## List of publications


Papers presented in seminars


A study on water hyacinth *Eichhornia crassipes* as oil sorbent

1M. Jansi Rani, 2M. Murugan, 3P. Subramaniam and 4E. Subramanian

1Department of Chemistry, Govindamal Aditanar College for Women, Tiruchendur-628215, Tuticorin (Tamil Nadu), INDIA
2Department of Chemistry, Sri K.G.S. Arts College, Srivaikuntam-628619, Tuticorin (Tamil Nadu), INDIA
3Research Department of Chemistry, Aditanar College of Arts and Science, Tiruchendur-628216, Tuticorin (Tamil Nadu), INDIA
4Department of Chemistry, Manonmaniam Sundaranar University, Tirunelveli-627012 (Tamil Nadu), INDIA

*Corresponding author. E-mail: mahalingam_murugan2004@yahoo.com*

Received: November 27, 2013; Revised received: February 24, 2014; Accepted: April 14, 2014

Abstract: The sorption of diesel, lubricant and castor oils onto different parts (root, stem and leaf) of the dry biomass water hyacinth was studied at the laboratory scale. The parts of the aquaplate water hyacinth (*Eichhornia Crassipes*) were characterized by physico-chemical methods and the characteristics were used to elucidate the oil sorption process. Hydrophobicity, wettability (capillarity), buoyancy and sorption capacity of oils in the presence/absence of water were studied to evaluate the suitability of the sorbent for application. In all the three sorbents, the oil sorption process increases with the increase of oil film thickness. However, of the three parts, the stem has a greater sorption capacity of 9.3, 7.8 and 11.08 g/g for the three oils such as diesel, lubricant and castor oils respectively, even though the root of water hyacinth showed a higher hydrophobicity and surface area. These sorption capacities are comparable with widely used commercial oil sorbent such as nonwoven polypropylene which has a sorption capacity in the range of 10-16 g/g.

Keywords: Buoyancy, *Eichhornia crassipes*, Hydrophobicity, Oil spillage, Sorption, Wettability

INTRODUCTION

Oil spillage and chemical leakage frequently occur during extraction, transportation, transfer and storage. They cause a loss of energy source and have a major negative effect on natural flora and fauna and on human health (Zhu *et al.*, 2011a,b; Rebeiro *et al.*, 2000). The conventional methods for the removal of oil spillage are oil skimming by oil skimming vessels, combustion and sorption. Among these methods the sorption process is desirable due to easy handling and availability of various sorbents (Ceylan *et al.*, 2009). Some of the adsorbents widely used in practical applications (Zhu *et al.*, 2011b) are sponges, wool-based nonwoven materials, polyvinyl chloride/polystyrene fibres, butyl rubber, zeolite, activated carbon, organo clay, hair, wool, straws (*Sun et al.*, 2002), wood (*Choi and Cloud*, 1992), cotton grass fibre (*Suni *et al.*, 2004), pine bark (*Haussard et al.*, 2003), pith bagasse (*Hussein *et al.*, 2008), coconut shell (*Amuda and Ibrahim*, 2006) etc. It has also been shown that some agricultural products such as straws, cellulosic fibre, milk weed, and cotton fibre significantly absorb more oil than the synthetic organic materials used commercially (*Sun et al.*, 2002). However, these products are not given adequate attention in the oil industry.

The present study concerns the sorption (absorption/adsorption) of organic oils onto the dry biomass water hyacinth (*Eichhornia crassipes*) (a freshwater aquaplate) which has good hydrophobicity, high uptake capacity, buoyancy and biodegradability essential for oil sorption. It is found in rivers and ponds. It grows and reproduces at a very high rate and is considered the worst aquatic plant (El-Sayed, 2003). The dense mats of water hyacinth float on the water surface, blocking navigation and interfere with irrigation, fishing, recreation, and power generation. These mats also prevent sunlight penetration and reduce the aeration of water, leading to oxygen deficiency. They competitively exclude submerged plants and reduce biological diversity. The control of water hyacinth invasion, mainly by mechanical collection and dumping is expensive and presents a solid waste problem to get rid of the water hyacinth dumps. Much research has been carried out for the best utility of dumped water hyacinth. The potential of the aquaplate as a low cost alternative for the treatment of oil effluents and spills has been attempted in this study.

