THE CASTOR SEED HUSK USED AS AN EFFECTIVE NATURAL ADSORBENT FOR TREATMENT OF TEXTILE EFFLUENT

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ABSTRACT

Rapid industrialization has leads to the discharge of waste effluents in environment and this has been great concern because of it has adverse effects. There are too many conventional methods used for treatment of waste effluent which includes sedimentation, precipitation, oxidation-reduction, ion exchange, reverse osmosis. These methods are costly, time consuming and often generate sludge. The purpose of the study is to investigate the utilization of Castor Seed Husk (CSH) as low cost natural adsorbent for treatment of textile effluent. CSH is treated with 0.2M NaOH and the powder particles are used in this experiment at different pH values (5pH, 6pH, 7pH) and different adsorbent dosages (0.1gm and 0.2gm) and at different contact times (5Hrs, 6Hrs, 7Hrs). The effluent parameters are analysed in laboratory with standard methods according to American Public Health Association (APHA & AWWA). According to analysis, optimum results were obtained at 6pH, 0.2gm dosage in 100ml sample at 6Hrs. CSH removes 81.25% COD, 78.40% Turbidity, 76.92% Phenol, 72.36% BOD, 70.27% TSS, 68.81% Sodium (%), 66.66% Chromium, 65.24%, %TS, 65.75%, Oil grease 63.46%, TDS, 63.33% sulphate, 58.40% Chloride, 41.78% Hardness, 36.46% Alkalinity and also CSH are able to adjust the alkaline pH to their permissible limits of effluent and reduce the colour in good amount. By increasing the adsorbent dosage the % removal is also increased and time is decreased (when the adsorbent dosages is 2 gm the optimum result was obtained at 50 minutes at pH 6). The main advantage of this method is treated adsorbent can be reused after washing with distilled water with 50% adsorption capacity and easy to dispose and this treated water can be directly discharged into inland surface water. So it is concluded that CSH can be used as cost effective adsorbent for treatment of Textile effluent successfully.

Key Words: Adsorption process, Castor Seed Husk (CSH), pH, Contact time, Adsorbent dosage, Effluent

INTRODUCTION

Textile effluent

As textile industry is one of the largest industries in the world and different fibres such as cotton, silk, wool as well as synthetic fibres are all pre-treated, processed, coloured and after treated using large amounts of water and a variety of chemicals, there is a need to understand the chemistry of the textile effluents very well. The textile waste characteristic needs to be understood clearly. Different methods and aspects of Textile Effluents and its management to save the environment from polluting the same needs to be understood. Major pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, colour, acidity, and other soluble substances whose chemistry will be emphasised. Textile processing involves many different steps. In almost all of steps, wastewater is generated. The amount and composition of these wastewaters depend on many different factors, including the processed fabric and the type of process. Changes in machines, used chemicals or other characteristics of the processes also change the nature of the generated wastewater. Until now, most research on textile effluents has been done on the mixed wastewater of a textile factory. However, when looking at water and
chemicals savings, the processes should be regarded separately. This does not always mean that all of those streams also have to be treated separately. Combining selected streams can lead to better treatable waste water. One can think of for instance mixing of acid and alkaline streams to obtain wastewater with a neutral pH. Sometimes a stream can be separated from other streams to facilitate recovery of water or chemicals, or to prevent dilution of a difficult to remove compound.

The consumption of water and generation of wastewater by textile industries greatly impact the environment. Textile industry can be classified into three required for production as well as wastewater generated. Other major uses of water in the textile industry is Steam generation (boiler feed water), Water treatment plant (reject stream, periodic cleaning of reverse osmosis plant, regeneration and washing of demineralization, softener plant, back wash of media filters; Cooling (processing machines, cooling tower); Humidification (spinning process); and Domestic purposes (irrigation of lawn and garden, sanitation, cleaning, drinking and miscellaneous uses).

