Animal Bone- Eco-friendly Adsorption Material in Waste Water Treatment

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ABSTRACT
The management of agricultural and animal husbandry waste is a pressing environmental challenge that requires innovative solutions aligned with the principles of a circular economy. One promising approach is the valorization of animal bone as an eco-friendly material for water treatment applications. The management of agricultural and animal husbandry waste is a pressing environmental challenge that requires innovative solutions aligned with the principles of a circular economy. One promising approach is the valorization of animal bone as an eco-friendly material for water treatment applications. Animal bones are composed of a complex matrix of minerals, primarily hydroxyapatite, and organic compounds, such as collagen. This unique composition endows animal bones with excellent adsorption properties, making them a viable alternative to conventional water treatment materials. Using animal bones in water treatment reduces waste disposal and contributes to sustainable resource management by repurposing a readily available agricultural byproduct. Recent studies have highlighted the efficiency of animal bone-based materials in the removal of various pollutants from wastewater streams. The porous structure with high animal bone surface area allows for effective adsorption and sequestration of these contaminants, effectively improving water quality. Moreover, integrating animal bone-based materials into wastewater treatment processes aligns with the principles of a circular economy. By recycling and repurposing agricultural waste, the environmental impact of waste disposal is reduced, and the burden on natural resources is alleviated. This approach not only enhances water treatment but also promotes sustainable resource management and reduces the ecological footprint of industrial activities.

Keywords: Valorization, Adsorption, sequestration, Sustainability Resource Management, Recycling, Eco-Friendly

1. Introduction

Industrial wastewater streams are treated using conventional methods such as clarifiers, and activated sludge processes. A physical separation process treats pollutants with a molecular larger size like sedimentation. Waste minimization in the production process is a priority to avoid waste. Surfactants, emulsifiers, and petroleum hydrocarbons used in the chemical industry reduce the performance efficiency of many treatment unit operations. This study aims to assess the treatment of wastewater with a heterogeneous catalytical oxidation system using animal bone as an eco-friendly material. The objectives of this study are to determine the characteristics of the effluent stream, prepare a lab-scale model of the FACCO reactor determine the optimum dose of ferric sulfate, hydrogen peroxide, and animal bone char for Fenton reactions, carry out an experimental study for FACCO treatment.

The most effective strategy for treating toxic industrial wastewater is at the source. The chemical industry has a significant impact on the environment. Industrial wastes have varying degrees of concentration and complexity. Since these waste stream characteristics vary from domestic sewage in general characteristics, pretreatment is required. In the chemical industry, the high variability, stringent effluent permits, and extreme operating conditions define the practice of wastewater treatment. Fenton process reagent requires no energy input to activate the hydrogen peroxide. Therefore, this method offers a cost-effective source of hydroxyl radicals, using easy-to-handle reagents. However, the disadvantages of using the Fenton reagent are due to the generation of a substantial amount of Fe (OH)3 precipitate and additional water pollution caused by the homogeneous catalyst added as an iron salt [3]. To solve these problems, the application of alternative iron sources as catalysts in oxidizing organic contaminants has been studied extensively. It is suggested that Fenton processes are viable techniques[2] for the degradation of degradable COD from the wastewater stream with relatively low toxicity, 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 complexity into biodegradability of wastewater. After the treatment, 62% COD removal is achieved.

1.1 Background:

The global demand for clean water and sustainable waste management practices has led to an increased focus on utilizing eco-friendly and cost-effective materials for wastewater treatment. One such promising approach is using animal bone, a readily available agricultural waste, as an adsorbent and filtering medium in wastewater treatment processes. Animal bones are composed of hydroxyapatite, a calcium phosphate mineral, which has a high surface area and the ability to adsorb various pollutants, making them an attractive option for wastewater purification. Traditional treatment methods use chemical coagulants and synthetic materials which can be harmful to the environment and costlier. So, Animal Bone Char can be an alternative material that can be adsorbent.

