Cost-effective Physicochemical Treatment of Carpet Industrial Wastewater for Reuse
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The main objective of this study is to investigate the efficiency of the physicochemical treatment process for removal of hazardous refractory wastewater from carpet industry. Characteristics of carpet industry wastewater in terms of COD, BOD, TSS were 60000, 110, 9800 mg/L. Their complete biodegradation is usually very slow as indicated from the immensely low value of BOD/COD, 0.002. High TSS promote the coagulation/flocculation in which coagulants such as ferric chloride, ferrous sulfate and flocculent are added to wastewater in order to destabilize the colloidal materials, eliminate as much as possible of suspended solids and organic materials. The results showed that ferric chloride (1.2g/L), flocculent (2mg/L) at pH 8 achieved COD removal efficiency of 97% whereas using ferrous sulfate (1.8 g/L), flocculent (2 mg/L) at pH 7 achieved 98% COD removal. Corresponding TSS removal values were 96 and 97%, respectively. Furthermore, lamellar sedimentation of the treated effluent followed by sand filtration upgrades the finally treated effluent for recycling inside the factory, the residual COD and TSS were 70 and 5mg/L respectively. The construction cost of the treatment unit (100 m³/d) is about US$ 26000 and the running cost is about US$ 3300/year, providing a saving of about US$ 8064/year.

Keywords: Carpet refractory wastewater, Coagulation-flocculation treatments, Sand filtration, Construction and running costs.

Introduction

Carpet industry as one of the textile industries, generates many hazardous pollutants such as organic and inorganic matters, latex and dyes in addition to various proportions of non-biodegradable constituents. These industries discharge huge amounts of wastewater with highly colorized feature. They are growing rapidly causing many environmental problems, as a result of these facts, these industries are categorized as one of the most polluting industries [1–3].

The wastewater can cause serious environmental problems due to their high color, large amount of suspended solids, and high chemical oxygen demand [4]. As this wastewater has high load of organic contaminants, it is very hard to discharge into the biosphere before suitable treatment [5-7].

Carpet manufacturing process is composed of three main processes: extrusion, weaving and tufting. Polypropylene and polyethylene granules in addition to pigments are introduced to the extrusion process where yarns are the product of this process. Yarns are then woven in the weaving process producing carpets as an output of this process. To make the bottom layer of the carpet (substrate), latex, filler are added in what is so called tufting process whereby the carpet bottom layer is threaded into a fabric. This is the final process of producing carpets. The wastewater produced by the described processes comes from; mixing of washing tank, machines and floor washing. It is worth mentioning that huge amount of wastewater is produced throughout the carpet manufacturing processes. The elimination of pollutants found in carpet industry wastewater is presently of great concern, since their complete biodegradation is usually very slow and requires
several days or weeks. There is no single process capable of adequate treatment of these wastewaters for reuse [4, 8].

Due to the high water consumption in the textile industry in general, carpet processing in particular, hybrid processes have been studied to treat textile wastewaters [8–11]. However, their application in an industrial plant becomes difficult due to the operation problems and to the costs. Chemical oxidation by ozone, or a combination of UV-radiation, ozone and \( \text{H}_2\text{O}_2 \), has great interest but cost still very high. Applications of membrane technologies in textile industries are not yet very common. Until now the reported applications are focused on the recovery of sizing agents from the de-sizing effluents and on the recovery of the dyes from the dyeing effluents by ultrafiltration [12, 13].

Regarding to Fenton process, due to the relatively high concentrations of ferrous sulfate and hydrogen peroxide which are required for the treatment, Fenton’s treatments could be evaluated as non-economical for the large volumes of textile wastewater [14].

The biosorption processes are found to be cost effective for removal of heavy metals but in case of highly polluted wastewater with organic matters like in case of the rug and carpet industrial wastewater where the COD could reach some grams per liter, the removal of these loads of organics via the biosorption processes will be practically difficult [15, 16].