Effects of pollution on environment

Due to rapid industrialization, environmental pollution is a matter of great concern. Surface water pollution is one of the elements of this pollution. Surface water is the water we find in the river, canals, cultivation field and other water bodies on the earth. Severe pollution of this water is causing serious health hazard in the neighbourhood, damaging fertility of the land, killing fishes and aquatic lives. Many issues are responsible for surface water pollution. Chemical processing industries especially textile processing industries are claimed to produce huge effluent to discharge in our river and other water bodies. Due to rapid development of industrial activities, the levels of heavy metals in water systems have substantially increased. Heavy metals can easily enter the food chain because of their high solubility in water. Cadmium, copper chromium, lead and zinc are extremely toxic heavy metals of widespread use in many industries. The heavy metals pollution represents an important problem with human health concerns and serious ecological consequences. It is therefore essential to remove heavy metal from effluent and drinking water. Plant materials are mainly comprised of cellulose materials that can adsorb heavy metal cations in aqueous solution. So we must keep this water safe for better environment and good health of the people.

Adsorption treatments

For the treatments of textile effluent use the natural adsorbent instead of chemical coagulants. In spite of their effectiveness, chemical coagulants are costly, which has a disadvantage when it comes to treatment of large volumes of wastewater. Another factor that makes chemical coagulants unfavourable is the large amount of sludge that is generated, thereby creating disposal problems. Thus there is need of other alternatives to eliminate or reduce the need of chemical coagulants.

Adsorption technique for waste water treatment has received considerable attention for the development of an effluent clean and economical technology. In general, adsorption of inorganic and organic pollutants on the surface of the adsorbent are studied under various experimental conditions to optimize maximum removal. Adsorption is the process (shown in Fig. 1) in which matter is extracted from one phase and concentrated at the surface of a second phase. The molecule which gets adsorbed is called adsorbate. The porous solid on which the adsorbate gets adsorbed is called adsorbent. The exact nature of the bonding depends on the details of the species involved, but the adsorbed material is generally classified as exhibiting Physical adsorption (Physisorption) or Chemical adsorption (Chemisorption). Physical adsorption is a result of intermolecular forces (Wan der waal force) of attraction between molecules of the adsorbent molecules and the adsorbate. Chemical adsorption is a result of attraction forces between adsorbed molecules and solids surface are due to chemical bonding. An adsorbent is a substance, usually porous in nature with high surface area that can adsorbed substances onto its surface by intermolecular forces. Adsorption can be a potential alternative to
traditional treatment processes of metal ions removal. Adsorption has been proved to be an excellent way to treat industrial waste effluents, offering significant advantages like the low-cost, availability, profitability, ease of operation and efficiency. In the present work, we have studied the potential of wastewater parameters bio sorption on an agro material which is a waste material of castor seed husk. Results from this study can be used to assess the pH, Turbidity, Colour, Chromium, Alkalinity, TSS, TDS, TS, COD, BOD, Hardness, Sulphate, Phenol, Oil and grease, Sodium(%) ,Chloride removal from effluent. For the application of adsorbents, it is necessary to know its characteristics as adsorbents. Various methods have been employed for this. The main is proximate analysis. The images of before and after adsorption can be used to observe the amount of adsorbate that gets covered on the surface of the modified natural adsorbent. The castor seed husk powder is made from castor seed’s waste, therefor cost of this natural adsorbents are negligible. It is better choice with respect to environment considering they will help in environmental sustainability. 

The aim of the present work is to study the treatment of textile effluent by natural adsorbent techniques through the use of castor Seed Husk (CSH) as low cost adsorbent. This study will emphasise on the usage of low cost natural adsorbent rather than using expensive adsorbents, leading to an economic and environmental friendly method of treating textile effluent. Organic and inorganic contaminants are present in effluent from many industries such as metal manufacturing, electroplating, textile industry, cotton manufacturing industry, dye and paint, chemicals and fertilizer. Removal of physicochemical parameters of effluent has become a serious environmental concern due to the toxic and cumulative nature of heavy metals and due to other parameters on various life forms. Adsorption method has proven to be an excellent way to treat effluent and also cost effective technique. A new low cost locally available biomaterial was tested for its ability to remove organic and inorganic contaminants including heavy metals from aqueous solution. Different adsorbent materials had been used to remove heavy metals from waste water; in this study new adsorbent Castor Seed Husk(CSH) was evaluated as a new sorbent for adsorption of parameters present in the textile effluent. 

