to remove contamination from water, wastewater, soil and air [15].

In recent years, considerable attention has been focused on biosorption process using aquatic plants because, it has more advances than over conventional treatment methods include: low cost; high efficiency; minimization of chemical and biological sludge. The application of phytoremediation technology by duckweed in wastewater treatment and management is quite interesting and revealing. *Lemna gibba L.* known as common duckweed is a small, free floating aquatic plant fast growing, adapt easily to various aquatic conditions and play an important role in the extraction and accumulation of pollutants from waters and wastewaters [16].

This study focused to remove the EC, sulphate and COD from a textile industrial wastewater in constructed wetlands by using aquatic macrophyte *Lemna gibba L.* Further, the experiment results of sulphate in a textile industrial wastewater are verified for their reproducibility using an aqueous solution. Also, this study was extended to identify the effectiveness of *Lemna gibba L.* through sorption model.

## II. MATERIALS AND METHODS

### A. Collection of Lemna gibba L.

*Lemna gibba L.* was collected from the local pond, which had no connection with any textile wastewater discharge points. The collected *Lemna gibba L.* was washed with deionized water and weighed. Further, the *Lemna gibba L.* was initially subject to stabilization in small plastic tanks containing well water and the same were preserved for 15 days period. In addition, these plastic tanks were filled with gravel and wetland soil (collected from the local pond) up to five inches in height and maintained at normal temperature.

### B. Collection of Textile Industry Wastewater

For the present study, textile industry wastewater samples were collected from the final clarifier of textile industrial wastewater treatment plant of Kangepuram, Tamil Nadu, India with the help of airtight sterilized bottles. Then, took the wastewater samples to the Environmental Laboratory and then they were stored in the refrigerator at a temperature of 278 K for analyzing electrical conductivity (EC), sulphate and chemical oxygen demand (COD) in later stages. In order to reduce the various parameters in textile industry wastewater, wetlands was constructed (plastic tanks) by using the *Lemna gibba L.* Conducted the adsorption study with various nutrient dosages, dilution ratio and pH against contact time.

### C. Biosorption Experiments

For the experiments, *Lemna gibba L.*, which maintained in the plastic tanks were collected, cleaned and introduced in the experimental tanks (constructed wetland). The experimental tanks also a plastic tank as similar to the plastic tank for preserving the *Lemna gibba L.* Approximately, 100 g of *Lemna gibba L.* was used in each experimental tank for this study. These experimental tanks were filled with textile industry wastewater of 1000 ml. Triplicate of each experimental setup was maintained. In order to reduce the EC, sulphate and COD in a textile industry wastewater, the experimental setup (constructed wetland) were examined for a period of 7 days by 1 day intervals by using aquatic macrophyte *Lemna gibba L.* and conducted the adsorption study with various nutrient dosages (10, 20, 30, 40, 50, 60 and 70 g), dilution ratio (2, 4, 6, 8, 10, 12 and 14) and pH (4, 5, 6, 7, 8, 9 and 10).

The nutrient used in this study was activated sludge collected from municipal wastewater treatment plants, Koyampet, Chennai. The dilution ratio was used such that 1 part of wastewater with various part of well water, thus, the ratio of 2, 4, 6, 8, 10, 12 and 14 represents these parts of well water mixed with raw wastewater. The pH was adjusted by using 0.1 M of NaOH and 0.1 M of HCl. The concentration of the various parameters in a textile industrial wastewater before and after treatment with *Lemna gibba L.* was determined as per the standard procedure stipulated by APPA [17]. The adsorption removal percentage of various parameters by *Lemna gibba L.* was calculated by using the following formula:

$$\text{Percentage Removal} = \frac{(C_1 - C_2)}{C_1} \text{X } 100 \qquad (1)$$

in which $C_1$ is the concentration of the parameter before treatment with *Lemna gibba L.* and $C_2$ is the concentration of the parameter after treatment with *Lemna gibba L.* The concentration of raw wastewater from textile industry for EC, sulphate and COD is given in Table 1.

