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Treatment of Textile Effluent using Nelumbonucifera, Nymphaea Nouchali and Musa Paradisiaca: A Comparative Study

P.Vivek¹, M.Karuppaiya², S.Thenesh Kumar³

Research Scholar, Department of Chemical Engineering, Annamalai University, Chidambaram, Tamil Nadu, India. ¹

Assistant Professor, Department of Chemical Engineering, Annamalai University, Chidambaram, Tamil Nadu, India. ²

Professor and Head, Department of Chemical Engineering, St. Peter's College of Engineering and Technology,
Chennai, India. ³

ABSTRACT: Textile is one of the oldest and most important commercial industries in India and it is characterised by the large volume and variability of the wastewater generated, with dyeing processes and finishing operations producing the largest amount of wastewater. Therefore, this study aims to treat textile effluent using three flower extracts namely *Nelumbonucifera*, *Nymphaea nouchali* and *Musa paradisiaca*. Among these flower extracts, *Nymphaea nouchali* is found to be more effective than the other two flower extracts. Different chemical parameters, such as pH, TDS, TSS, chloride, sulphate, nitrogen, BOD, COD, oil & grease content, are examined for both untreated and treated effluents and the results were compared.

KEYWORDS: Textile effluent, *Nelumbonucifera*, *Nymphaea nouchali*, *Musa paradisiaca*

I. INTRODUCTION

The textile industry is one of the most active chemical industries and is considered as the main cause of water pollution. Textile dyeing process demands a large amount of water and produces a substantial volume of wastewater. Major pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, colour, acidity and other soluble substances (Dae-Hee et al., 1999). Colour is imparted to textile effluents because of various dyes and pigments used. In addition to dyes, various salts and chemicals are the major sources of heavy metals in wastewater. Sediments, suspended and dissolved solids are important repositories for toxic heavy metals and dyes causing rapid depletion of dissolved oxygen leading to oxygen sag in the receiving water (Alihameed et al., 2008). The metals and contaminants like dyes tend to persist indefinitely, circulating and eventually accumulating throughout the food chain. The dyes and metals have direct and indirect toxic effects in the form of cancers, allergies besides, inhibiting growth at different trophic levels (Kant, 2012).

Untreated discharge of textile effluents into natural water bodies causes not only environmental degradation but also increases health risks to human beings (Kongjao et al., 2007). Therefore, there is an alert of increasing water pollution in addition to the already existing one. The environmental degradation occurs causing depletion of dissolved oxygen in streams/rivers, eutrophication of water bodies, toxicity to fishes and other aquatic flora and fauna (Kolomaznik et al., 2009; Durai and Rajasimman, 2011).

Such effluents can be effectively treated and considered as a resource that can be used in a more beneficial way rather than being wasted. Reusing of treated effluents for agricultural and landscape irrigation is an opportunity that can potentially reduce the use of canal water for irrigation and helps to save the remaining freshwater resources (Lefebvre et al., 2005).

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Pollution Control Board (CPCB), New Delhi, India, declared that effluents are required to meet zero liquid discharge (ZLD) norms because of the potential threat to the environment and human beings before discharging into the environment. Therefore, several methods are being followed to treat textile effluent.

There are several chemical methods followed for treating the harmful chemicals present in the effluent. Though it is a cheaper method, it also adds negative impact on the environment. Therefore, an alternate biological method is required that should be easy to operate, eco-friendly and less economic flexibility. Among several biological methods, this study suggests using plant extracts for treating textile effluent, especially flower part.

II. MATERIALS AND METHODS

Collection of Sample

Flowers from three plant materials were collected in and around Chennai, Tamil Nadu, India. They were thoroughly washed and dried under sunlight in a hygienic condition. Then they were powdered by the mixer and stored for further use. The textile effluent was collected from PMK TEXTILES, Solapuri Amman Kovil Street, Thottapalayam, Vellore - 632004 Tamil Nadu, India. The effluent was preserved at a temperature of 4 ± 1 °C in airtight plastic containers to avoid contamination.

Preparation of the samples

The powdered samples were shade dried and treated for forty-eight hours and were packed in a specially designed reactor in such a way that the effluents passed through each of them before elution.

