Treatment of Textile Wastewater Using Sodium Alginate Beads

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Abstract. Textile is one of the important industry. Conversion of fiber to fabric takes place which involves many process and synthetic chemicals. The fabric is then dyed or printed, fabricated into clothes. The extraction of dyes from the wastewater industry becomes a worldwide issue. Water contamination due to industrial discharge is the big threat to the environment. Hence an attempt was made in this study to treat textile wastewater using natural anionic polysaccharide sodium alginate as adsorbing agent. The optimum condition was obtained by varying dosage, pH, flow rate and depth of beads for varying contact time. For optimum conditions, the textile wastewater was analyzed. Results showed 32%, 56% and 75% removal of sulphates, alkalinity and nitrates respectively. Hence sodium alginate proved efficient in treatment of textile wastewater.

Keywords: Textile industry, Adsorbing agent, Sodium alginate, SEM technique

1. Introduction

The raw material used are either natural or synthetic using products of the chemical industry. Dyes present in effluent of textile industry are visible and components of degradation of dyes are usually carcinogenic in nature. Toxic, organic and inorganic components of the waste require treatment before disposal. Problems still persists even after treatment of textile wastewater in the final disposal effluent. Hence an efficient treatment method is required which is best suited for disposal. Recent studies have showed that pollutants can be removed using sodium alginate beads. Apart from the alginate based material chemical modification of various biopolymers, chitosan, cellulose, dextrin, xanthan gum and biopolymer based Nano composites are also employed. In this aspect, batch adsorption is a versatile and simple method. Adsorption is a simple process used for the removal of contaminants of textile industrial wastewater. This is particularly suitable for the treatment of wastewater streams containing pollutants. The main objective of this research work is to study the effectiveness of sodium alginate as a polymeric material in the textile wastewater treatment.

Sodium alginate is the extract of polysaccharide from the cell wall of seaweed. Calcium chloride is added to sodium alginate, cross-link of calcium ions with polymers takes place in many points. A gel bead which is flexible and soft is formed. When this is soaked for longer time, more calcium ions move in mesh of gel bead with more cross link and firmer texture (Figure 1 & 2).

![Figure 1: Structure of sodium alginate beads](image-url)
2 MATERIALS AND METHODOLOGY

2.1 Study Area
Nanjangud is one of the most popular industrial area; it is a town in Mysore district in the Indian state of Karnataka. Nanjangud lies on the bank of the river Kapila (Kabini), 23 Km from the city of Mysore. The Reid and Taylor textile industry is situated at Nanjangud which involves design of cloth. Synthetic products of the chemical industry are used as raw material. Figure 3 shows the location of Reid and Taylor textile industry.

2.2 Sample Collection
The wastewater sample was collected from Reid and Taylor textile industry Figure 4 shows the location of sampling station. The physical and chemical characteristics of Reid and Taylor textile wastewater were analyzed. The sample was collected in a clean plastic can of 5 liters capacity. The can was rinsed with the sample and collected it from tap provided for wastewater storage tank. Sample is brought to laboratory for analysis using analytical techniques and sample is stored in a cooler. The wastewater was analyzed for parameters like pH, wastewater temperature, Electrical conductivity, Total acidity, Alkalinity, Total dissolved solids, Chloride, Iron, Nitrates, Sulphates, Chemical oxygen demand and Biochemical oxygen demand.

2.3 Methodology
The method for synthesis of sodium alginate beads done by mixing 3% weight by volume of sodium alginate with 100 mL of distilled water. The alginate gel solution was refrigerated for half an hour. Adding drop wise of this into a 30% weight by volume of calcium chloride with one liter of distilled water solution under a gentle stirring at room temperature. Equal size of Calcium alginate hydrogel sphere of size 2.5 mm to 3.0 mm prepared and is stabilized by allowing over a night. Filtration is used to remove the cross linker in excess and distilled water is used several times to wash it. Beads were then used to remove pollutants from wastewater in batch adsorption experiments.
RESULT AND DISCUSSION

3.1 General
Sodium alginate beads analyzed using Scanning Electron Microscopy (SEM) at Vijnan Bhavan, University of Mysore, Manasagangothri, Mysore, Karnataka.

3.2 Physico-chemical characteristics of textile Wastewater
The pH of initial concentration of textile wastewater is found to be 6 which is slightly acidic in nature (Table 1). The electrical conductivity of the wastewater depends on the quantity and cloth processes but it was found to be very much higher. The concentration of EC for Reid and Taylor was found to be 1.6 mmoh/cm. The amount of hydrochloric acid that can be added to a certain amount of wastewater until a pH of 4.3 is reached. Causes of acid capacity deficits in wastewater treatment plant. The concentration of alkalinity is found to be 729 mg/L as CaCO₃. In wastewater due to oxidation of bicarbonate in carbonate there may be increase of carbonate concentration. The concentration was observed to be 8.99 mg/L. This indicates that in the textile industry the process may not include which increases the concentration of chloride in the wastewater.