MATERIALS AND METHODS

Water hyacinth (*E. crassipes*) was collected locally from the Tamirabarani river bed. It was washed several times with tap water and finally with double distilled water to remove sand and other coarse impurities. Then it was dried in sunlight for 5 days. The root, the stem and the leaves of the dried plant were powdered separately and later sieved to get particles’ the size of
75 microns ASTM (American Standard for Testing of Materials). Kept intact in polyethylene containers, the root, the stem and the leaf portion were used for adsorption study as such in the native state without further processing. The surface area of the root, the stem and the leaf of the biomass water hyacinth was determined by the Methylene blue method (Palit and Moulik, 2000).

**Tested oils:** Three types of oils namely diesel oil, lubricant oil and castor oil were used to investigate the sorption characteristics of root, stem and leaves of the biomass. Physical characteristics of the oils used in sorption study are given (Table 1).

**Methodologies of oil sorption experiments**

**Buoyancy test:** The sorbents that are used for water spills should undergo the buoyancy test (Rebeiro et al., 2000). The buoyancy test was carried out using literature procedure (Radetic et al., 2008) by static system. 1g of the sorbent was gently and evenly placed on the surface of 250 mL water in a 500 mL beaker for 15 min. Then the floated sorbent mass was measured to calculate the buoyancy percentage.

**Hydrophobicity:** The tendency of the leaf, the stem and the root of the biomass water hyacinth to be removed from the water phase into a non-polar phase was determined by testing the partition of the biomass between aqueous and hexane phases (Rebeiro et al., 2000). In this experimentation, a sample of approximately 1.0 g was placed in a beaker and was stirred for 3 min. The mixture was then left stand for 5 min, the time necessary for the separation of the phases. The quantity of material transferred to the organic phases was determined by filtration followed by subsequent drying and weighing. The results are expressed in terms of the proportion of material transferred to the organic phase or remained at the interface. This value is an estimation of the degree of hydrophobicity of the biomass.

**Wettability:** The wettability of biomass by both oil and water, as expressed in terms of capillary rise, was determined by using an experimental procedure (Rebeiro et al., 2000) based on the rate and amount of liquid rise in a packed bed of particle size 75 microns of the leaf, the stem and the root biomass of water hyacinth. The 75 micron powder prepared by grinding and screening, was manually packed in a glass tube (1cm inner diameter and 40 cm long) and closed at its lower end with a cotton frit. This column was then dipped in a beaker containing the liquid (hexane or water) and the liquid rise was measured as a function of time. The time $t = 0$ was taken when the levels in the tube and in the beaker was the same.

**Sorption capacities of the oils onto the biomass in the absence of water:** For the determination of the sorption capacity of the oils onto the biomass in the absence of water following the procedure (Rebeiro et al., 2000; Radetic et al., 2008). All the tests were performed at 27 ± 4°C. In order to analyze the oil sorption capacity of leaf, stem and root of biomass water hyacinth sorbent in oil without water, 1.0 g of sorbent was placed on top of 100 ml of oil in a glass beaker. After 60 min of sorption, the oil was drained for 2 min and the wet sorbent was weighed. The oil sorption capacity (Choi and Cloud, 1992) of the sorbent was determined by the following equation (1)

$$q = \frac{(m_f - (m_o + m_w))}{m_o} \quad (1)$$

Where, $q$ is the sorption capacity (g/g), $m_f$ is the weight of the sorbent after 2 min of drainage (g), $m_o$ is the initial weight of the sorbent (g), and $m_w$ is the weight of the water (g). It is found that oil without any water is a medium where $m_w$ is equal to zero.

**Sorption capacities of the oils onto the biomass in the presence of water:** For determination of the relations between oil/water selectivity and oil thickness in the water surface, different volumes of the oil (lubricant oil, castor oil and diesel) were poured onto 100 ml of sea water in a series of 250 ml glass beakers. The oil thicknesses were found to be 0.5, 1.3, 1.5, 2.6 and 2.8 cm respectively. After attaining a steady state, 1.0 g water hyacinth biomass was placed in the beakers. After 60 min of sorption, the wet sorbent was removed, drained for 2 min, and weighed. The saturated sorbent was squeezed. Then the liquids recovered from the sorbent were centrifuged according to the standard method D4007-81. The oil capacity of the sorbent was determined by equation (1).