TABLE 1
THE CHARACTERISTICS OF TEXTILE INDUSTRY WASTEWATER

| Sl. No. | Characteristics | Concentration |
|---|---|---|
| 1 | Electrical Conductivity, m.mhos/cm | 4856 |
| 2 | Sulphate, mg/L | 758 |
| 3 | Chemical Oxygen Demand (COD), mg/ | 3458 |

## III. RESULTS AND DISCUSSION

The different process parameters like nutrient dosage, dilution ratio and pH were selected for conducting the constructed wetland adsorption study using *Lemna gibba L.* to reduce the various parameters like EC, sulphate and COD in a textile industry wastewater.

### *A. Effect of Nutrient Dosage*

Experimental investigations were conducted by changing the nutrient dosage from 10 g to 70 g with an increment of 10 g using *Lemna gibba L.* against the different contact time from 1 day to 7 days with an increment of 1 day. Fig.1 indicates the percentage reduction of various parameters like EC, sulphate and COD in a textile industry wastewater using *Lemna gibba L.* against different nutrient dosage with a contact time of 6 days, dilution ratio of 6 and pH of 7. Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained from the day 1, 2, 3, 4, 5 and 7 were not present in this study.

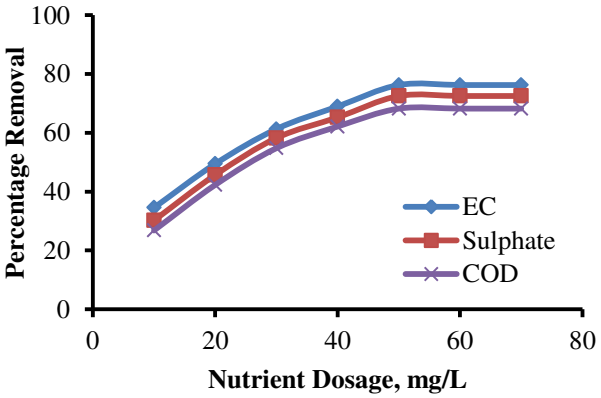


Fig.1 The Percentage Reduction of Various Parameters in a Textile Industry Wastewater using *Lemna gibba L.* against Nutrient Dosage

The results revealed that the percentage removal of the selected various parameters is low by *Lemna gibba L.* at low nutrient dosages and then increases with nutrient dosage. This is because, the active adsorption sites in the supplied nutrient could not be effectively utilized by the various parameters and thereafter sorbent sites of nutrient could be effectively utilized. Up to nutrient dosage 50 g, the adsorption of various parameters in a textile industry

wastewater increased by *Lemna gibba L.* steadily and for the nutrient dosage of 60 g and 70 g, the percentage removal results showed the resembles of the results obtained nutrient dosage 50 g. Hence, the optimum nutrient dosage found in this study for the maximum removal of various parameters in a textile industry wastewater by *Lemna gibba* L. is 50 g.

The removal percentage for various parameters was not significant even the contact time and nutrient dosages were higher, it is more likely that an even sufficient contact time available, a significant portion of the available active sites remains undiscovered, leading to lower specific uptake for the nutrient dosage of 60 g and 70 g and for the contact time of 7 days. Thus, the maximum adsorption removal percentage for various parameters in a textile industry wastewater by *Lemna gibba L.* against nutrient dosage is 76.25, 72.52, and 68.23 % respectively for the parameters EC, sulphate and COD (Fig.1).

*B. Effect of Dilution Ratio*

Experimental investigations were conducted by changing the dilution ratio from 2 to 14 (wastewater 1 : well water 2) with an increment of 2 using *Lemna gibba L.* and for the different contact time from 1 day to 7 days with an increment of 1 day. Fig.2 indicates the percentage reduction of various parameters like EC, sulphate and COD in a textile industry wastewater using *Lemna gibba L.* against different dilution ratio with an optimum contact time of 6 days, an optimum nutrient dosage of 50 g and pH of 7. Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained from the day 1, 2, 3, 4, 5 and 7 were not present in this study.

