Optimization of Treatability by FACCO for Treatment of Chemical Industry Effluent

Shiv H Mehta
PG Student
Department of Environmental Engineering
BVM engineering College, Gujarat, India

Dr. D S Vyas
Retired Professor
Department of Environmental Engineering
BVM engineering College, Gujarat, India

Ms. Sejal M Patel
Chemical Engineer
Aditya Environment & Research Consultancy, Vapi
Gujarat, India

Dr. Arti Pamnani
Professor
B.N.D.VVN, Anand, Gujarat, India

Helly Mehta
Assistant Professor
Department of Civil Engineering
C.G.P.I.T, Bardoli, Gujarat, India

Abstract

This Research has been carried out to study Optimization of treatability by (FACCO) Fenton Activated Carbon Catalytical Oxidation for treatment of Chemical Industry Effluent. FACCO as a treatment can be a good option to increase biodegradability of chemical wastewater. The optimum ratio of \([\text{Fe}^{2+}]\) to \([\text{H}_2\text{O}_2]\) will be finalize based on experiment while the optimum pH was from 2.5 to 3.5, a treatment technique , known as Fenton Activated Carbon Catalytic Oxidation (FACCO) ,consisting of coagulation-flocculation using alum, lowering of pH was from 2.5 to 3.5 using sulphuric acid, chemical dosed with hydrogen peroxide and Ferrous sulphate (known as Fenton reagent), Treatment of such waste had always been difficult because of the presence of refractory organic pollutants such as different types of organic dye. In this study, treatment of chemical effluent was carried out using combined system of Fenton oxidation process followed by adsorption on granular activated carbon (GAC). The effects of operating condition on Fenton oxidation processes such as hydrogen peroxide and iron concentration were investigated. In addition, the lab-scale study of the adsorption process was elaborated. The lab scale model suggested that the rate of reaction was highly affected by the concentration of hydrogen peroxide. Moreover, the results indicated that the treatment module was very efficient in removing the organic pollutant.

Keywords: Advanced oxidation processes (AOPs), Fenton, Ferrous Sulphate, Hydrogen peroxide, Hydroxyl radical

I. INTRODUCTION

The chemical industry is of importance in terms of its impact on the environment. The wastewaters from this industry are generally strong and may contain toxic pollutants. Chemical industrial wastes usually contain organic and inorganic matter in varying degrees of concentration. It contains acids, bases, toxic materials, and matter high in biological oxygen demand, color, and low in suspended solids. Surfactants, emulsifiers and petroleum hydrocarbons that are being used in chemical industry reduce performance efficiency of many treatment unit operations (EPA, 1998). The best strategy to clean highly contaminated and toxic industrial wastewater is in general to treat them at the source (Peringer, 1997) and sometimes by applying onsite treatment within the production lines with recycling of treated effluent (Hu et al., 1999). Since these wastes differ from domestic sewage in general characteristics, pretreatment is required to produce an equivalent effluent (Meric et al., 1999). In chemical industry, the high variability, stringent effluent permits, and extreme operating conditions define the practice of wastewater treatment (Bury et al., 2002). Hu et al. 1999 proposed concept to select the appropriate treatment process for chemical industrial wastewater based on molecular size and biodegradability of the pollutants.

Chemical industrial wastewater can be treated by some biological oxidation methods such as trickling filters, rotating biological contactor (RBC), activated sludge, or lagoons (Nemerow, and Dasgupta, 1991; Jobbagy et al., 2000). Pollutants with a molecular size larger than 10,000- 20,000, can be treated by coagulation followed by sedimentation or flotation (Hu et al., 1999). Waste minimization in the production process in chemical industry is the first and most important step to avoid waste formation during the production (Carini, 1999; Alvarez et al., 2004). The aim of this study is to assess the treatment of wastewater coming from one of a Chemical Industry using a Heterogeneous catalytical oxidation system called FACCO (Fenton activated carbon catalytical oxidation) system. The objective of this study are to determine characteristics of chemical effluent, to prepare a lab scale model of FACCO reactor & other experimental setups, to determine optimum dose of ferric Sulphate & hydrogen peroxide for Fenton reaction, to carry out Experiment based study for FACCO-CACCO treatment and to treat chemical
wastewater by improving parameters such as pH, COD, TDS, NH3-N. In 1987, (Glaze 1987) defined AOPs as “near ambient temperature and pressure water treatment processes which involve the generation of hydroxyl radicals in sufficient quantity to effect water purification”. These treatment processes are considered as very promising methods for the remediation of contaminated ground, surface, and wastewaters containing non-biodegradable organic pollutants. Hydroxyl radicals are extraordinarily reactive species that attack most of the organic molecules. AOPs involve the two stages of oxidation: (i) The formation of strong oxidants (e.g., hydroxyl radicals) and, (2) The reaction of these oxidants with organic contaminants in water. Several methods are available for generating -OH radicals. These include both: (i) Non-photochemical, and (ii) Photochemical methods