Jar-tests allow the evaluation of a treatment to reduce suspended, colloidal and non-settleable matter from water by chemical coagulation-flocculation followed by gravity settling [17]. Thus, these method are a valuable tool in wastewater treatment in relation to the economical factor [18]. The use of membranes in combination with physical-chemical processes is very interesting to produce water to be reused from the global effluent of the industry. The factors that limit their application are the management of the membranes retentate streams due to their high conductivities and the durability of the membranes due to fouling and concentration polarization [19, 20].

Chemical wastewater treatment relies on collecting suspended matter in untreated water together for further settling and for preparation of water for filtration [21].

Coagulation is summarized in three main steps, which are: Coagulation, Flocculation, and Sedimentation. Untreated wastewater may contain organic and inorganic matter as well as various proportions of non-biodegradable constituents. The function of coagulation is to remove these particles. Collides in wastewater are stabilized by negative electric charges on their surface, forcing them to repel each other. The particles repulsion inhibits their settling and retains them in suspension [22]. Thus, the equilibrium between the repulsive and attractive forces that the particles exert as they become close to each other makes the stability of the colloidal considerations. These charges assist clouds of counter-ions to form around the particles, giving rise to repulsive forces that inhibit aggregation and minimize the effectiveness of subsequent solid-liquid separation phases. Therefore, chemical coagulants are often added to suppress the repulsive forces of the particles. The three main types of coagulants are inorganic electrolytes (such as alum, lime, ferric chloride, and ferrous sulfate), flocculent with anionic or cationic functional groups [23].

The main objective of this study is to investigate the efficiency of the coagulation-flocculation treatment processes followed by sand filtration for removal of hazardous refractory wastewater from rug and carpet industry for reuse. Specific objectives are: evaluation of the physical-chemical treatment with jar-tests for carpet wastewater treatment, optimization of pH and coagulant and flocculent concentration for the treatment processes.

**Experimental**

This study was carried out in two steps. The first step consisted of the characterization of the collected wastewater samples. In the second step a physico-chemical treatment was applied to wastewater in order to reduce COD and TSS for compatible recycling limits.

**Sampling collection and analysis**

The carpet industry under investigations produces more than 36000 m\(^3\)/year of hazardous refractory wastewater. Composite wastewater samples representing the normal daily flow discharge from the end-off-pipe were collected. The samples were preserved in an ice box at a temperature of 4 °C and transferred directly to the laboratory for analysis. The analyzed parameters were; total suspended solids (TSS), kjeldahl nitrogen (TKN), and chemical oxygen demand (COD), biological oxygen demand (BOD), Oil&
Grease and all extracted materials by chloroform (O&G), hydrogen sulfides, total phosphorus (TP), phenol and cyanides. All the analyses, unless otherwise specified, were carried out according to the Standard Methods for the Examination of Water and Wastewater [24]. BOD, or biochemical oxygen demand, is the measure of the oxygen consuming capabilities of organic matter biologically. Water with high BOD indicating the presence of biodegradable decomposing organic matter. COD was measured according to dichromate method 5210-D. BOD was measured according to 5-D BOD test method (5210-B). pH was measured using bench pH meter model Adwa AD 8000. TKN was measured using mercuric sulfate digestion method followed by titration method (4500-Norg). TP was measured according to the method (4500-C). Oil and grease were measured using the gravimetric partitioning method (5520-B). Total suspended solids were measured gravimetrically after sample filtration using GF/C paper method 2540-D. Total sulfides were measured according to method 4500-E in APHA 2017 [24].