### RESULTS AND DISCUSSION

**Characterisation of water hyacinth (E. crassipes):**

Table 2 presents the results of the physico-chemical characterization of the root, the stem and the leaf of the biomass water hyacinth. The root of water hyacinth had a higher surface area than the stem and the leaf. The surface morphologies of the root, the stem and the leaf of water hyacinth are shown in Fig. 1. It can be seen that the surface morphologies displayed a smooth surface caused by different micro structures without

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stem</th>
<th>Leaf</th>
<th>Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density (g/cc)</td>
<td>0.0139</td>
<td>0.0278</td>
<td>0.031</td>
</tr>
<tr>
<td>Particle density (g/cc)</td>
<td>0.0078</td>
<td>0.0125</td>
<td>0.023</td>
</tr>
<tr>
<td>Pore space volume (ml)</td>
<td>3.2</td>
<td>4.0</td>
<td>2.200</td>
</tr>
<tr>
<td>Surface area (m²/g)</td>
<td>5.4</td>
<td>10.2</td>
<td>77.88</td>
</tr>
<tr>
<td>Pore volume (cm³)</td>
<td>17.78</td>
<td>22.22</td>
<td>13.75</td>
</tr>
<tr>
<td>Buoyancy (%)</td>
<td>40.1</td>
<td>12.5</td>
<td>37.9</td>
</tr>
<tr>
<td>Hydrophobicity (%)</td>
<td>22</td>
<td>2.1</td>
<td>15.1</td>
</tr>
</tbody>
</table>

### Table 1. Characteristics of oils used in sorption study.

<table>
<thead>
<tr>
<th>Oil</th>
<th>Density (g/ml)</th>
<th>Viscosity (pa/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>0.844</td>
<td>4.401</td>
</tr>
<tr>
<td>Lubricant oil</td>
<td>0.850</td>
<td>5.153</td>
</tr>
<tr>
<td>Castor oil</td>
<td>0.961</td>
<td>2.420</td>
</tr>
</tbody>
</table>

### Table 2. Characteristics of the parts of the adsorbent water hyacinth (75 micron).
any ripple due to the coverage of plant wax.  

Buoyancy test: The buoyancy test showed that the stem had higher percentage of buoyancy than the leaf and the root of biomass water hyacinth. The hydrophilicity test showed that the root part had higher percentage of hydrophilicity than the stem and the leaf of biomass water hyacinth.  

Capillary rise: Figs. 2 and 3 showed the water and hexane capillary rise respectively through the stem, the leaf and the root of the biomass water hyacinth. The water capillary rise showed that the root part was more hydrophilic than the stem and the leaf of biomass water hyacinth. The hexane capillary rise showed that leaf was more hydrophobic than the stem and the root of biomass water hyacinth.  

Oil sorption capacity of parts of the biomass water hyacinth in the absence of water: Table 3 presents the results of the sorption of diesel, castor oil and lubricant oils onto the root, stem and leaf of water hyacinth biomass in the absence of water. The sorption capacity of castor oil was greater than the lubricant and diesel oils onto the biomass stem, leaf and root of water hyacinth. This may be due to the increased viscosity of the pollutant which decreases the rate of sorption (Ceylan et al., 2009). The sorption capacity of the stem part was higher than the root and the leaf parts for all the three oils.  

Oil sorption capacity of parts of the biomass water hyacinth in the presence of water: Sorption selectivity between oils and water is an important parameter for oil sorbent used in the spill cleanup on the water surface. The oil sorption capacities of the three parts, the root, the stem and the leaf of biomass water hyacinth in the presence of oil over water baths containing different thicknesses of oil film for diesel oil, castor oil and lubricant oil are given in figs. 4-6. The amount of

<table>
<thead>
<tr>
<th>Oil</th>
<th>Sorption Capacity (g/g)</th>
<th>Root</th>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>3.105</td>
<td>9.010</td>
<td>4.401</td>
<td></td>
</tr>
<tr>
<td>Lubricant oil</td>
<td>4.643</td>
<td>9.289</td>
<td>5.153</td>
<td></td>
</tr>
<tr>
<td>Castor oil</td>
<td>6.300</td>
<td>11.08</td>
<td>4.92</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil</th>
<th>Sorption Capacity (g/g)</th>
<th>Root</th>
<th>Stem</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>3.058</td>
<td>8.066</td>
<td>3.466</td>
<td></td>
</tr>
<tr>
<td>Lubricant oil</td>
<td>4.434</td>
<td>8.560</td>
<td>3.631</td>
<td></td>
</tr>
<tr>
<td>Castor oil</td>
<td>6.004</td>
<td>10.310</td>
<td>4.120</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3. Oil sorption capacity of the parts of water hyacinth in the absence of water.**