The AOPs techniques are mainly used as a pre-treatment stage for industrial wastewater remediation. These techniques improve the destruction of persistent contaminants. Among various AOPs, the Fenton reagent (H2O2/ Fe2+) is one of the most effective methods of organic pollutant oxidation. The Fenton reagent has been found to be effective in treating various industrial wastewater components including aromatic amines, a wide variety of dyes as well as many other substances, e.g. pesticides and surfactants [35]. Therefore, the Fenton reagent has been applied to treat a variety of wastes such as those associated with the textile and chemical industries. The advantage of the Fenton reagent is that no energy input is necessary to activate hydrogen peroxide. Therefore, this method offers a cost-effective source of hydroxyl radicals, using easy-to-handle reagents. However, disadvantages in using the Fenton reagent include the production of a substantial amount of Fe (OH)3 precipitate and additional water pollution caused by the homogeneous catalyst that added as an iron salt, cannot be retained in the process [48]. To solve these problems, the application of alternative iron sources as catalysts in oxidizing organic contaminants has been studied extensively. A number of researchers have investigated the application of iron oxides such as hematite, ferrihydrite,

With Fenton processes, COD reduction of wastewater can be achieved successfully. It is suggested that Fenton processes are viable techniques for the degradation of Atenolol from the waste water stream with relatively low toxic by-products in the effluent which can be easily biodegraded in the activated sludge process. Hence, the Fenton process with H2O2/Fe+2 is considered a suitable pretreatment method to degrade the active pharmaceutical molecules and to improve the biodegradability of waste water. After the treatment 66 % COD removal can be achieved,[51] Also the removal of COD from industrial effluent by EC using Aluminium and stainless steel electrode material was investigated in this paper. Several working parameters, such as current density, initial concentration of solution and operating time were studied in an attempt to achieve a higher removal capacity. Aluminium and stainless steel electrodes were found to be effective in the reduction of COD. The removal efficiencies of COD were more than 90 %. In addition, the experimental results also show that the electro coagulation can neutralize pH of wastewater. A value of 7.33 pH was obtained through the experiment.[45]

II. FACCO TREATMENT

The Fenton reaction was discovered by Fenton in 1894 [14]. Forty years later the Haber-Weiss [39] mechanism was postulated, which revealed that the effective oxidative agent in the Fenton reaction was the hydroxyl radical.

The Fenton reaction can be outlined as follows:

\[
\text{Mn}^+ + \text{H}_2\text{O}_2 \rightarrow \text{M}^{(n+1)+} + \text{HO}^- + \text{HO}^•
\]

where M is a transition metal as Fe or Cu

The HO• radical mentioned above, once in solution attacks almost every organic compound. The metal regeneration can follow different paths. For Fe2+, the most accepted scheme is described in the following equations [58].

\[
\begin{align*}
\text{Fe}^{3+} + \text{H}_2\text{O}_2 & \rightarrow \text{Fe}^{2+} + \text{HO}^- + \text{HO}^• \\
\text{Fe}^{3+} + \text{H}_2\text{O} & \rightarrow \text{Fe}^{2+} + \text{HO}^• + \text{H}^+ \\
\text{Fe}^{2+} + \text{HO}^• & \rightarrow \text{Fe}^{3+} + \text{HO}^- \\
\text{HO}^- + \text{H}_2\text{O}_2 & \rightarrow \text{HO}^- + \text{H}_2\text{O} \\
\text{Fe}^{3+} + \text{HO}^• & \rightarrow \text{Fe}^{2+} + \text{H}^+ + \text{O}_2 \\
\text{Fe}^{3+} + \text{O}_2^- & \rightarrow \text{Fe}^{2+} + \text{O}_2 \\
\text{Fe}^{2+} + \text{HO}_2^- & \rightarrow \text{Fe}^{3+} + \text{HO}^- + \text{HO}^•
\end{align*}
\]

Fenton reaction rates are strongly increased by irradiation with UV/visible light [38].