**MATERIAL AND METHODS**

- **Collection of sample**: The sample is collected by composite method. It was collected and containerized in air tight bottle. The sample is taken out from mercerizing stage of textile industry.
• **Analytical testing of samples:**
  Several parameters such as pH, Total solids(TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Alkalinity, Chromium, Turbidity, Colour, Hardness, Sulphate, Phenol, Oil & grease, Chloride, Sodium(%) were measured according to prescribed methods in “Standard Methods for examination of water and waste water-23rd edition of APHA and AWWA.”

• **Adsorbents:**
  The adsorbent used for adsorption are treated to use as an adsorbents. Castor seeds are able to tolerate the environmental stresses, particularly to drought stress, is one of the strengths of castor as a crop.

![Fig. 2](image1.png)

*Fig. 2:* Castor seed husk as a natural adsorbent

• **Preparation of adsorbent:**
  The castor seed husk (CSH) (shown in Fig. 2) was thoroughly rinsed with water to remove dust and soluble material. Then it was allowed to dry at room temperature. The dried castor seed husk was grounded to a fine powder in a grinding mill and sieved to get fine powder. The fine powder was then treated with sodium hydroxide (0.2 mol/l) to improve the biosorption capacities. For this purpose 100 gms of dried castor seed husk powder soaked in solution of 500ml NaOH (0.2 mol/l) for 20 hrs. Then filter it and washed with de-ionized water until the pH value of the solution reached 7.0, then castor seed husk powder was dried at 110°C in an oven for 14 Hrs and was then stored in desiccators for final study. (Fig. 3)

![Fig. 3](image2.png)

*Fig. 3:* CSH treated with 0.2M NaOH
Materials
All the chemicals used were of analytical reagent (AR) grade. Stock solution of 1000mg/l in distilled water. Desired test solutions of physical and chemical parameter were prepared using appropriate subsequent dilution of the stock solution. The range of concentrations of various chemical parameter prepared from standard solution varies between 10 and 100mg/l. Before mixing the adsorbent, the pH of solution was adjusted to the required values with 0.1 m.

Adsorption Study (Batch Process)
The dried 200 mg of Castor Seed Husk (CSH) powder was taken in a stoppered bottle and standard solution 100 ml containing various concentration of chemical parameters was added in the bottle (shown in Fig. 4) and shake well. The equilibrium was achieved by shaking the contents of the solution at room temperature. The content was filtered. The adsorbate and adsorbent were separated by filtration. Effect of initial concentration, agitating time and the adsorbent dose was also studied.

Fig. 4 : Mixture of adsorbent and textile effluent

Proximate analysis:
(a) Moisture content-
1gm of dried sample was taken in a crucible, weighed and kept in an electrical oven at 105°C for a 1 hour. The crucible is removed and kept in desiccator for cooling. It is then weighted again and the difference in weight is reported in percentage (%) as the amount of inherent moisture.

(b) Volatile matter – The sample is then heated in a muffle furnace which is maintained at 925°C for exactly 7 minutes. The crucible is again weighed after cooling in a desiccator. The loss in weight is reported as volatile matter on percentage (%) basis.

(c) Ash content –
The residue in the crucible in heated in the muffle furnace at 725°C for half an hour. After attaining a constant weight, it is weighed again and the loss in weight is reported as percentage (%) ash content.

(d) Fixed carbon –
The sum total percentage of moisture, volatile matter and ash subtracted from 100 gives the percentage of fixed carbon.