**Table 4. Oil sorption capacity of the parts of water hyacinth in the presence of water.**
water pickup is low, which allows the indication of sorbent selectivity between oil and water. As shown in these figures the oil sorption capacity of the sorbents increases with the increase of oil film thickness until the sorbent is saturated with oil. At low thickness of oil spilled over water, almost the entire amount of added oil can be picked up by the sorbent. In oil/water mixture systems, the maximum oil capacity of the biomass stem of water hyacinth onto the diesel oil, lubricant oil and castor oil is given in Table 4. The sorption capacity of the stem part is higher than the root and the leaf parts for all the three oils. There is a difference in oil sorption capacities for pure oil and oil/water mixture system. This may be due to the absorption of water over oil in the pores of the leaf, the stem and the root.

**Oil sorption mechanisms:** The mechanism of oil sorption by sorbents can be adsorption, absorption, capillary action, or a combination of these (Radetic et al., 2008). The adsorption is based on the specific surface area of the adsorbent and the hydrophobic interaction between the adsorbate. This mechanism is a function of the hydrophobicity of the sorbent, the porosity of the sorbent and the volume of the sorbent. In many cases the sorption of non polar hydrocarbons occurs through a combination of both mechanisms. Thus, both the capillarity and the hydrophobicity of the leaf, the stem and the root of biomass water hyacinth, contribute to the total oil sorption. The relative significance of these mechanisms depends on the properties of the sorbent and sorbate.

**Conclusion**

The results obtained in this study showed the stem, the leaf and the root of the biomass water hyacinth, have a good oil sorption capacity. The parts of the biomass material showed a rapid oil sorption and a high sorption capacity, high degree of hydrophobicity and low water uptake make water hyacinth a suitable alternative to traditional synthetic oil sorbents applied to the oil recovery in the absence/presence of water. The material is inexpensive and abundantly available in tropical regions but the expensive control of water hyacinth invasion by mechanical collection, dumping and solid waste problems can be reduced by using it as an oil sorbent. Thus the findings project the inference that the stem, the leaf and the root of the biomass water hyacinth can be deemed low cost yet efficient oil sorbent.

**REFERENCES**


Adsorptive removal of arsenic from aqueous solution on PSLW carbon (Prosopis spicigera L. wood): Equilibrium, kinetics, thermodynamics and home water treatment studies

Jansi Rani M.¹, Murugan M.², Subramaniam P.³ and Subramanian E.⁴

¹. Department of Chemistry, Govindammal Aditanar College for Women, Tiruchendur, Tuticorin, 628 215, Tamilnadu, INDIA
². Sri K.G.S. Arts College, Sivavakuntam, Tuticorin, 628 619, Tamil Nadu, INDIA
³. Department of Chemistry, Aditanar College of Arts and Science, Tiruchendur, Tuticorin, 628 216, Tamilnadu, INDIA
⁴. Manonmaniam Sundaranar University, Tirunelveli 627012, Tamil Nadu, INDIA

*mahalingam_murugan2004@yahoo.com

Abstract

In this study, an activated carbon from a low cost and waste plant, Prosopis spicigera L. wood (PSLW) was used as adsorbent for the removal of As(III) ion in aqueous solutions. The adsorbent was well characterized by Boehm titrations, FTIR, SEM, pH_{zpc} and BET methods. In batch mode the optimum conditions for adsorption were established as a function of pH, initial As(III) concentration, contact time, adsorbent dosage and temperature. In a contact time of 120 min at 30 °C and with the adsorbent dose of 2g/L and As(III) initial concentration of 300, 750 and 1000mg/L, the maximum adsorption capacity of PSLW carbon was found to be 64.1, 64.26 and 65.41mg/g respectively. Temperature enhanced the adsorption which followed Langmuir isotherm model.

Pore diffusion was a key step in adsorption which was facilitated at higher temperature. Pseudo second order kinetics explained the adsorption rate process that involves complex formation between As(III) species and functional groups in PSLW carbon. As an application, As(III) adsorption was tested with home water filter containing PSLW carbon in clay column. Encouraging results were obtained proving the validity and applicability of PSLW carbon.