By following the above method for Soak liquor having the characteristics as BOD - 757 mg/L, COD - 2178 mg/L, TOC - 553 mg/L, Dissolved solids - 20801 mg/L, Dissolved Protein - 1011 mg/L. This pollution load is removed using Fenton Activated Carbon Catalytic Oxidation (FACCO). First, pre-treatment coagulation & flocculation using Alum is given to wastewater after then pH of waste water is reduced to 3 and hydrogen peroxide(0.01ml/L) & Ferrous sulphate(0.1g/L) are added in wastewater after then the coagulated-flocculated and Fenton reagent added soak liquor was applied at a surface loading rate of 1.46m3/m2/day and volumetric loading rate of 0.83 m3/m3/hr to the reactor packed with mesoporous activated carbon this wastewater containing Fenton’s reagents is passed over a meso porous activated carbon supported over sand & gravels for catalytic oxidation. The treated wastewater is collected from bottom under drain system of reactor.[28] Also Flax can be used in many industrial sectors like textile, linseed oil, flax seed oil, pulp and paper production and composite materials. There are many studies regarding the treatment of flax retting wastewater such as the use of up flow anaerobic sludge blanket (UASB) conducted with membrane bioreactor (MBR). Recently, the development of novel treatment methods such as advanced oxidation processes (AOPs) has been considered for the oxidation of hardly degraded organic pollutants. Among various AOPs, the Fenton oxidation process (H2O2/Fe2+) is one of the most effective decontamination method of organic pollutant. [56]
According to the author S. A. Messelea, many industrial and some of the municipal effluents contain refractory and/or bio toxic compounds, which need a specific chemical treatment in order to eliminate or partly reduce the pollutant concentration to the required level which allows direct discharge to conventional sewage plants. [52] Phenolic compounds are normally found in waste water of pharmaceutical, petrochemical, chemical industries. The main objective of his work was to prepare catalysts based on iron supported over activated carbon (AC) and to test its activity for catalytic wet peroxide oxidation(CWPO) of phenol in a batch system. Calculated amount of ferrous nitrate to obtain 3.9% wt of iron load on the catalyst was dissolved in a small quantity of deionized water and then mixed with the AC for 10 min. After impregnation, the slurry was left for 2 h at room temperature, dried overnight at 60°C, calcinated at 200°C for 4 h, and allowed to cool down naturally. Unincorporated free Fe was removed using a sieve. [52] Different techniques like N₂ adsorption/desorption, inductively coupled plasma-atomic emission spectroscopy (ICP-OES), X-ray diffraction (XRD), scanning electron microscopy (SEM) were used to characterize activated carbon. the reaction is carried out in a magnetically stirred jacketed batch reactor where hydrogen peroxide and activated carbon is added in phenolic solution & Reaction continues for 120 minutes. The catalytic activity towards phenol degradation was found to be enhanced by iron supported on activated carbon catalysts. Phenol conversion above 95% can be reached using this catalyst for 120 min of reaction and the stoichiometric hydrogen peroxide for phenol concentration of 150 mg/L.[52]