Treatment of Effluent

The textile effluent was treated in this sample packed powder of each plant and various physicochemical parameters were examined for untreated and treated effluents.

Estimation of TDS

The sample was filtered and the sediment leftover on the filter was scraped off and dried in an oven. Then the dry weight of the sediment was measured.

Estimation of TSS

TSS of effluent is determined by pouring one litre through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water.

COD

2.5 ml of the sample was taken in the tube, 1.5 ml of 0.25 N $K_2Cr_2O_7$ (potassium dichromate), one spatula of mercuric sulphate $HgSO_4$ and 3.5 ml of COD acid were added and kept in COD reactor for 2 hrs at 150°C. After cooling the sample it was titrated against FAS (standard ferrous ammonium sulphate 0.1N) ferroin is used as an indicator. The endpoint is reddish brown colour. In the blank tube, 2.5 ml of distilled water was taken and then follow the same procedure in the sample. Finally, below calculation is used for COD analysis:

$$COD = \frac{(\text{Blank value} - \text{titrated value}) \times N \text{ of FAS} \times 8000}{\text{Volume of sample}}$$

BOD

Take 5 litres of distilled water and aerate for 3.5 hours. Later added 1 ml of nutrient which contains $FeCl_3$, $CaCl_2$, PO_4 , $MgSO_4$, domestic water to 1 litre aerated distilled water. The solution was further aerated for 30 minutes. BOD was calculated from the formula:

$$BOD = \frac{(\text{Blank value} - \text{titrated value}) \times 300}{\text{Volume of sample}}$$

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Determination of pH

The pH is determined by measurement of the electromotive force of a cell comprising an indicator electrode (an electrode responsive to hydrogen ions such as glass electrode) immersed in the test solution and a reference electrode (usually a calomel electrode). Contact is achieved by means of a liquid junction, which forms a part of the reference electrode. The emf of this cell is measured with pH meter.

Analysis of Sulphate Concentration

About 100ml of the sample was treated with 20ml of buffer solution A (30 g of MgC_{12} and was dissolved in 5g of sodium acetate, 1g of KNO_3 and 20ml of CH_3COOH in 500ml distilled water). A spoonful of BaC_{12} was added to it. The turbidity was measured. Using standard graph, the concentration of sulphate was measured.

Estimation of Chloride

Ten millilitres of effluent samples in a conical flask was taken and 1ml potassium chromate was added to get light yellow colour. It was then titrated with standard silver nitrate solution till colour change from yellow to brick red.

III. RESULTS AND DISCUSSION

Textile effluent treated using three aqueous extracts of flower from *Nymphaea nouchali*, *Musa paradisiaca* and *Nelumbonucifera* were taken. Of which *Nymphaea nouchali* showed better treatment efficiency. Among three extracts *Nymphaea nouchali* was more effective. Several physicochemical analyses of treated and untreated textile effluents were carried out and summarised below.

Total Dissolved solids

Total dissolved solids are mainly due to carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates, nitrogen, calcium, sodium, potassium and iron (Kannan et al., 2009). High level of TDS may be due to the insoluble organic and inorganic present in the effluent (Nagarajan et al., 2005). Solids in effluent are either dissolved or suspended. Suspended solids will not pass through a filter, whereas the dissolved solids can pass through it. When effluent with high dissolved solids enters the aquatic system, entire ecosystem will be affected. The salts dehydrate the skin of animals. High concentrations of dissolved solids will also add a laxative effect to water or cause the water to have an unpleasant mineral taste. Hence, removal of TDS is most important. Calcium and magnesium salts are the main constituents of TDS. In this study TDS of untreated effluent is 6380 mg/ml, whereas it was reduced to 2019 mg/ml when treated with *Nymphaea nouchali* followed by *Musa paradisiaca* and *Nymphaea nouchali*, 2796 and 3764 mg/ml, respectively, as shown in Table 1