The presence of low concentration if iron in wastewater of 1.4mg/L was due to the use of iron complexed dyes. The concentration of nitrate found in the wastewater is very low of about 1.55mg/L. Presence of nitrate is due to the dyes used in the textile industry. Various dyes have nitrate has functional group. The concentration of textile wastewater is 170 mg/L. This is due to chemical used and variety of cloth processes. The concentration of COD was observed to be 380mg/L which indicates presence of chemicals in the wastewater. This is because of usage of chemicals and dyes in various stages in the manufacturing of textiles. Concentration of BOD i.e. found to be 68 mg/L. This is responsible for high biochemical oxygen demand in the nearby water bodies if discharged without any treatment.

3.3 Optimization of Column Parameters
3.3.1 Effect of initial pH value
Removal efficiency was observed with pH 7 for initial dye solution. pH was slightly reduces to 6.5 and 6 to observe the percentage removal of dye. Influence of positively charged dye groups onto adsorbent surface is due to surface charge on the adsorbent. In the acidic condition, positive charge decrease and negative charges increases. Hence electrostatic repulsion occurs dye cations which are positively charged did not allow for adsorption. Then pH was increased above 7 to 7.5, 8, 8.5, 9, 9.5 and 10. Optimum pH was found to be 98% for pH 9 which is shown in Figure 4.

3.3.2 Effect of flow rate
For 2 cm height sodium alginate bed, and the initial dye concentration of 7.5, 10 and 15mg/L, also with varying the flow rate (50, 100, and 150 cc/hour) the adsorption of Rhodamine B was studied. It
was observed that with higher flow rate, the breakthrough occurred faster (Table 3). But in case of low flow rate, time of contact is high, hence higher removal of dye can be achieved (Figure 5). Column saturation occurred at faster rate along with mass transfer rate increased with flow rate. Due to insufficient residence time, lower adsorption with high flow rate.

3.3.3 Effect of bed height
It was observed that the as the bed height increased the breakthrough also increased. In the study bed height of 5cm and 10cm for flow rate of 50 cc/hr was carried out (Table 4). With the increase in the bed height (Figure 6), the sites available for adsorption are high, hence the removal efficiency of dye increased. Increased adsorption was observed with highest bed height, since binding sites for adsorption increased.

3.3.4 Effect of initial Rhodamine B concentration
For optimum condition of bed height 10cm, flow rate 50cc/hour and pH 9, the effect of initial concentration of dye on the adsorption process was studied. It was observed that as the initial Rhodamine B concentration increased column exhaustion time decreased (Figure 7). Due to the availability of sufficient active sites for the adsorption, removal efficiency of the dye increased at the start (Table 5). At higher concentration due to less availability of adsorption sites, most of the dye are left unabsorbed and hence the decrease in percentage removal of dye was observed.

3.3.5 Treatment of textile wastewater
For optimum conditions, the textile wastewater is passed through sodium alginate to study the efficiency of in the treatment of textile wastewater. Physico-chemical characteristics of wastewater analyzed before as well as and after the treatment, to know the efficiency of sodium alginate in textile wastewater treatment (Table 6).

The wastewater with pH 9, bed height 10cm and flow rate 50cc/hr was passed through beads. The treated wastewater was analyzed which is show in Table 6. The results showed 32% removal of Sulphate, 56 % removal of alkalinity and 75% removal of nitrates.

### Plate: 1 Color of Textile Wastewater before and after the treatment

### Plate: 2 Color of Sodium Alginate beads before and after the treatment

### Table: 1 Physico-Chemical characteristics of wastewater sample
| PARAMETERS               | INITIAL CONCENTRATION |
|-------------------------|-----------------------|
| pH                      | 6                     |
| BOD₅ (mg/L)             | 62                    |
| COD (mg/L)              | 380                   |
| Chlorides (mg/L)        | 8.99                  |
| Sulphate (mg/L)         | 170                   |
| Alkalinity (mg/L as CaCO₃) | 729                  |
| Acidity (mg/L as CaCO₃) | 81                    |
| Electrical conductivity (m-mho/cm) | 1.6     |
| Nitrates (mg/L)         | 1.55                  |
| Solids (mg/L)           | 1.066                 |
| Iron (mg/L)             | 1.4                   |