In the year 2015, Stile showed iron catalyst dispersed on granular activated carbon (GAC) was prepared by impregnating Fe(NO₃)₃ solution on GAC. The investigation of optimum conditions suggested that initial pH at 3 provided the highest efficiency of MO removal. In addition, the concentration of hydrogen peroxide at 8 ppm was the most suitable. The optimum condition of amount of catalyst was 5 g/L. In conclusion, the iron/GAC catalyst was successfully synthesized and applied to dye treatment using heterogeneous Fenton reaction. The catalyst showed high efficiency of MO removal and could be reused many times.[23] Siyong Zhang in this work showed that a heterogeneous catalytic wet peroxide oxidation process combined activated carbon (AC) and hydrogen peroxide (H₂O₂) was applied for the removal of organic matter from the salicylaldehyde industry wastewater with high organics content, strong acid and ultrahigh salinity. The optimal operating conditions established through the experiments were as follows: reaction temperature 60°C, initial pH of 3, H₂O₂ concentration of 21.7 g/L, AC dose of 15 g/L and reaction time of 1 h. Under such operation conditions, the removal efficiency of TOC, COD, phenol and formaldehyde were 91.21%, 88.52%, 99.54% and 97.18%, respectively. Furthermore, the catalytic stability of AC was evaluated through the continuous reuse experiments.[55] According to Vijayalakshmi Gosu in the present study, the treatment of chemical wastewater in terms of organic content (COD, TOC) has been investigated using advanced catalytic per-oxidation with granular activated carbon supported nano zero valent iron (Fe/GAC). At optimum conditions, 81% COD and 76% TOC removal was attained. Moreover, advanced catalytic per-oxidation process was more favourable to the complete oxidation. The two-step kinetics can be attributed primarily to the oxidation of organic compound first to short chain molecular structures (organic acids) followed by their complete oxidation to produce carbon dioxide and water. Moreover, the average oxidation state (AOS) got raised from 1.8 to 2.1, which represents the strong mineralization and the generation of highly oxidized intermediates. Thus, the treatment of pharmaceutical wastewater using Fe/GAC + H₂O₂ could be considered to be an effective alternative treatment option.[60]

According to Yamin Wang the catalytic efficiency of four kinds of activated carbon catalysts derived from coconut shell (SAC), coal tar pitches (PAC), coal (CAC), and oak wood (WAC) was unprecedentedly evaluated in catalytic wet peroxide oxidation (up to 2000 h) for m-cresol wastewater. The physical and chemical characteristics of activated carbon catalysts were determined by scanning electron microscopy, X-ray Fluorescence, Brunauer-Emmett-Teller method, Raman spectroscopy and temperature-programmed desorption. The results indicated that the superiority of activated carbon, especially SAC, in m-cresol degradation was ascribed to the quantity of structural electron-rich active sites, which is proportional to the product of the structural disordered degree and specific surface area, and could improve the efficiency of H₂O₂ usage to above 95%. Upon modification with iron, the catalytic activity of SAC and PAC could be further improved that enhanced above 90% m-cresol conversion even after 2000 h continuous reaction under stoichiometric H₂O₂ dose[61].

III. MATERIALS AND METHOD

A. Chemical industry wastewater collection:

The related untreated wastewater sample was collected after the primary treatment of Effluent treatment plant (ETP) of a chemical industry located near Vapi, Gujarat, India. The sampling container was cleaned and rinsed carefully with with distilled water, filled and seal air tightly.
Optimization of Treatability by FACCO for Treatment of Chemical Industry Effluent

(B) List of Chemicals used in Characterization of Waste Water are:
Standard potassium dichromate, Mercuric Sulphate, Silver Sulphate, Concentrated H₂SO₄, Ferroin indicator solution, Standard ferrous ammonium Sulphate, Sodium hydroxide solutions, Borate buffer, Dechlorinating agent and different catalysts.

(C) Apparatus used for Analysis of Waste Water:
pH meter, Chemical oxygen demand (COD) apparatus, Jar test apparatus, Kjeldahl analytical setup, Magnetic stirrer, Gas chromatograph (GC), Batch reactor, Pump, Air compressor, Heater, Catalytic Bed.

(D) Experimental Procedure:
1) pH meter:
pH meter consist of potentiometer, a glass electrode, a reference electrode, and a temperature compensating device the range of instrument is pH 0.0 to 14.0 equipped with temperature compensation adjustment range 0°C to 100°C is used to find pH value.

2) Analytical sampling of NH₄-N:
The standard method for the detection of NH₄-N is Kjeldahl method though other method can be used like nessler’s reagent method. Standard Method by APHA Ed.22nd .2012,4500 NH₃-B& C was followed for this research study.