The search for eco-friendly or "green" materials led to the discovery of a variety of materials derived from natural or renewable sources. Their use is particularly intense in construction, although animal bone in this context remains almost a novelty. Just as in civil construction, the increase in plastic waste generated encourages research in wastewater treatment systems to address its macro-issues. This consists of a lack of efficient, sustainable, and economic techniques. On the other hand, simple, natural, and practical solutions can reduce the environmental and economic liabilities generated by current anthropogenic behavior but remain little explored, such as the use of animal bones.

Animal bone is far from resistant, but a nontrivial peculiarity offers the possibility of finding abandoned residues in natural environments that allow us to return these to circulation. This can occur through the use of animal bone as a blast protection filter due to plastic waste, favoring both the environment and the economy. Therefore, this work aims to present an inventory of treatment structures with low cost, focusing on bone-based technologies for gray water treatment with a minimum reduction of the ratio of bone area to waste. All of these are strategies that induce the return of the bone to nature after a second cycle used in wastewater treatment, closing the chain.

1.2 FACCO Treatment

After 40 years of Fenton reaction discovery, the Harber-Weiss mechanism says that hydroxyl radicals are effective oxidative reagents. The HO· radical mostly attacks all the organic compounds as described in the following equation.[23]

Equation 0-1Fe3+ + H2O2 → Fe3+ + HO• (1)

Equation 0-2Fe3+ + H2O2 → Fe2+ + HO2 • + H+ (2)
Equation 0-3Fe2+ + HO• → Fe3+ + HO•- (3)
Equation 0-4HO• + H2O2 → HO2 • + H2O (4)
Equation 0-5Fe3+ + HO• → Fe2+ + H+ + O2 (5)
Equation 0-6Fe3+ + O2 •- → Fe2+ + O2 (6)
Equation 0-7Fe2++ HO2 • → Fe3+ + HO2•- (7)

The research shows that at pH 3 it gives the highest efficiency of COD removal.