Table: 2 Removal Efficiency of Rhodamine B for varying pH

| pH | 0.5 minutes | 1.0 minutes | 1.5 minutes | 2.0 minutes |
|----|-------------|-------------|-------------|-------------|
| 6.0| 66          | 69          | 58          | 52          |
| 6.5| 65          | 67          | 61          | 57          |
| 7.0| 63          | 66          | 62          | 59          |
| 7.5| 87          | 87          | 78          | 71          |
| 8.0| 93          | 88          | 85          | 76          |
| 8.5| 95          | 96          | 86          | 77          |
| 9.0| 97          | 98          | 92          | 81          |
| 9.5| 88          | 78          | 64          | 65          |
| 10.0| 67          | 65          | 59          | 43          |
Figure: 5 Removal Efficiency of Rhodamine B for varying Ph

Table: 3 Removal Efficiency of Rhodamine B for varying Flow rate

| Flow rate, cc/hour | 0.5 minutes | 1.0 minutes | 1.5 minutes | 2.0 minutes |
|-------------------|-------------|-------------|-------------|-------------|
| 50                | 98          | 96          | 91          | 85          |
| 100               | 96          | 95          | 87          | 81          |
| 150               | 80          | 77          | 71          | 64          |

Figure: 6 Removal efficiency of Rhodamine B for varying Flow rate

Table: 4 Removal Efficiency of Rhodamine B for varying Bed Height

| Bed height, cm | 0.5 minutes | 1.0 minutes | 1.5 minutes | 2.0 minutes |
|----------------|-------------|-------------|-------------|-------------|
| 5              | 81          | 85          | 77          | 70          |
| 10             | 93          | 96          | 87          | 81          |
Figure: 7 Removal Efficiency of Rhodamine B for varying Bed height

| Initial concentration, mL | Removal Efficiency (%) |
|---------------------------|------------------------|
|                           | 0.5 minutes | 1.0 minutes | 1.5 minutes | 2.0 minutes |
| 7.5                       | 93          | 95          | 90          | 84          |
| 10                        | 81          | 86          | 78          | 76          |
| 15                        | 75          | 77          | 71          | 68          |

Figure: 8 Removal efficiency for varying dye concentration at optimum conditions

Table: 6 Removal Efficiency of Physico-Chemical parameters of Wastewater sample after treatment

| Parameters  | Initial Concentration | Final Concentration | Removal Efficiency (%) |
|-------------|------------------------|---------------------|------------------------|
| pH          | 6                      | 8.5                 | -                      |
| Sulphate(mg/L) | 170                  | 115                | 32                     |
|                           | 729 | 576 | 21 |
|---------------------------|-----|-----|----|
| Alkalinity (mg/L as CaCO₃) | 729 | 576 | 21 |
| Acidity (mg/L as CaCO₃)   | 81  | 36  | 56 |
| Electrical conductivity (moh/cm) | 1.6 | 0.95 | 41 |
| Nitrates (mg/L)           | 1.55| 0.38| 75 |
| COD (mg/L)                | 380 | 80  | 78 |
| Iron (mg/L)               | 1.4 | 0.36| 74 |
| Solids (mg/L)             | 1.066| 0.356| 66 |

3.4 SEM Analysis
SEM analysis was done to scan the surface. Magnification of 50μm to 1μm was done to carry analysis of bulk capsule. Slight change in morphology and visualization of micro-pitting was achieved with further magnification. The SEM analysis was done for Sodium alginate beads before (Plate 3) and after (Plate 4) passing textile wastewater through beads. It is clearly observed from the SEM images that the deformation of gel occurred due to adsorption of components present in wastewater in the pore sites after the passing of wastewater through beads. The morphology of the beads appeared to be a porous and spongy. However, to obtain a clear size, shape and structural image of the beads can be analyzed using Transmission Electron Microscopy.

Plate: 3 SEM images of sodium alginate for different magnification before treatment of textile wastewater

Plate: 4 SEM images of sodium alginate for different magnification after treatment of textile wastewater

4 CONCLUSIONS
• The initial concentration of COD 380 mg/L, BOD₅ 62mg/L with pH 6 and alkalinity 729 mg/L as CaCO₃ textile wastewater was observed. This indicates the textile wastewater concentration from Reid and Taylor was slightly polluted which requires low treatment.
• The optimum condition obtained for the column study was pH 9, bed length 10cm and flow rate 5cc/hr
• Results showed 32% removal of Sulphate, 56% removal of alkalinity and 75% removal of nitrates which shows efficiency of sodium alginate proved efficient in treatment of textile wastewater
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