Keywords: Arsenic removal, Prosopis spicigera L. Wood (PSLW) carbon, Clay filter, Thomas model.

Introduction

Presence of arsenic at elevated levels in drinking water causes health hazards such as cancer, various skin lesions etc. It is a teratogen and crosses the placental membrane into the metabolic system of foetus. Therefore, the WHO has reduced the potable limit of arsenic in drinking water from 50μg/L to 10μg/L. Arsenic contamination in drinking water supplies is a specific problem in certain parts of Taiwan, Mexico, Chile, Vietnam, West Bengal (India), Bangladesh and China. Arsenic is introduced into water by geological process and anthropogenic activities such as smelting, petroleum refining, fertilizer, pesticides, herbicides, glass and ceramic manufacturing industries. The usual methods of arsenic removal recommended by USEPA are adsorption, ion exchange, reverse osmosis, membrane filtration, modified coagulation/filtration and enhanced lime softening. Among the above-mentioned processes, still adsorption remains the most effective technique for the removal of arsenic in laboratory as well as industrial scale.

There are many adsorbents available for arsenic removal; however activated carbons are the widely used materials due to their exceptionally high surface area, well developed internal micro porosity and wide spectrum of surface functional groups. Activated carbons can be prepared from biomass because biomass is renewable in nature, widely available, low cost and environmental friendly. Some of the biomasses used for activated carbon preparation are forest residues, agricultural wastes and municipal wastes.

In the present work, arsenic removal from aqueous solution is attempted with carbon prepared from a dry land plant Prosopis spicigera L.wood (PSLW). This plant is available all over India especially in the dry lands and deserts and its materials are low-cost and abundantly available.

Material and Methods

Materials: PSLW plant material used in the present work was collected from the dry land area of Tiruchendur in Thoothukudi district, Tamil Nadu State, India. Activated carbon was prepared from the collected plant material as follows. The branches and roots of the tree were cut into pieces and pilled up on a firing hearth. Before firing, the heaped wood pieces were enclosed by fresh plantain pith and the whole mass was covered and plastered with layers of wet clay. This arrangement prevented the direct-entry of air into wood pieces and hence prohibited burning of wood and becoming ash. After 48h of continuous firing and subsequent natural cooling, the activated carbon was obtained. After removing non-carbonaceous materials like plantain pith, clay-mud etc., carbon was isolated, crushed into fine powder and sieved to 75 micron particles.

The specific carbon material was stored in bottles and used as such for adsorption study after subjecting it to various physico-chemical parameters determination.

Characterization of the adsorbent: The standard procedures were adopted to find the characteristics of
Fluoride Removal From Aqueous Solution Using Batch, Column and Home Water Treatment Method by Low Cost Adsorbent: *Prosopis spicigera* L. Wood (PSLW) Carbon

M. Murugan, M. Jansi Rani, P. Subramaniam and E. Subramanian

*Sri K.G.S. Arts College, Department of Chemistry, Srivakutnam, Tuticorin-628 619*

An agricultural low-cost material, *Prosopis spicigera* L. wood (PSLW) was carbonized and used as an adsorbent for removal of fluoride from aqueous solution by batch, column and clay filter (home water treatment) methods. The adsorbent was characterized by BET method (nitrogen adsorption at 77 K) for pore and textural properties, scanning electron microscopy for surface morphology, potentiometric titration for pH_{pzc}, FTIR for surface functional group and Boehm estimation of surface functional groups. The adsorption of fluoride ion on PSLW carbon was carried out at different pHs, adsorbate concentrations and contact time, adsorbent dosage and temperature conditions to determine the optimum condition for adsorption. Batch adsorption experiments show that maximum defluoridation was at pH 1.0. Pseudo first order kinetics (Lagergren), pore diffusion and surface mass transfer models were used to evaluate the kinetic parameters and adsorption mechanism. To describe the equilibrium isotherm process, the data were analyzed using Langmuir model. Thermodynamic behaviour of the adsorption reaction indicates an endothermic spontaneous adsorption process. Column data were analyzed using Thomas model. Exhaustered PSLW carbon was regenerated with alkali.