3) Analytical sampling of COD:
Standard Method by APHA Ed.22nd .2012,5220 – B was carried out for COD analysis of wastewater.
IV. RESULTS AND DISCUSSION

A. Initial Characteristic of Waste Water:

Sampling of the wastewater was carried out at different days and their characteristics are as shown in below tables.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Parameter</th>
<th>Method specification</th>
<th>Permissible limit</th>
<th>Unit</th>
<th>Result at different sampling days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>Standard Method by APHA Ed.22nd .2012,4500 - H+B</td>
<td>6.5-8.5</td>
<td>-</td>
<td>6.65 6.70 7.17 6.93 7.23</td>
</tr>
<tr>
<td>2</td>
<td>TDS</td>
<td>Standard Method by APHA Ed.22nd .2012,2540 – C</td>
<td>2100</td>
<td>Mg/l</td>
<td>19890 18804 29698 17952 25569</td>
</tr>
<tr>
<td>3</td>
<td>COD</td>
<td>Standard Method by APHA Ed.22nd .2012,5220 – B</td>
<td>250</td>
<td>Mg/l</td>
<td>2354 2354 2260 2668 2354</td>
</tr>
<tr>
<td>4</td>
<td>NH₄-N</td>
<td>Standard Method by APHA Ed.22nd .2012,4500 NH₄-B &amp; C</td>
<td>50 mg/L</td>
<td>Mg/l</td>
<td>9 13 9 10 13</td>
</tr>
</tbody>
</table>

From above table it is clear that the range of pH exists between 6.65 to 7.3, TDS from 17952 to 29698, COD between 2260 to 2668, and Ammonical Nitrogen from to 9 to 13. Thus further studies were carried out to determine the optimum dose of Ferrous Sulphate (FeSO₄) By Keeping Hydrogen Peroxide (H₂O₂) Constant & Optimum Dose keeping Hydrogen Peroxide (H₂O₂) varying & Ferrous Sulphate (FeSO₄) constant.

B. Determining of Optimum Dose keeping Hydrogen Peroxide (H₂O₂) varying & Ferrous Sulphate (FeSO₄) constant

Dose of H₂O₂:- Varying, Dose of FeSO₄ (Fixed):-200 mg/L, pH (Fixed):- 3 and Temperature (Room temperature):- 25°C

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Dose of H₂O₂(mg/L)</th>
<th>COD before treatment(mg/L)</th>
<th>COD after treatment(mg/L)</th>
<th>% COD removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 (Initial)</td>
<td>2592.9(Initial)</td>
<td>2592.9(Initial)</td>
<td>0(Initial)</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
<td>2592.9</td>
<td>1723.1</td>
<td>33.54</td>
</tr>
<tr>
<td>3</td>
<td>500</td>
<td>2592.9</td>
<td>1644.7</td>
<td>36.57</td>
</tr>
<tr>
<td>4</td>
<td>600</td>
<td>2592.9</td>
<td>1613.4</td>
<td>37.78</td>
</tr>
<tr>
<td>5</td>
<td>700</td>
<td>2592.9</td>
<td>1488.1</td>
<td>42.61</td>
</tr>
<tr>
<td>6</td>
<td>800</td>
<td>2592.9</td>
<td>1350.1</td>
<td>40.22</td>
</tr>
</tbody>
</table>

From above table it is clear that when dose of FeSO₄ is taken as 200 ml/L, the reduction in COD is Maximum, i.e 42.61%, keeping the dose of H₂O₂ as 700 mg/L. Thus, from above experiments it is clear that the dosing of H₂O₂ as 700 mg/L and FeSO₄ as 200 mg/L gives maximum reduction. So the further experiment will be carried out keeping this values for conducting experimental procedures for FAACO treatment.
C. Determining of Optimum Dose keeping Hydrogen Peroxide (H2O2) varying & Ferrous Sulphate (FeSO4) constant:

Dose of H2O2 (30% Concentrated) - Varying (5.5 to 7.5) mg/L, Dose of FeSO4 (Fixed) - 0.1 g/L, pH (Fixed) - 2, Temperature (Room temperature) - 25°C