**Physico-chemical experiments**

A multiple stirrer Jar-Test apparatus will be considered for the physicochemical treatment of the wastewater. Experiments were performed using Ferrous sulfate heptahydrate (FeSO$_4$ˑ7H$_2$O) and ferric chloride (FeCl$_3$ˑ6H$_2$O) (from Merck Company) and polyelectrolyte anionic flocculent of anionic polyacrylamide. Calcium oxide was used as a coagulant aid in chemical coagulation process. The following solutions were prepared and used in the experiments: CaO (20 %), HCl (10%), (FeSO$_4$ˑ7H$_2$O) and (FeCl$_3$ˑ6H$_2$O) (30 %), anionic polymer (0.1 %).

The optimum dose and pH of the coagulant were investigated using jar test procedure. One liter of wastewater sample was transferred to each jar. The samples were rapidly mixed at a paddle speed of 250 rpm, and coagulants were added then finally, polymer was instantaneously added. The rapid mixing was for 1 min., followed by slow mixing for 20 min. at 20 rpm and then settling for 1 h. The supernatant was withdrawn by means of a suction device for analysis. Lamellae sedimentation followed by sand filtration will be carried out for recycling of the treated wastewater [25].

**Sand filter**

The effluent from the Lamellae sedimentation unit is fed to the sand filter at top side via equidistance nozzles to ensure uniform distribution. The function of the sand filter is polishing the effluent such that treated wastewater can be used for washing process in the factory. The sand filter was made from Perspex material with 110 litre capacity. Main dimensions of: 60 cm x 40 cm x 46 cm d. Three layers of equal depth 0.15 m each constitute the sand filter content. Top layer of gravel bed with particle size from 0.3 mm to 0.45 mm, middle layer of fine sand with size between 0.15 and 0.2 mm, bottom layer of gravel bed with particle size from 0.3 mm to 0.45 mm. Hydraulic surface Loading rate of sand filter ranged between 0.25 and 1.5 m$^3$/m$^2$/day, this type belongs to slow sand filters [26, 27].

**Results and Discussion**

**Factory Baseline**

A factory, located in an industrial city, North Cairo, Egypt. The factory produces a huge amount of rug and carpet and has an average consumption of water, 36000 m$^3$ per year. Wastewater is produced from production lines and cleaning operations of equipment’s and floors as described in Fig. 1. This wastewater is usually milky in color containing finely dispersed solids of macromolecules called colloidis. As this wastewater has high load of organic contaminants

![Fig. 1. Schematic diagram of Carpet industry wastewater sources.](image-url)
then it is very hard to reuse the wastewater or to discharge into the public sewerage system before treatment [5].

**Raw wastewater characteristic**

Five composite samples from the end-off-pipe of the factory were collected for physico-chemical analysis. The characteristics of this wastewater indicated its containment of refractory and non-biodegradable organic substrates. This is obvious from the average values of BOD (110 mg/L) and COD (60000 mg/L), (Table 1) and from the ratio of BOD/COD which was less than 0.002 [28]. The oil & grease with an average value of 7155 mg/L, average value of TSS concentration was 9800 mg/L. Therefore, as a result of the high concentration of TSS, chemical treatment using coagulation-flocculation process followed by sedimentation and sand filtration were investigated intensively.

**Treatment of wastewater using coagulation-flocculation process**

Coagulation/flocculation is a core and usually the first unit process in water and industrial wastewater treatment processes [30]. It is the most important process for the removal of suspended particles. This process occurs through destabilizing the balanced colloidal particles then they agglomerate into larger flocks and settle [31]. Bench scale chemical coagulation process was preferred utilizing a Jar test procedure to get the appropriate pH value and coagulant dose required for the best removal of the contaminants. For the favored removal of pollutants ferrous sulfate and ferric chloride aided with polymer has been investigated for this type of wastewater.

**Effect of pH on COD removal by various coagulants**

In order to study the effect of pH on the COD removal, eight tests were carried out for each coagulant FeCl₃ and FeSO₄. Different pH values were examined (2, 3, 4, 5, 7, 8, 9, 10) at constant suggested doses of coagulants 0.75 g/L, and flocculent (anionic polymer), 2.5 mg/L. Figure 2 depicts the results of the residual COD for the two coagulants used. As can be seen, at acidic pH, a minimal removal of COD were achieved (around 20%). A considerable decrease in the residual COD of the contaminated solution is observed when raising the pH which reaches optimum values of 8 and 7 for Ferric chloride and ferrous sulfate respectively.