**KEYWORD**


**INTRODUCTION**

Fluoride is essential to health and its dietary intake (for maintaining fluoride concentration of 1 mg/L) strengthens enamel of teeth and bones. However, excess intake of fluoride through drinking water causes health hazards, such as dental, skeletal fluorosis, brain and kidney damages (Harrison, 2005). The anthropogenic activities that enrich the fluoride concentration in drinking water are the discharges of industrial effluents from cement and bricks, electronic industries, the refining of aluminium and the processing of slag from electric furnaces, steel industry, coal power plants, glass and ceramic industries, fertilizer and rubber manufacturing industries (Raichur and Basu, 2001; Shen et al., 2003). Globally India, China, Sri Lanka, West Indies, Spain, Holland, Italy, Mexico, North and South America have high fluoride content in the ground water (Ayoob et al., 2008). It is estimated that more than 70 million people have been affected by fluorosis worldwide. The WHO has set the potable limit of fluoride concentration in drinking water as 1.5 mg/L (WHO, 2002). Hence, it is essential to remove the excess fluoride from drinking water resources beyond the potable limit of 1.5 mg/L.

Several methods are available for defluoridation (Ayoob et al., 2008; Ma et al., 2011). They are coagulation followed by precipitation, electrochemical degradation, ion exchange, osmosis and adsorption. In coagulation followed by precipitation, trace amounts of fluoride tends to remain in so-
Use of activated carbon prepared from Prosopis Spicigera L. wood (PSLW) plant material for the removal of rhodamine 6G from aqueous solution

Mahalingam Murugan\textsuperscript{a,}\textsuperscript{*}, Manickam Jansi Rani\textsuperscript{b}, Perumal Subramaniam\textsuperscript{c}, Esakkiappan Subramanian\textsuperscript{d}

\textsuperscript{a}Department of Chemistry, Sri K.G.S. Arts College, Srivaikuntam, Tuticorin 628 619, Tamil Nadu, India, Fax: 04630255252; email: mahalingam_murugan2004@yahoo.com
\textsuperscript{b}Department of Chemistry, Govindammal Aditanar College for Women, Tiruchendur, Tuticorin 628 215, Tamil Nadu, India
\textsuperscript{c}Department of Chemistry, Aditanar College of Arts and Science, Tiruchendur, Tuticorin 628 216, Tamil Nadu, India
\textsuperscript{d}Department of Chemistry, Manonmaniam Sundaranar University, Tirunelveli 627012, Tamil Nadu, India

Received 25 March 2014; Accepted 28 October 2014

ABSTRACT

The removal of rhodamine 6G dye from aqueous solution using carbon prepared from cheaply available agro-product, Prosopis spicigera L. wood (PSLW), was investigated. This work involves studies of physical and chemical properties of adsorbent, batch sorption experiments, and continuous run in a packed column at laboratory scale. Optimum condition for rhodamine 6G dye adsorption on PSLW carbon was determined by varying pHs, adsorbate concentrations, contact time, adsorbent dosage, and temperature. Lower solution pH favored the adsorption of Rh 6G dye. Adsorption onto the surface, surface mass transfer, and pore diffusion of dye molecules were the main process involved in the removal of Rh 6G dye. The adsorption followed Langmuir isotherm and the maximum adsorption capacity was found to be 8.86 mg/g for an initial concentration of 30 mg/L at 30\(^\circ\)C. Thermodynamic parameters indicated that the adsorption interaction was spontaneous and exothermic in nature. The column study was explained using Thomas model.

Keywords: Adsorption; Kinetics; Prosopis spicigera L. wood (PSLW) carbon; Rhodamine 6G; Thomas model

1. Introduction

Dyes are indispensable in the modern sophisticated life to magnify the value of the product [1]. Colored effluents released into water bodies cause a serious health hazard to human beings and significantly affect photosynthetic activity in aquatic life [2,3]. A small quantity of dye in water is greatly noticeable and can be lethal to individuals in water. Rhodamine 6G (Rh 6G) is one such type of highly water-soluble cationic dyes. It belongs to xanthane class and is used in biological, analytical, and optical sciences [4]. It is used in textile, leather, and jute industries for dyeing cotton, silk, leather, paper, wood, and bamboo. But it makes toxic effect in the environment [5] and causes irritation to the skin, eyes, gastrointestinal tract, and respiratory tract. Therefore, the removal of Rh 6G and other coloring dyes from water is essential. Different treatment technologies such as adsorption [6], precipitation [7], ion-exchange [8],