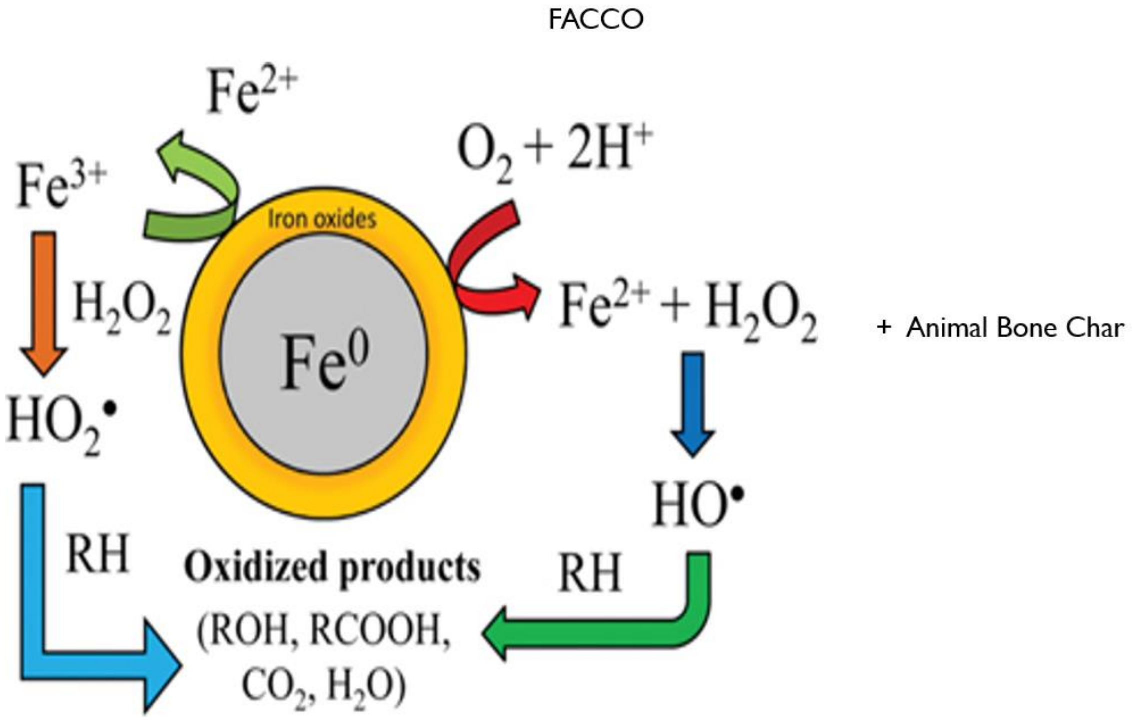

Figure -1 FACCO Reaction

In the FACCO treatments the activated carbon and Fenton reagents are used. FACCO treatment is a good option to increase the biodegradability of wastewater streams. Treatment of complex wastewater using a combined system of Fenton oxidation process followed by adsorption on Activated carbon. The FACCO treatment happens at a lower pH with the range of 2 to 4 using sulphuric acid with the chemical dose of hydrogen peroxide, ferrous ions known as Fenton reagents, and activated carbon, Check pH value and % COD removal.

1.2 Mechanism of adsorption

Activated Carbon has a good adsorption rate but animal bone char is a good eco-friendly material replacing it. Although Animal bone charcoal displays a relatively low surface area (283 $m^2 \cdot g^{-1}$), it shows a high copper removal capacity (34.9 $mg \cdot g^{-1}$). Animal bone charcoal has calcium phosphate as a major component which is crucial as a source of adsorption and enabling ion exchange process:

$\equiv PO^- + H^+ \rightarrow \equiv POH$

$\equiv CaOH_2^+ \rightarrow \equiv CaOH + H^+$

In the presence of Cu^{2+}, the following reactions occur:

$\equiv POH + Cu^{2+} \rightarrow \equiv POCu^+ + H^+$

$\equiv PO^- + Cu^{2+} \rightarrow \equiv POCu^+$

In the presence of Zn^{2+}, the following reactions occur:

$\equiv POH + Zn^{2+} \rightarrow \equiv POZn^{+} + H^{+}$

$\equiv PO^{-} + Zn^{2+} \rightarrow \equiv POZn^{+}$

$\equiv CaOH + Zn^{2+} \rightarrow \equiv CaOZn^{+} + H^{+}$

$\equiv CaOH + Cu^{2+} \rightarrow \equiv CaOCu^{+} + H^{+}$

In the presence of Ca^{2+}, the following reactions occur:

$\equiv POH + Ca^{2+} \rightarrow \equiv POCa^{+} + H^{+}$

$\equiv PO^{-} + Ca^{2+} \rightarrow \equiv POCa^{+}$

$\equiv CaOH + Ca^{2+} \rightarrow \equiv CaOCa^{+} + H^{+}$

1.2 Need of Study

The need for advanced wastewater treatment technologies arises due to various reasons

1. Water Scarcity
2. Stringent Regulatory Requirements
3. Emerging Contaminants
4. Nutrient Removal
5. Energy Efficiency and resource recovery
6. Climate change Resilience
7. Public Health Protection
8. Protection of aquatic ecosystems