In case of using FeCl₃, at the optimum working pH value, 8, concentration of ferric hydroxide Fe(OH)₃ is very high when compared to other iron salts. Thus the principal treatment phenomena of COD are the precipitation and adsorption of contaminants onto the Fe(OH)₃ flocks formed. For ferrous sulfate, the optimum pH for COD removal

### TABLE 1. Carpet and rug industry wastewater characteristics.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Min.</th>
<th>Max.</th>
<th>Average*</th>
<th>MD44/2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>--</td>
<td>4.5</td>
<td>4.9</td>
<td>4.7±0.2</td>
<td>6-9.5</td>
</tr>
<tr>
<td>Chemical Oxygen demand(COD)</td>
<td>mg/L</td>
<td>58885</td>
<td>64385</td>
<td>60000±243</td>
<td>1100</td>
</tr>
<tr>
<td>Biochemical oxygen Demand(BOD₅)</td>
<td>mg/L</td>
<td>104</td>
<td>142</td>
<td>110±16</td>
<td>600</td>
</tr>
<tr>
<td>Total Suspended Solids(TSS)</td>
<td>mg/L</td>
<td>8723</td>
<td>9941</td>
<td>9800±105</td>
<td>800</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen(TKN)</td>
<td>mg/L</td>
<td>365</td>
<td>443</td>
<td>422±32</td>
<td>100</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/L</td>
<td>6362</td>
<td>7554</td>
<td>7155±85</td>
<td>100</td>
</tr>
<tr>
<td>Settleable Solids at 30 minutes</td>
<td>mL/L</td>
<td>1.2</td>
<td>1.7</td>
<td>1.2±0.2</td>
<td>15</td>
</tr>
<tr>
<td>Total Sulfides</td>
<td>mg/L</td>
<td>38</td>
<td>55</td>
<td>41±6</td>
<td>10</td>
</tr>
<tr>
<td>Total Phosphorus(TP)</td>
<td>mg/L</td>
<td>8.0</td>
<td>11.4</td>
<td>10.7±1.6</td>
<td>25</td>
</tr>
<tr>
<td>Phenols</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.05</td>
</tr>
<tr>
<td>Cyanides(CN)</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*Average of 5 samples ND: Not detected

**MD 44/2000**: Egyptian permissible limits for wastewater discharge into sewerage system [29].
was found to be 7. At this pH, the presence of Fe$^{2+}$ and Fe(OH)$^+$ is maximum and the COD removal takes place by charge neutralization and sweep flocculation [32].

**Determination of optimum coagulant dosage**

The results of the effects of different dosages of FeCl$_3$ and FeSO$_4$ as primary coagulants on the removal of COD from the wastewater at the optimum pH of 8 & 7 respectively, and polymer constant dose of 2.5 mg/L are presented in Fig. 3 and 4. The removal efficiencies of COD increased rapidly up to 93.7 and 93.3% at 1.2 and 1.8 g/L for FeCl$_3$ and FeSO$_4$ respectively.

This may be attributed to the following reasons: the increase of adsorptive surface due to increase of ferric hydroxide precipitates and the formation of flocks and acid anion complexes by electrostatic interaction. The complexes led to an enhancement of colloids removal, whereas between 1.2 to 1.8 g/L for FeCl$_3$ and 1.8 to 3 g/L for FeSO$_4$, the removal of COD increased slowly. Addition of the coagulant above 1.2 g/L for FeCl$_3$ and 1.8 g/L for FeSO$_4$ caused the removal efficiency to appear constant. These results are higher than those obtained by Mahmoud, 2009 [33] who reported that the maximum removal of COD was 62.3% when he used 0.2 g/L FeCl$_3$.
Also, these results are slightly higher than those obtained by Nabi et al. 2007 [34] who reported that the maximum removal of COD was 90% when he used 0.4 g/L FeSO$_4$.