Total Suspended Solid

The suspended solids component of an effluent is the quantity of insoluble materials present in the wastewater. Somnath (2003) reported that larger solid particulate matter remains suspended as a result of charges on the surface of small particles in the effluent. The presence of total suspended Solids (TSS) in water leads to turbidity resulting in poor photosynthetic activity in the aquatic system (Goel, 2000). The turbidity of the effluent might be due to the discharge of high concentration of carbonates, bicarbonates and chlorides of calcium, magnesium and sodium (Chakrapani, 2005). These insoluble materials when exceeding the normal level, cause a variety of problems when discharged from a site. High levels of TDS are aesthetically unsatisfactory and may also produce distress in human and livestock (Patel et al., 2009). Table 2 shows TSS content of treated and untreated effluent. In our study, TSS of untreated effluent was about 482 mg/ml and it was reduced to 132, 205, 310 mg/ml, respectively, which were treated with *Nymphaea nouchali*, *Musa paradisiaca* and *Nelumbonucifera*.

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) test is the best method for organic matter estimation and rapid test for the determination of total oxygen demand by organic matter present in the sample. The average value of COD was 1825 mg/L which is beyond the permissible limit of WHO (2003). This study showed a high level of COD, 2849 mg/ml in the untreated effluent. Increased amount of COD may be due to the high amount of organic compounds which are not

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affected by the bacterial decomposition (Nagarajan and Ramachandramoorthy, 2002). COD was reduced to 210 mg/ml when treated with *Nymphaea nouchali*, followed by *Musa paradisiaca* and *Nelumbonucifera*, 302 and 600 mg/ml, respectively, refer Table 3.

Biological Oxygen Demand (BOD)

BOD is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in the water sample at certain temperature over a specific time period. Therefore, if effluent with a high oxygen demand is discharged directly into the surface water, the sensitive balance maintained in the water becomes overloaded. Oxygen is stripped from the water causing oxygen dependent plants, bacteria, fish as well as the river or stream itself to die. The outcome is an environment populated by anaerobic bacteria leading to toxic water conditions and there is an indispensable need to bring back the BOD to normal level. Table 4 shows BOD of untreated effluent which is very high, i.e., 1466 mg/ml. The increase in BOD which is a reflection of microbial oxygen demand leads to depletion of Dissolved Oxygen (DO) which may cause hypoxia conditions with consequent adverse effects on aquatic biota (Jerin, 2011). BOD reduced to 593 mg/ml in the effluent treated with *Nymphaea nouchali* followed by *Musa paradisiaca* and *Nelumbonucifera* with 612 and 692 mg/ml, respectively.

pH

pH of the effluent was 8.7, Table 5, which is highly alkaline. The high pH of effluent indicates the excessive use of dyes. According to Saxena and Shrivastava (2002), alkaline nature of the textile effluent may be due to the presence of carbonates and bicarbonates present in it, therefore, discharge of effluent with alkaline pH into ponds, rivers, etc., for irrigation may be detrimental to aquatic bodies such as zooplankton and fishes. Acceptable limits for the discharge of wastewaters to both, surface water and sewers vary, ranging between from pH 5.5 to 10.0. Although stricter limits are often set, greater tolerance is shown towards higher pH since carbon dioxide from the atmosphere or from biological processes in healthy surface water systems tends to lower pH levels very effectively to neutral conditions. If the surface water pH shifts from the normal pH range, i.e., 6.5–7.5, sensitive fish and plant life are susceptible to loss. Effluent treated with three different plant extracts showed pH values of 7.2, 7.8, 7.9. Therefore, among three plants *Nymphaea nouchali* was found to be effective, i.e., the pH that falls under WHO standard, followed by *Musa paradisiaca* and *Nelumbonucifera*.

Total Kjeldahl Nitrogen (TKN)

Several components in textile effluent contain nitrogen as part of their chemical structure. The most common chemicals are ammonia from delimiting materials and the nitrogen contained in proteinaceous materials which is from liming/unhairing operations. High concentration of N_2 in aquatic system leads to eutrophication. Though comparatively small volumes being produced from liming and unhairing when discharged into aquatic life has drastic effects. It was observed 570 mg/ml of total Kjeldahl nitrogen in raw effluent. Similar to the above results effluent treated with *Nymphaea nouchali* exhibited lowest concentration of nitrogen with 39 mg/ml followed by *Musa paradisiaca* and *Nelumbonucifera* with 62 and 130 mg/ml, respectively, as shown in Table 6.