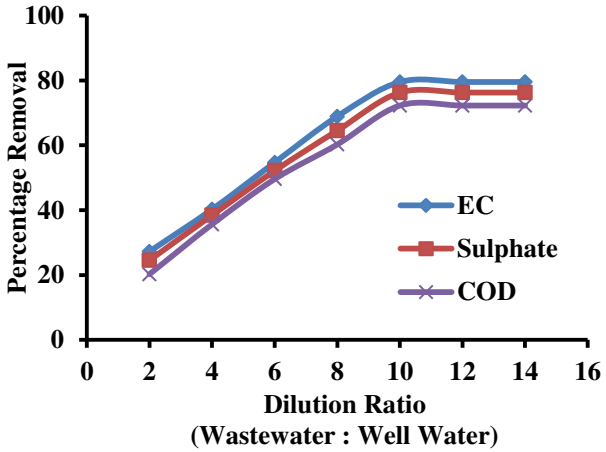


Fig.2 The Percentage Reduction of Various Parameters in a Textile Industry Wastewater using *Lemna gibba L.* against Dilution Ratio

The results revealed that the percentage removal of the selected various parameters is low at the less dilution ratio and then increases with high dilution ratio. This is because, diluted concentration of all parameters in a textile industry wastewater were absorbed easily by the *Lemna gibba L.* than high concentrated aqueous solution. In other words, the active sites in the *Lemna gibba L.* could not be effectively utilized by the various parameters at the beginning and thereafter sorbent sites of *Lemna gibba L.* could be effectively utilized in later stages. Up to dilution ratio of 10, the adsorption of various parameters in a textile industry wastewater by *Lemna gibba L.* Increased steadily and in the dilution ratio12 and 14, the percentage removal results showed resembles of the results obtained for the dilution ratio 10. Hence, the optimum dilution ratio found in this study for the maximum removal of various parameters in a textile industry wastewater is 10.

The removal percentage for various parameters was not significant even the contact time and dilution ratio were higher, it is more likely that an even sufficient contact time available, a significant portion of the available active sites remains undiscovered, leading to lower specific uptake for the dilution ratio12 and 14 and for the contact time of 7 days. Thus, the maximum adsorption removal percentage for various parameters in a textile industry wastewater by *Lemna gibba L.* against dilution ratio is 79.51, 76.45 and 73.20 % respectively for the parameters EC, sulphate and COD (Fig.2).

*C. Effect of pH*

Experimental investigations were conducted by changing the pH from 4 to 10 with an increment of 1 using *Lemna gibba L.* and for the different contact time from 1 to 7 days with an increment of 1 day. Fig.3 indicates the percentage reduction of various parameters like EC, sulphate and COD in a textile industry wastewater using *Lemna gibba L.* against pH with an optimum contact time of 6 days, an optimum nutrient dosage of 50 g and an optimum dilution ratio of 10. Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained from the day 1, 2, 3, 4, 5 and 7 were not present in this study.

The results revealed that the percentage removal of the selected various parameters is low at the beginning and then high with pH increases. This is because, with a slight alkaline to alkaline condition, the active sites in the *Lemna gibba L.* could be effectively utilized by the various parameters at the alkaline condition than in acidic condition. Up to pH of 7, the adsorption of various parameters in a textile industry wastewater by *Lemna gibba L.* increased steadily and for the pH 8, 9 and 10, the percentage removal results showed the resembles of the results obtained for the pH 7. Hence, the optimum pH found in this study for the maximum removal of various parameters in a textile industry wastewater is 7.

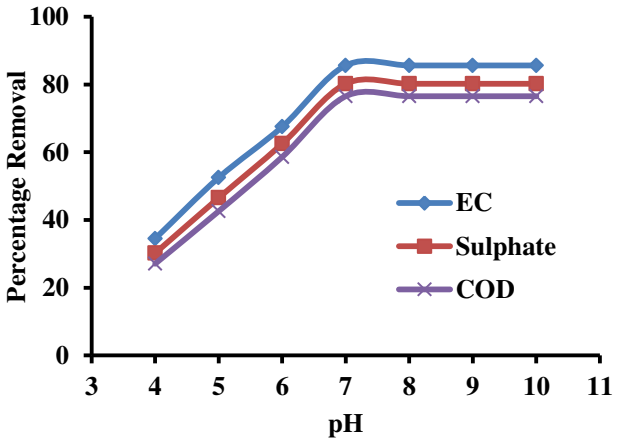


Fig.3 The Percentage Reduction of Various Parameters in a Textile Industry Wastewater using *Lemna gibba L.* against pH

The adsorption of various parameters in a textile industry wastewater on day 7 and for the pH 8, 9 and 10, the removal percentage for various parameters was not significant even the contact time and pH were higher, it is more likely that an even sufficient contact time available, a significant portion of the available active sites remain undiscovered, leading to lower specific uptake for the pH of 8, 9 and 10 and for the contact time of 7 days. Thus, the maximum adsorption removal percentage for various parameters in a textile industry wastewater by *Lemna gibba L.* against pH is 85.61, 80.20 and 76.52 % respectively for the parameters EC, sulphate and COD (Fig.3).