**Determination of optimum polymer dosage**

Several studies in the treatment of industrial wastewater investigated the use of both polyelectrolyte (as a coagulant aid or flocculent) and chemical coagulant [35]. In this research the dose of polyelectrolyte (anionic polyacrylamide) was changed from 0.5 to 3 mg/L at constant doses of FeCl$_3$, 1.2 g/L and FeSO$_4$, 1.8 g/L at pH 8 and 7, respectively. In order to examine the optimum dose of the polyelectrolyte, the percentage removal of COD was considered. From Fig. 5 and 6, it can be seen that removal of COD reached 70 and 55.8% during the use of 1 mg/L polyelectrolyte for both coagulants. The removal of COD was slowly increased to 98.8 and 97.9% when the dose of the polyelectrolyte was increased to 2 mg/L for both FeCl$_3$ and FeSO$_4$, respectively. Further increase in the dose of the polyelectrolyte did not cause further increase in the percentage removal of COD.
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COD. Thus, the optimum dose for both FeCl₃ and FeSO₄ was 2mg/L. According to Nabi et al., 2007, the optimum dose of polymer was 1 mg/L when using 0.2 g/L FeSO₄, a 90% removal of COD was achieved [34].

Efficiency of coagulation-flocculation process for the treatment of the wastewater

The results presented in Fig. 7 and Tables 2&3 show that the quality of treated effluent agrees with the national public sewerage law. In the case of FeCl₃, the concentration of COD, TSS, TKN, TP and O & G were reduced from 60000 to 520, 9820 to 54, 422 to 9.5, 41 to 0.9 and 7155 to 13.5 mg/L, respectively. The corresponding removal efficiency was 97, 96, 95, 88 and 96%, respectively. In the case of FeSO₄, the concentration of COD, TSS, TKN, TP and O & G were reduced from 60000 to 425, 9800 to 24, 422 to 8.4, 41 to 1.2 and 7155 to 12 mg/L, respectively. The corresponding removal efficiency was 98, 97, 96, 87 and, 97%, respectively.

These removals are slightly higher than those obtained by Nabi et al., 2007 who reported that TSS removals reached 90 % [34].

Analysis of the produced chemical sludge indicated a production of 140 L/m³. This volume of sludge has 1.9 kg of dry solid with 40% organic matter. The sludge volume index (SVI) was 74 ml/g which indicates very good settling properties. Characteristics of the treated effluent using FeCl₃ and FeSO₄ agree with the national permissible limits for discharging into the sewerage system (Tables 2 and 3). Based on the laboratory results a schematic diagram of the chemical treatment system is proposed (Fig. 8).

Efficiency of post treatment using the sand filter for recycling the treated effluent

Using some tertiary treatment processes as sand filter, the quality of the produced effluent is improved [36]. The sand filter is a relatively simple, inexpensive and environmentally-friendly treatment method used for purifying wastewater in three distinct ways; filtration, chemical sorption and assimilation.

For sustainable and economic factors, recycling of the treated wastewater is an important issue. The coagulation-flocculation process is followed by the lamella sedimentation and the treated effluent was subjected to sand filtration for further removal of COD and TSS. The physico-chemical analysis of the finally treated effluent is illustrated in Tables 2&3. The characteristics of the treated effluent in terms of residual COD and TSS were about

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**Fig. 6. Effect of different polymer doses on COD removal using ferrous sulfate.**
Fig. 7. Efficiency of coagulation process using FeCl$_3$ and FeSO$_4$ as coagulants on the treatment of carpet and rug wastewater at optimum operating conditions.