Sulphate

The high concentration of sulphate in the untreated wastewater is due to use of sulphuric acid in various steps of dyeing and printing process (Hussain and Hussain, 2012). When the effluent with high sulphate concentration is shed into aquatic water without treatment leads to dehydration and diarrhoea. Animals are also sensitive to high levels of sulphate. In young animals, high levels may cause severe, chronic diarrhoea, and in some cases can cause death. The desirable limit of sulphate concentration is set as 150 mg/l by IS 10500, where the untreated effluent exhibited 280 mg/ml sulphate. After treating with *Nymphaea nouchali* extract, sulphate concentration decreased to 153 mg/ml, which is near the permitted limit, Table 7. Effluent treated with two other plants, *Musa paradisiaca* and *Nelumbonucifera* showed 178 and 230 mg/ml of sulphate, respectively.

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Chloride

Chloride in the wastewater may be due to water softening process or when sodium chloride is used to recharge softeners. As per EPA 1986, the permissible limit of chloride for inland surface water is about 1000mg/l and for on land is about 600mg/l. Being highly soluble and stable, they are unaffected by effluent treatments, thus remaining as a burden to the environment. Increased salt content in groundwater, especially in areas of high industrial density, is now becoming a serious environmental hazard. Chlorides inhibit the growth of plants, bacteria and fish in surface waters; high levels can lead to breakdowns in cell structure. If the water is used for irrigation purposes, surface salinity increases through evaporation and crop yields fall. When flushed from the soil by rain, chlorides re-enter the ecosystem and may ultimately end up in the groundwater. High salt contents are only acceptable if the effluents are discharged into tidal/marine environments. Since most of the effluents are discharged into the nearby water bodies, it is much to decrease the chloride content. Table 8 displays chloride content in both treated and untreated effluents. Chloride was efficiently removed when treated with *Nymphaea nouchali*, followed by *Musa paradisiaca* and *Nelumbonucifera* with 503, 763, 836 mg/ml, respectively, whereas the untreated effluent showed 1076 mg/ml of chloride.

Oils and Grease

Floating grease and fatty particles may agglomerate to form 'mats' which then bind other materials will cause a potential blockage problem especially in effluent treatment systems. If the surface waters are contaminated with grease or thin layers of oil, oxygen transfer from the atmosphere is reduced. If these fatty substances emulate, they create a very high oxygen demand on account of their biodegradability. Untreated effluent had 0.05 mg/ml of oil and grease, which is higher than the recommendations of WHO (2003), whereas effluent treated with *Nymphaea nouchali* showed 0.02 mg/ml of oil and grease followed by *Musa paradisiaca* and *Nelumbonucifera*, 0.029 and 0.045 mg/ml, respectively, as shown in Table 9

Tables and Interpretation:

Table 1 TDS of untreated and treated textile effluent by plant extracts

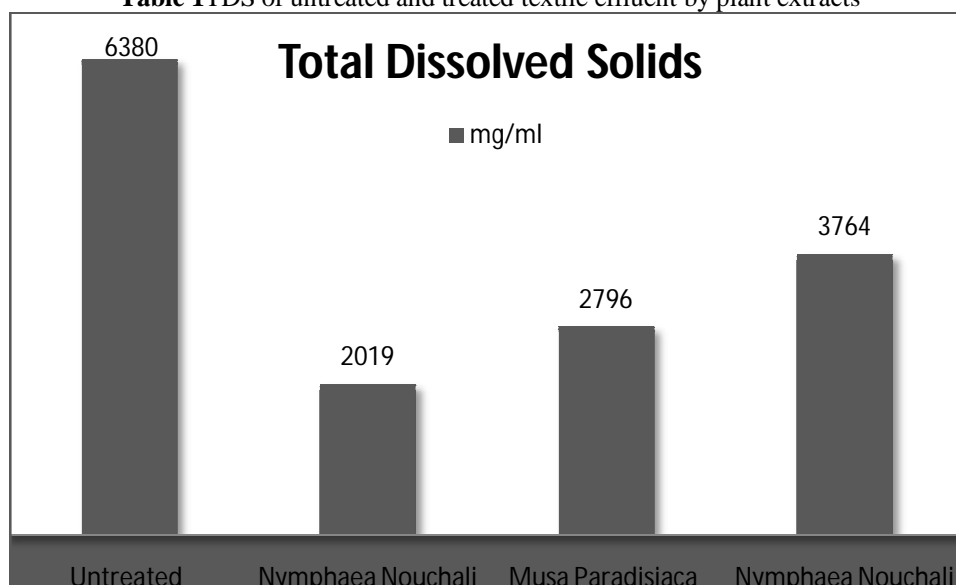


Table 2 TSS of untreated and treated textile effluent by plant extracts

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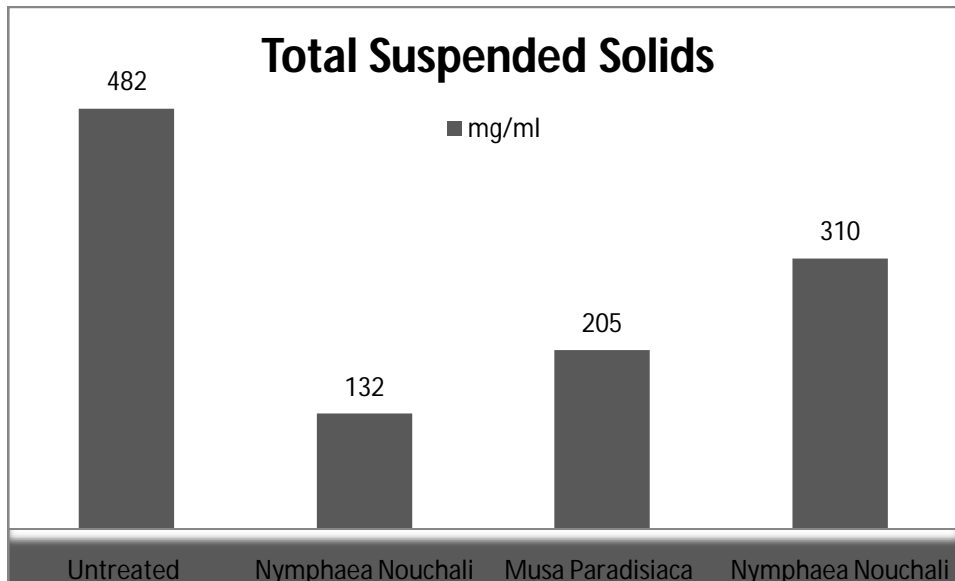
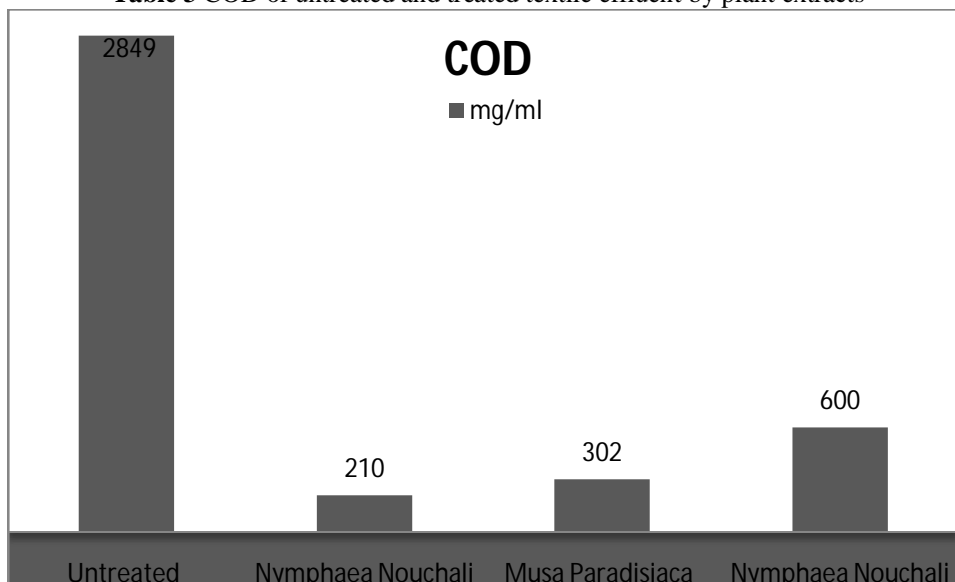