Analysis of sample collected:
The physicochemical parameters of sample pH, Total solids(TS), Total Suspended Solids(TSS), Total Dissolved Solids(TDS), Chemical Oxygen Demand(COD), Biological Oxygen Demand(BOD), Dissolve Oxygen (DO), Alkalinity, Chromium, Turbidity, Colour, Hardness, Sulphate, Phenol, Oil and grease, Chloride, Sodium (%) were analysed as per standard methods as summarised in Table 1. The results of analysis for the
Table 2: Physicochemical characteristics of textile effluent sample (Untreated sample)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Results (mg/L)</th>
<th>IS For Inland Surface Water (IS 2012) (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.7</td>
<td>5.5-9</td>
</tr>
<tr>
<td>COD</td>
<td>2,560</td>
<td>250</td>
</tr>
<tr>
<td>BOD</td>
<td>866.5</td>
<td>30</td>
</tr>
<tr>
<td>TS</td>
<td>2,820</td>
<td>500</td>
</tr>
<tr>
<td>TDS</td>
<td>2,080</td>
<td>2100</td>
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<tr>
<td>TSS</td>
<td>740</td>
<td>100</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.63</td>
<td>0.1</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>746</td>
<td>600</td>
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<tr>
<td>Turbidity</td>
<td>88 NTU</td>
<td>5 NTU</td>
</tr>
<tr>
<td>Hardness</td>
<td>2,130</td>
<td>600</td>
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Table 1: Analysis method for water quality parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Reference</th>
<th>Method/Instrument</th>
</tr>
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<tbody>
<tr>
<td>pH</td>
<td>APHA &amp; AWWA 23rd Ed. 4500-B (4-95)</td>
<td>Electrolytic method (Digital pH Meter)</td>
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<tr>
<td>COD</td>
<td>APHA &amp; AWWA 23rd Ed. 5220-B (5-18)</td>
<td>Open reflux method</td>
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<tr>
<td>BOD</td>
<td>APHA &amp; AWWA 23rd Ed. 5210-B (5-6)</td>
<td>5-Day BOD test</td>
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<tr>
<td>TS</td>
<td>APHA &amp; AWWA 23rd Ed. 2540-B (2-68)</td>
<td>Drying &amp; Gravimetric method</td>
</tr>
<tr>
<td>TDS</td>
<td>APHA &amp; AWWA 23rd Ed. 2540-C (2-69)</td>
<td>Drying &amp; Gravimetric method</td>
</tr>
<tr>
<td>TSS</td>
<td>APHA &amp; AWWA 23rd Ed. 2540-C (2-70)</td>
<td>Drying &amp; Gravimetric method</td>
</tr>
<tr>
<td>Chromium</td>
<td>APHA &amp; AWWA 23rd Ed. 3500-B (3-71)</td>
<td>Spectrophotometric method</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>APHA &amp; AWWA 23rd Ed. 2320-B (2-37)</td>
<td>Spectrophotometric method</td>
</tr>
<tr>
<td>Turbidity</td>
<td>APHA &amp; AWWA 23rd Ed. 2130-B (2-13)</td>
<td>Nephelometric method (Digital Turbidity Meter)</td>
</tr>
<tr>
<td>Hardness</td>
<td>APHA &amp; AWWA 23rd Ed. 2340-C (2-48)</td>
<td>Titrimetric method</td>
</tr>
<tr>
<td>Sulphate</td>
<td>APHA &amp; AWWA 23rd Ed. 4500-E (4-199)</td>
<td>Spectrophotometric method</td>
</tr>
<tr>
<td>Phenol</td>
<td>APHA &amp; AWWA 23rd Ed. 5530-D (5-52)</td>
<td>Spectrophotometric method</td>
</tr>
<tr>
<td>Chloride</td>
<td>APHA &amp; AWWA 23rd Ed. 4500-B (4-75)</td>
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<tr>
<td>Oil- Grease</td>
<td>APHA &amp; AWWA 23rd Ed. 5520-B (5-42)</td>
<td>Drying &amp; Gravimetric method</td>
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<tr>
<td>Sodium (%)</td>
<td>APHA &amp; AWWA 23rd Ed. 3500-B (3-99)</td>
<td>Flame photometric method</td>
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</table>
Graphical representation of various parameters’ value of untreated textile effluent is shown in Fig. 5.

**Fig. 5**: Concentration of Textile effluent’s parameters in untreated samples in mg/L

**Note**: All parameters are measured in mg/L except of sodium (%), pH and Turbidity (NTU)

The high values of the physiochemical parameters indicates that the waste water should be treated before it discharged into inland surface streams or irrigation land. Removal of colour after treatment is shown in Fig. 6.