*D. Verification Experiment*

In order to validate the above experiments in reducing the various parameters in a textile industry wastewater, a separate experiment has been performed with an optimum nutrient dosage (50 g), dilution ratio (10), and pH (7) for the removal of sulphate in an aqueous solution. The maximum removal percentage of sulphate in a textile industry wastewater and in an aqueous solution by *Lemna gibba L.* is shown in Fig.4. The initial concentration of sulphate in an aqueous solution is similar to the initial concentration of sulphate in a textile industry wastewater.

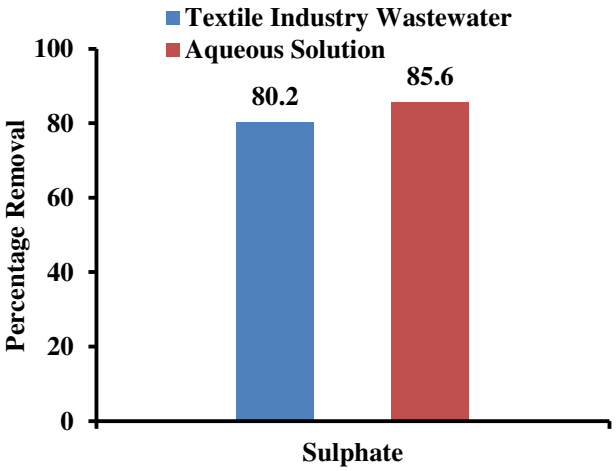


Fig.4 The Percentage Reduction of Sulphate in a Textile Industry Wastewater and Aqueous solution using *Lemna gibba L.* against Optimum Nutrient Dosage (50 g), Dilution Ratio (10) and pH (7)

The results (Fig.4) showed that the maximum removal percentage for various parameters sulphate in an aqueous solution by *Lemna gibba L.* is about 85.6 %. It may be observed from Fig.4 that the result of the removal percentage of sulphate in an aqueous solution is greater than the removal percentage of sulphate in a textile industry wastewater. The reason for maximum removal in an aqueous solution is due to there are no competitive ions present in the aqueous solution than in a textile industry wastewater, where other several competitive ions available, which are coming from usage of chemical in various processes. Based on the results, it may be concluded that *Lemna gibba L.* may be used as biosorbent for removing the various parameters like EC, sulphate and COD in a textile industry wastewater.

*E. Sorption Model*

In order to validate the above experiments, bioaccumulation and translocation factors are used.

The bioaccumulation factor (BCF) is defined as the ratio of metal concentrations in the roots to those in the soil or water, and is determined using Eq. (2)

$$BCF = P_{plant} / P_{water} \qquad (2)$$

where $P_{plant}$ is the parameters concentration in plants and $P_{water}$ is the parameters concentration in water. If BCF > 1 indicates that the plant is accumulator.

The translocation factor (TF) is defined as the ratio of metal concentration in the shoots to those in the roots

$$TF = P_{shoot} / P_{root} \qquad (3)$$

where $P_{shoot}$ is the parameters concentration in shoot of the plant to the $P_{root}$ is the parameters concentration in root of the plant. If TF >1, indicates that the plant translocates metals effectively from the roots to the shoots.

The Maximum mass removal of EC, sulphate and COD in a textile industry wastewater per unit kg mass of *Lemna gibba L.* is presented in Table 2.