Table 3 COD of untreated and treated textile effluent by plant extracts



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Table 4BOD of untreated and treated textile effluent by plant extracts

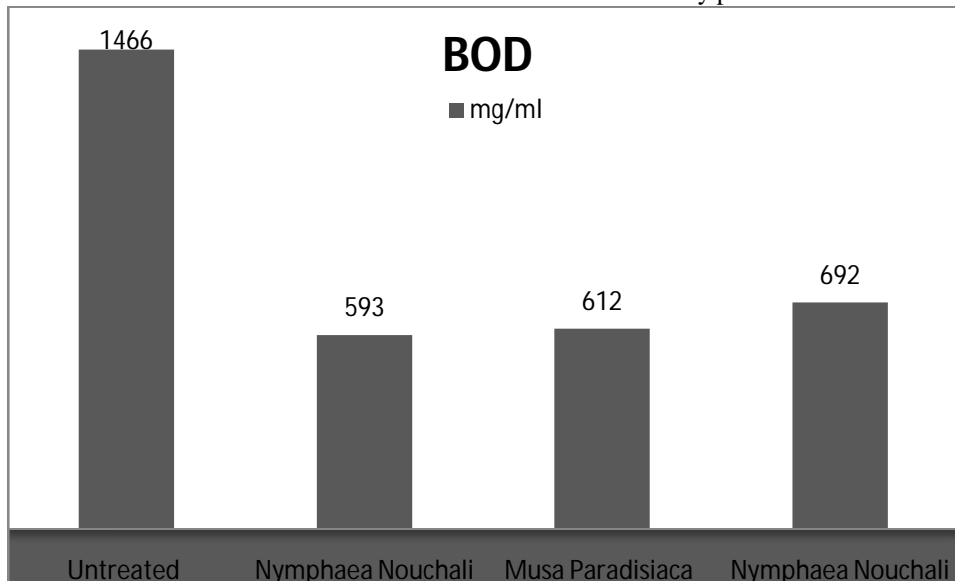
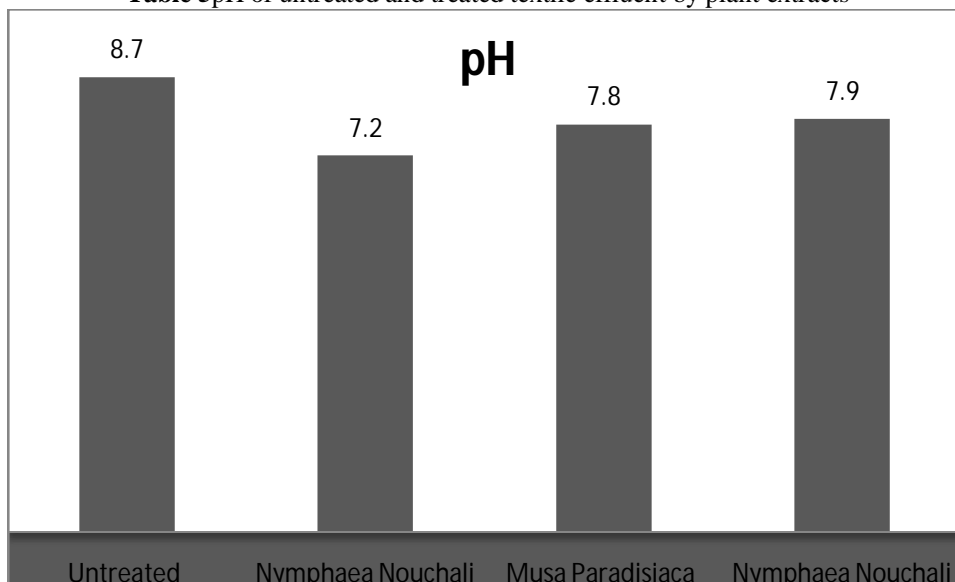