### TABLE 2. Characteristics of the finally treated carpet and rug wastewater coagulation using FeCl$_3$ aided with polymer at operating conditions.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Raw Average*</th>
<th>Coagulation-Flocculation</th>
<th>Sand filtration</th>
<th>MD 44/2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>--</td>
<td>4.7±0.2</td>
<td>8.6±0.1</td>
<td></td>
<td>6-9.5</td>
</tr>
<tr>
<td>Chemical Oxygen demand (COD)</td>
<td>mg/L</td>
<td>60000±243</td>
<td>520±16</td>
<td>75</td>
<td>1100</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD$_5$)</td>
<td>mg/L</td>
<td>110±16</td>
<td>15</td>
<td>9</td>
<td>600</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>mg/L</td>
<td>9800±105</td>
<td>54±8</td>
<td>v</td>
<td>800</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>mg/L</td>
<td>422±32</td>
<td>9.5±0.3</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>Oil and Grease (O&amp;G)</td>
<td>mg/L</td>
<td>7155±85</td>
<td>13.5±1.4</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>mg/L</td>
<td>41±6</td>
<td>0.9±0.1</td>
<td>0.4</td>
<td>25</td>
</tr>
</tbody>
</table>

*Average of 5 samples

MD44/2000: National permissible limits for wastewater discharge into sewerage system

### TABLE 3. Characteristics of the finally treated carpet and rug wastewater coagulation using FeSO$_4$ aided with polymer at optimum operating conditions.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Raw Average*</th>
<th>Coagulation-Flocculation</th>
<th>Sand filtration</th>
<th>MD 44/2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>--</td>
<td>4.7±0.2</td>
<td>7.8±0.2</td>
<td>7.7</td>
<td>6-9.5</td>
</tr>
<tr>
<td>Chemical Oxygen demand (COD)</td>
<td>mg/L</td>
<td>60000±243</td>
<td>425±14</td>
<td>70</td>
<td>1100</td>
</tr>
<tr>
<td>Biochemical oxygen Demand (BOD$_5$)</td>
<td>mg/L</td>
<td>110±16</td>
<td>14</td>
<td>7</td>
<td>600</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>mg/L</td>
<td>9800±105</td>
<td>24±6</td>
<td>6</td>
<td>800</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>mg/L</td>
<td>422±32</td>
<td>8.4±0.3</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>Oil and Grease (O&amp;G)</td>
<td>mg/L</td>
<td>7155±85</td>
<td>12±1.1</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>mg/L</td>
<td>41±6</td>
<td>1.2±0.1</td>
<td>0.5</td>
<td>25</td>
</tr>
</tbody>
</table>

*Average of 5 samples

MD44/2000: National permissible limits for wastewater discharge into sewerage system

75 mg/L and 7 mg/L which allow the treated effluent for recycling inside the factory. The removal of COD and TSS were more than 80% which near to the results obtained by Assayed et al. (2014) [37].

**Economic evaluation of the proposed treatment system**

The economic evaluation is made for the proposed system that is capable of treating 100 m$^3$/d. The economic evaluation is based on the construction, operation and maintenance costs.

**The construction cost evaluation considers the following**

- The system is to be constructed from mild steel coated internally with a protective coating layer.
- The construction cost includes the cost of the following components: Materials used in construction, Pumps for pumping wastewater from the collection sump to the treatment system, media used inside the sand filter, piping for the system influent and effluent. The construction cost of the treatment plant shown in Fig. 8 is around US$ 26000.

**The operation and maintenance costs evaluation consider the followings**

- Power consumption (electricity) required for system operation and for pumping, Labours required for system operation and maintenance, spare parts, cleaning, changing of media every 3 years and removal of sludge from the system. The running cost is about US$ 3300/year.

Assuming 20 years depreciation and 100 m$^3$ of treated wastewater/day hence the total construction cost per m$^3$ of treated wastewater will be US$ 0.036. In addition, the daily costs of operation and maintenance of the proposed system will be US$ 0.09 /m$^3$ of wastewater.