Table – 3

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Dose of H2O2 (mg/L)</th>
<th>COD before treatment(mg/L)</th>
<th>COD after treatment(mg/L)</th>
<th>% COD removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 (Initial)</td>
<td>3604</td>
<td>3604(Initial)</td>
<td>0(Initial)</td>
</tr>
<tr>
<td>2</td>
<td>550</td>
<td>3604</td>
<td>3234</td>
<td>10.26</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
<td>3604</td>
<td>3485</td>
<td>03.30</td>
</tr>
<tr>
<td>4</td>
<td>650</td>
<td>3604</td>
<td>3589</td>
<td>00.42</td>
</tr>
<tr>
<td>5</td>
<td>700</td>
<td>3604</td>
<td>2785</td>
<td>22.72</td>
</tr>
<tr>
<td>6</td>
<td>750</td>
<td>3604</td>
<td>3031</td>
<td>15.89</td>
</tr>
</tbody>
</table>

D. Determining of Optimum Dose keeping Hydrogen Peroxide (H2O2) varying & Ferrous Sulphate (FeSO4) constant:

Dose of H2O2 (30% Concentrated) - Varying (0 to 3) mg/L, Dose of FeSO4 (Fixed) - 0.1 g/L, pH (Fixed) - 3, and Temperature (Room temperature) - 25°C

Table – 4

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Dose of H2O2 (mg/L)</th>
<th>COD before treatment(mg/L)</th>
<th>COD after treatment(mg/L)</th>
<th>% COD removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 (Initial)</td>
<td>3604</td>
<td>3604(Initial)</td>
<td>0(Initial)</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>3604</td>
<td>2008</td>
<td>44.28</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>3604</td>
<td>2329</td>
<td>35.37</td>
</tr>
</tbody>
</table>
Optimization of Treatability by FACCO for Treatment of Chemical Industry Effluent

**D. Determining of Optimum Dose keeping Hydrogen Peroxide (H₂O₂) varying & Ferrous Sulphate (FeSO₄) constant:**

Dose of \( H₂O₂ \) (30% Concentrated): - Varying (0 to 3) mg/L, Dose of \( FeSO₄ \) (Fixed): - 0.1 g/L, pH (Fixed): - 3, Temperature (Room temperature): - 25°C

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Dose of ( H₂O₂ ) (mg/L)</th>
<th>COD before treatment(mg/L)</th>
<th>COD after treatment(mg/L)</th>
<th>% COD removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 (Initial)</td>
<td>3604</td>
<td>3604</td>
<td>0 (Initial)</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>3604</td>
<td>2008</td>
<td>44.28</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>3604</td>
<td>2329</td>
<td>35.37</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>3604</td>
<td>2128</td>
<td>40.95</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>3604</td>
<td>2503</td>
<td>30.54</td>
</tr>
<tr>
<td>6</td>
<td>3.0</td>
<td>3604</td>
<td>2610</td>
<td>27.58</td>
</tr>
</tbody>
</table>

It is clear from above table that by keeping \( FeSO₄ \) constant at 0.1 mg/L, the maximum reduction at which COD is reduced up to 44.28% is 1 mg/L. Thus, it is clear from all the above sets of experiments that about 45% of reduction can be obtained by Fenton Process on this particular chemical wastewater.
V. CONCLUSIONS

The present investigation draws the following conclusion:-

1) Waste water generated from chemical industries is less amenable to biological treatment which is due to the presence of dyes and other non-biodegradable chemicals.
2) Primary clarification of wastewater removes suspended solids and less of dissolved organics.
3) Fenton’s reagent, a mixture of hydrogen peroxide and ferrous iron, is capable of releasing hydroxy radicals which may take part in oxidation of dissolved organics in wastewater.
4) Fenton’s reagent added salt laden wastewater was further catalytically oxidized in meso porous activated carbon packed column.
5) The oxidation of dissolved organics by Fenton’s reagent and adsorption on granular activated carbon (GAC) resulted in the percentage removal of COD, TDS, NH₃-N were found out respective.

ACKNOWLEDGEMENT

I would like to thank below mentioned persons who help in my research study up till now with their knowledge, guidance and sincere efforts: Dr. D.S. Vyas (retired professor and PG co-ordinator), environment engineering department, BVM engg. College, Co-Guided Mrs. Sejal Patel (consultant) and to all my friends of Environment Engineering branch. Also I would like to acknowledge Ms. Helly H Mehta for her encouragement throughout these research work till its completion.

REFERENCES