Table 5pH of untreated and treated textile effluent by plant extracts



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Table 6 Total Kjeldahl nitrogen content of untreated and treated textile effluent by plant extracts

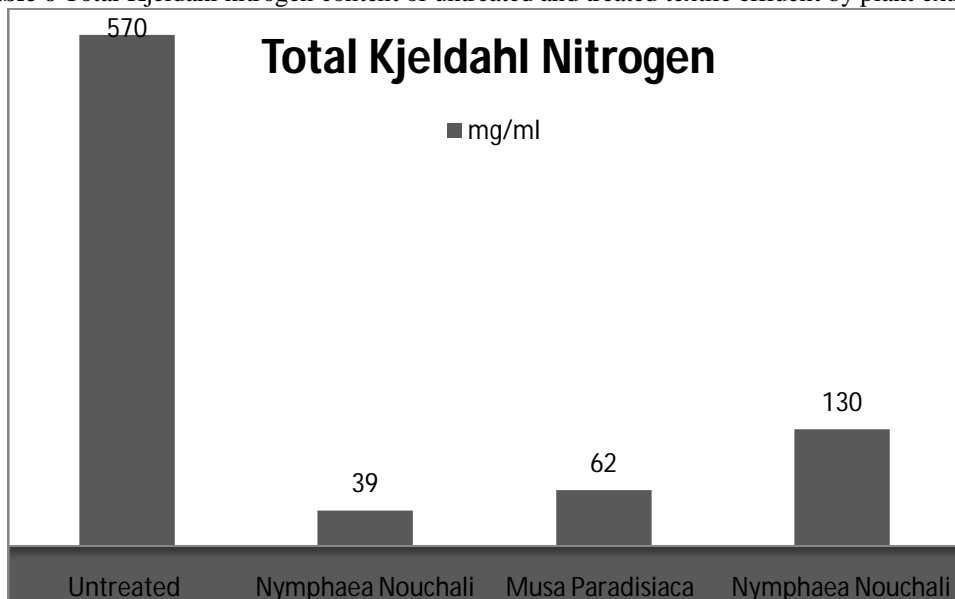
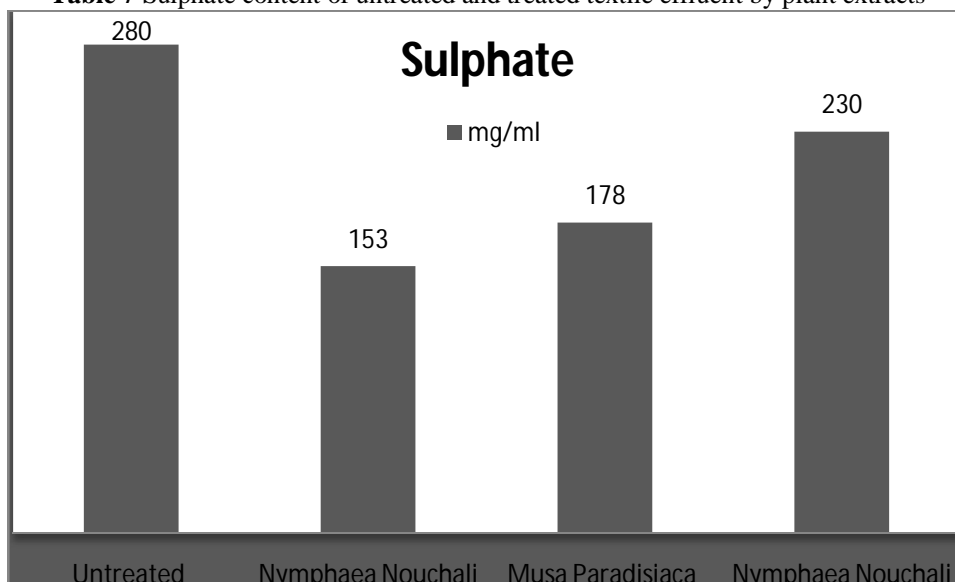


Table 7 Sulphate content of untreated and treated textile effluent by plant extracts



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Table 8 Chloride content of untreated and treated textile effluent by plant extracts