**Fig. 6**: Colour removal after treatment
Past research work in this field also support these findings. The Initial and final concentration of various parameters are shown in Table 3. The Initial and final concentration of various parameters are shown in Table 3, with the IS inland surface water standard and IS irrigation standards. % Removal and adsorption capacity of various parameters are also shown in Table 3.

The graphical representation of various parameter’s value of treated textile effluent is shown in Fig. 7.

### Table 3: Characteristic of textile effluent and standard values

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Initial Conc. (mg/L)</th>
<th>Final Conc. (mg/L)</th>
<th>IS Inland surface water standards(mg/L)</th>
<th>IS irrigation Standards(mg/L)</th>
<th>% Removal</th>
<th>Adsorption capacity (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.7</td>
<td>6.3</td>
<td>6-9</td>
<td>6-9</td>
<td>20.68</td>
<td>0.9</td>
</tr>
<tr>
<td>COD</td>
<td>2.560</td>
<td>480</td>
<td>250</td>
<td>250</td>
<td>81.25</td>
<td>1.040</td>
</tr>
<tr>
<td>Turbidity</td>
<td>88</td>
<td>19</td>
<td>5</td>
<td>5-10</td>
<td>78.40</td>
<td>34.5</td>
</tr>
<tr>
<td>Phenol</td>
<td>65</td>
<td>15</td>
<td>1.0</td>
<td>1.0</td>
<td>76.92</td>
<td>25</td>
</tr>
<tr>
<td>TSS</td>
<td>740</td>
<td>220</td>
<td>100</td>
<td>200</td>
<td>70.275</td>
<td>260</td>
</tr>
<tr>
<td>BOD</td>
<td>866.5</td>
<td>236.0</td>
<td>30</td>
<td>100</td>
<td>72.36</td>
<td>315.25</td>
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<tr>
<td>Sodium (%)</td>
<td>0.0186</td>
<td>0.0052</td>
<td>-</td>
<td>0.007</td>
<td>68.81</td>
<td>0.0067</td>
</tr>
<tr>
<td>Cl(^{6+})</td>
<td>0.63</td>
<td>0.21</td>
<td>0.1</td>
<td>1.0</td>
<td>66.66</td>
<td>0.21</td>
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<td>Oil-Grease</td>
<td>1.720</td>
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<td>10</td>
<td>65.75</td>
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<tr>
<td>TS</td>
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<td>980</td>
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<td>200</td>
<td>65.24</td>
<td>920</td>
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<td>TDS</td>
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<td>760</td>
<td>2100</td>
<td>2100</td>
<td>63.46</td>
<td>660</td>
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<tr>
<td>Sulphate</td>
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<td>220</td>
<td>400</td>
<td>10</td>
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<td>Hardness</td>
<td>2,130</td>
<td>1,240</td>
<td>600</td>
<td>600</td>
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<tr>
<td>Alkalinity</td>
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<td>474</td>
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<td>-</td>
<td>36.46%</td>
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<tr>
<td>Chloride</td>
<td>2,034</td>
<td>834.74</td>
<td>600</td>
<td>600</td>
<td>58.96%</td>
<td>599.63</td>
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</table>

**Note**: All parameters are measured in mg/L except of pH, sodium (%) and Turbidity (NTU)

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**Fig. 7**: Conc. of textile effluent’s parameter after treatment in mg/L

(Obtained at optimum condition which is 6pH, 0.2gm dosage in 100ml sample at 6Hrs.)

**Note**: All parameters are measured in mg/L except of Sodium(%), pH and Turbidity (NTU)
Graphical representation of % Removal at optimum condition is shown in Fig 8. CSH removes 81.25% COD, 78.40% Turbidity, 76.92% Phenol, 72.36% BOD, 70.27% TSS, 68.81% Sodium (%), 66.66% Chromium, 65.24% TS, 65.75% Oil-grease, 63.46% TDS, 63.33% Sulphate, 58.40% Chloride, 41.78% Hardness, 36.46% Alkalinity. Past research work in this field also support such findings. The Comparison between initial and final Conc. textile effluent parameter after treatment are shown in Fig. 9.