The total cost (construction and operation) for treating wastewater for recycling in the factory will be US$ 0.126/m$^3$. As the cost of municipal water is US$ 0.35/m$^3$. Thus, this treatment and recycling system is estimated to save about US$ 8064/year since the saving is US$ 0.224/m$^3$.

**Conclusion**

Wastewater characteristics of carpet industry which represents one sector of the textile industry determine the adequate treatment system. The wastewater generated from carpet industries is characterized by high concentration of COD, TSS and low BOD values. Their complete biodegradation is usually very slow as indicated from the very low BOD/COD ratio (0.002), requiring several days or weeks. Due to high concentration of suspended solids, coagulation-precipitation was selected as feasible solution for the treatment. Chemical coagulation process using either ferric chloride aided with polymer or ferrous sulfate aided with polymer produced effluent characteristics complying with the National permissible limits for wastewater discharge into public sewerage system. However, the treated

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Effluent by ferric chloride was found to be more favorable for economic reasons. Further application of lamella sedimentations followed by sand filtration allows the treated effluent for recycling inside the factory. This treatment and recycling system is estimated to save about $8064/year.

References


21. Nasr F.A., Doma H.S., El-Shafai S.A. and Inas A. T., Management of Industrial Wastewater (Case Study). Applied Sciences Research, 8(6), 3004-


الهدف الرئيسي من هذه الدراسة هو استخدام طرق المعالجة بالتخسير والتريوب في إزالة الملوثات صعبة التحلل (BOD/COD) البيولوجي من مياه الصرف الصناعي الناتجة من صناعة السجاد والمكوث. حيث أن قيم الملجم/لتر (BOD) الالتحال البيولوجي (BOD) قد قدرت ب (0.002) ملم/لتر. ونظراً لقيمة المرتبطة لتركيزات المواد العضوية الضارة (60000 ملم/لتر) مع انخفاضاً ملحوظاً للمواد العضوية القابلة للتحلل البيولوجي (BOD) حيث قدرت ب (110 ملم/لتر) فكان من الصعوبة استخدام الطرق البيولوجية في المعالجة، نظرًا لارتفاع قيم تركيزات المواد العالقة فقد تم استخدام كلوريد الحديد وكبريتات الحديد وكذلك إضافة البوليمر للمساعدة في سرعة الترسيب والفصل. أظهرت النتائج أنه بإضافة كلوريد الحديد بتركيز (1.2 جم/لتر) والبوليمير بتراكيز (2 ملم/لتر) عند الرقم الهيدروجيني (7) حققت كفاءة إزالة الملجم/لتر (BOD) على التوالي 97% 98% بينما عند استخدام كبريتات الحديد بتركيزات (1.8 جم/لتر) والبوليمير بتراكيز (2 ملم/لتر) عند الرقم الهيدروجيني (7) كانت نسبة إزالة الملجم/لتر (BOD) هي (80% 84%) ونسبة إزالة المواد العالقة الكلية (TSS) هي (80% 100%) حيث وصلت تركيزاتها المناسبة حوالي 75 ملم/لتر ترسيب مائي يتم تحسن نسبة الازالة لتركيزات كبريتات الحديد بتركيز (2.1 جم/لتر) وتركيزات كبريتات الحديد بتركيز (2 ملم/لتر) عند الرقم الهيدروجيني (7) بلغت تركيزاتها البترواني في المياه المعالجة إلى 7 ملم/لتر مما يسمح باستعمال المياه المعالجة في غسيل المعدات ونواحي التصدير داخل الولايات الصناعية مما يوفر 8064 دولار أمريكي في السنةlevels. تم حساب تكلفة إنشاء وحدة المعالجة وقد بلغت حوالي 26000 دولار أمريكي وتكلفة التشغيل بلغت حوالي 3300 دولار أمريكي في السنة.