TABLE 2
MAXIMUM MASS REMOVAL OF EC, SULPHATE AND COD IN A TEXTILE INDUSTRY WASTEWATER PER UNIT KG MASS OF *LEMNA GIBBA L.*

| Parameters | $P_{Water,}$ | $P_{plant}$ | $P_{root}$ | $P_{shoot}$ |
|---|---|---|---|---|
| EC | 6.98 | 41.57 | 2.52 | 39.05 |
| Sulphate | 1.51 | 6.08 | 0.45 | 5.63 |
| COD | 8.11 | 26.46 | 1.65 | 24.81 |

Similarly, the BCF and TF of EC, sulphate and COD in a textile industry wastewater per unit kg mass of *Lemna gibba L.* is presented in Table 3.

TABLE 3
BCF AND TF OF EC, SULPHATE AND COD IN A TEXTILE INDUSTRY WASTEWATER OF *LEMNA GIBBA L.*

| Parameters | BCF | TF |
|---|---|---|
| EC | 5.96 | 15.50 |
| Sulphate | 4.03 | 12.51 |
| COD | 3.26 | 15.04 |

From the Table 3, it may be observed that the BCF and TF are greater than 1 and the result of BCF and TF indicated that *Lemna gibba L.* is potentially useful for reducing EC, sulphate and COD in a textile industry wastewater.

## IV. CONCLUSION

In the present study, the experiments were conducted to find out the suitability of *Lemna gibba L.* in removing the various parameters like EC, sulphate and COD in a textile industry wastewater. The ability of *Lemna gibba L.* for removing various parameters in a textile industry wastewater by various nutrient dosages, dilution ratio, pH and contact time were monitored. The maximum

percentage reduction of various parameters in a textile industry wastewater by *Lemna gibba L.* were obtained at an optimum nutrient dosage of 50 g, dilution ratio of 10, pH of 7 and contact time of 6 days. From the validation experiments, it was found that the maximum removal is EC followed by sulphate and COD in a textile industry wastewater. Further, from the validation experiments, it was found that the experiments were reproduced at an optimum value obtained from the experiments conducted for the removal of EC, sulphate and COD in a textile industry wastewater. Also, this study was extended to identify the effectiveness of *Lemna gibba L.* through sorption model. Thus, this study concluded that *Lemna gibba L.* might be used as biosorbent for removing various parameters in a textile industry wastewater.

## REFERENCES


[1] D Sivakumar and G Swaminathan. Indian Journal of Environmental Protection, 2008, 28(1), 49-59.

[2] D Sivakumar. Int. J. Environ. Sci. Tech., 2011, 8(3), 593-604.

[3] S Irina-Isabella, and B Romen. Environmental Engineering and Management Journal, 2008, 7(6), 859-864.

[4] HR Guendy. Journal of App. Sci. Res., 2010, 6(8), 964-972

[5] D Sivakumar. Global Journal of Environmental Science and Management, 2015, 1(1), 27-40.

[6] D Sivakumar and D Shankar. International Journal of Environmental Sciences, 2012, 2(3), 1386-1397.

[7] D Sivakumar, N Murugan, R Rajeshwaran, T Shobana, C Soundarya, VS Vanitha. International Journal of ChemTech Research, 2014, 6(9), 4373-4378.

[8] D Shankar, D Sivakumar, M Thiruvengadam and M Manojkumar. Pollution Research EM International, 2014, 33(3), 499-503.

[9] C Fersi, L Gzara and M Dhahbi. Desalination, 2005, 185(1-3), 399-409.

[10] D Dogan and T Haluk. Pol. J. Environ. Stud., 2012, 22(5), 1185-1190

[11] M Ramesh Kumar, CV Koushik and K Saravanan. Elixir Chem. Engg., 2013, 54A, 12713-12717.

[12] D Sivakumar, AN Kandaswamy, V Gomathi, R Rajeshwaran and N Murugan. Pollution Research EM International, 2014, 33(3), 553-558.

[13] Z Ismail and A Beddri. Water Air Soil Pollut., 2009, 199, 57-65.

[14] GD Ji, TH Sun and JR Ni. Bio. Techno, 2007, 98, 436-441.

[15] D Patel and V Kanungo. The Bio Sci., 2010, 5(3), 355-358.

[16] D Sivakumar, D Shankar, P Dhivya, and K Balasubramanian. Pollution Research EM International, 2014, 33(3), 531-536.

[17] APPA, AWWA, and WEF, Standard methods for the examination of water and wastewater, 20$^{th}$ ed., APHA Publication, Washington D.C., 2005.