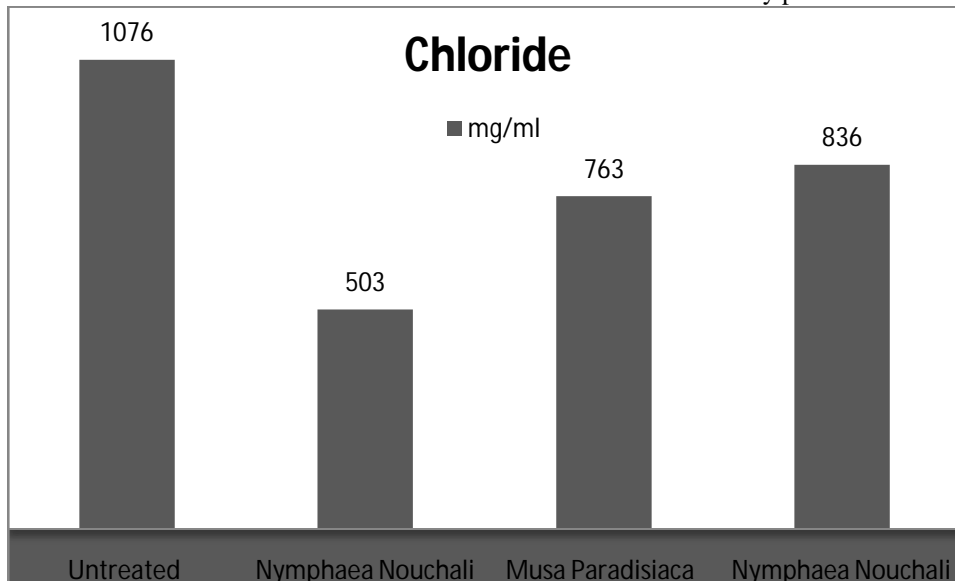
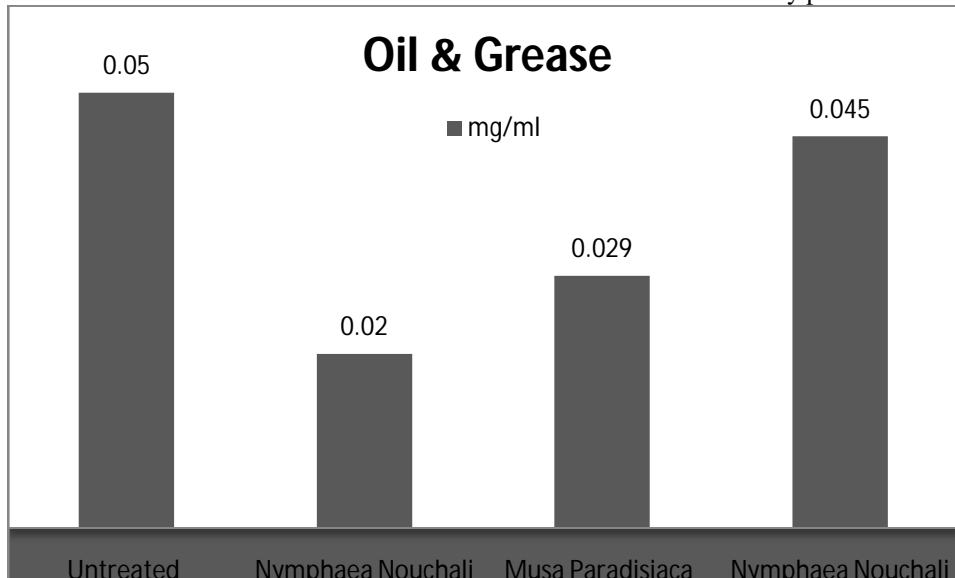


Table 9 Oil & Grease content of untreated and treated textile effluent by plant extracts



IV. CONCLUSION

Therefore, It is well evidenced that using plant extracts, flower parts, for treating textile effluent is a promising method, which can be further enhanced by treating with particular phytochemical responsible for effluent treatment and this study can be hopefully extended further. Three plant extracts namely, flower extract of Nymphaea nouchali, Musa paradisiaca and Nelumbonucifera were used for treatment; among these Nymphaea,Nouchali showed better efficiency than other two extracts.

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