The result for proximate analysis of CSH obtained was: Moisture 16.00%, Volatile Matter 6.73%, Ash 8.35%, and Fixed Carbon 68.92% suggests its ability to work as a good adsorbent in terms of large surface area of carbon particle. Which provide sites for
adsorption of various parameters from wastewater.

**Use of natural adsorbent (CSH) in ETP**

The effluent can be treated by adding suitable dose of adsorbent of Castor Seed Husk (CSH) and by application of flocculator / instrument with 120 rpm. Maintain pH of 6 and contact time 6h for optimum result. The residue or sludge settled at bottom of clarifier can be taken out by rotating scarper with pump. The adsorbent and Cr\(^{6+}\) and impurities can be recovered by giving treatment of H\(_2\)SO\(_4\) to this sludge. The sludge of CSH is biodegradable. The effluent of any ETP and natural water in which concentration of physicochemical parameters is high above its permissible limits that can be treated by using the studied species of natural adsorbent (CSH) with adsorption technology. By using this eco-friendly technique we can get rid of the hazardous sludge disposal problem which is generated by chemical treatments.

**Disposal of used natural adsorbent:**

After the use of Castor Seed Husk (CSH) for treatment of wastewater it can be recovered.\(^9\) The treated CSH is reused as a natural adsorbent.\(^9,19,20\) This recovered CSH is washed with deionized water and give the alkaline treatment to maintain the neutral pH and give the treatment of H\(_2\)SO\(_4\) to remove pollutants adsorbed onto it.\(^19,20\) Further it is safely and easily disposed in any agricultural land and in barren land.\(^9,21-29\)

**CONCLUSION**

- CSH was used as adsorbent for physicochemical parameters of textile effluent, it is good adsorbent for the removal of these parameters. Adsorption process is rapid at the starting and it becomes slow at the saturated stage. It is dependent on an initial concentration of adsorbate and also time for adsorption.
- This study shows the knowledge of textile effluent’s composition and stability related to available treatment methods. Effectiveness determines appropriate treatment in order to meet regulatory requirements for discharge.
- Textile effluent is characterized by TS, TSS, TDS, COD, BOD, DO, Alkalinity, Chromium, Turbidity (NTU), Colour, Hardness, Sulphate, Phenol etc. Such effluent sample is to be treated with natural adsorbent.
- CSH removes 81.25\%COD, 78.40\% Turbidity, 76.92\% Phenol, 70.27\%TSS, 72.36\% BOD, 68.81\%Sodium (%), 66.66\% Chromium, 65.24 \%TS, 65.75\% oil grease, 63.46\%TDS, 63.33\% Sulphate, 58.40\% Chloride, 41.78\% Hardness, 38.83 \% Alkalinity and also CSH are able to adjust the alkaline pH to their permissible limits of effluent and reduce the colour in good amount.
- Increased dose of CSH also increases percentage of adsorption and time is decreased.
- Adsorption process is good at pH 6. (pH was increased from 6 to 6.3. It increase due to adsorbent dosage effect.
- For Chromium and Alkalinity adsorption process is good at pH 5 and pH 7 respectively.
- As increasing the adsorbent dose the concentration of all parameters is decreased and the treated water is easily discharged into inland surface water or used for irrigation purposes.
- Temperature effect shows that with increasing temperature capacity of adsorption increases.
- CSH could be exploited for commercial application. The cost of adsorbent CSH is very low and is easily available and CSH is biodegradable. The adsorbent CSH can be disposed safely.
- The main advantage of this method is the adsorbent and impurities can be recovered by giving treatment of H\(_2\)SO\(_4\) to this sludge. Treated adsorbent can be reused after washing with distilled water and easy to dispose as it is biodegradable and this treated water can be directly discharged in inland surface water. So it is concluded that CSH can be used as cost effective adsorbent for treatment of Textile wastewater successfully.
- So, it is concluded that this is eco-friendly and cost effective method.

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