1.3 Objective:

In this review, recent research and application of animal bone as an effective eco-friendly material have been extensively and critically evaluated in the area of environmental engineering, especially in wastewater treatment. Selected pollutants, including heavy metals, organic and inorganic matter, nutrients, and waterborne pathogens, are considered and discussed. Characteristics of each type of application for the respective pollutants have been comprehensively evaluated. Recommendations for future research and development on the practical application of animal bone in wastewater treatment are presented. In response to defining the most suitable animal bone for specific usage in treating wastewater, systematic reviews have been presented. Methods for the fabrication of these bone materials and varying conditions under which they have been characterized, as well as their roles in the removal process, are discussed. Studies on bone leaching and carryover in wastewater treatment are crucial to ensure no secondary pollution is derived from the treatment process and will also be discussed in this paper. This review provides the first comprehensive evaluation of the animal bone material in its use in wastewater treatment. It will provide theoretical knowledge and practical support for the development of eco-friendly materials in environmental engineering and point to relevant recent investigations with conclusions that will aid the optimization of these materials for wider application at a low cost for carbon reduction. The work involves defining and improving the treatment process for wastewater. This includes the degradation and mineralization of various contaminants. The wastewater is analyzed to assess the effectiveness of the treatment process proposed and tested for the studied parameters.

According to the statement, the objectives of this work can be outlined as follows:

Determine the characteristics of the effluent.

Prepare a lab-scale catalysis experimental setup.

Determine the optimum dose of ferrous sulfate, ferric chloride, and hydrogen peroxide.

Compare the efficiency of Fe (II) and Fe (III) iron, as well as animal bone char.

1.4 Literature Review:

The literature reviewed is from various sources and standard publications. This review provides extensive background to enhance understanding of the subject. Following with various major findings of the reviews as follows:

Fenton's reagent is a mixture of two hydrogen peroxide and ferrous iron capable of releasing hydroxyl radicals which take part in the oxidation process and dissolved organics from the wastewater.

The percentage removal of COD is higher by Fenton's reagent with adsorption of activated carbon catalyst.

Wastewater generated is less amenable to biological treatment which is due to the presence of non-biodegradable chemicals.

The oxidation of dissolved organics by Fenton's reagent and adsorption on bone char resulted in the percentage removal of complex pollutants respectively.

Bone char preparation method and characterization

2. Method

The process of using animal bone for wastewater treatment typically involves several steps. First, the bones are collected, cleaned, and processed to remove any organic matter or impurities. The bones are then crushed or ground into a fine powder to increase the surface area available for adsorption. The bone powder can then be used as a coagulant or filter media in the wastewater treatment process, effectively removing complex contaminants heavy metals, organic matter, and total suspended solids.

2.1 Possible treatment for wastewater

Various treatment options are available for wastewater, including thermal, chemical, physical, and biological methods. The most commonly used thermal treatment methods are incineration and open burning. Chemical methods include ozonation/UV radiation, Fenton oxidation, electro-oxidation, coagulation, photocatalytic degradation, and AOP. Physical treatment methods like adsorption, reverse osmosis, nanofiltration, electrodialysis, and membrane distillation. However, these techniques are often not cost-effective or environmentally friendly. Nowadays, the Fenton oxidation process is considered more effective than conventional methods followed by adsorption.

Method	Merits	Demerits
Biodegradation	oxidizable substances Removal is 90%	Less degradability
Coagulation-Flocculation	Removal of insoluble substance	blocking of filter due to sludge
Adsorption on activated carbon	Reduction of suspended solids and organic substances	High Costs of activated carbon
Ozone Treatment	Effective decolorization	Less COD reduction
Electrochemical processes	Adaptability to different volumes and pollution loads	High Iron hydroxide sludge generation

Table -1 Possible Treatment Method stating their Merits & Demerits

2.2 Wastewater Characterization in Fertiliser Industries

The fertilizers have properties like Persistence, toxicity, mobility, Tran's boundary transport, bioaccumulation, and bio magnifications. The fertilizers are persistent if they stay in nature for a long period degrade very slowly and have a long half-life. Fertiliser may remain adsorbed to the soil or dissolved in water. So, it generates groundwater pollution or soil pollution. If the ratio of the Fertiliser bound to the soil particle than dissolved into the water is high, the fertilizers bound to the soil are leached to ground water or run-off to surface water. Some fertilizers are volatile or semi-volatile and contaminate the air, even carried to contaminate a virgin area. Waste Characterization

This section includes the characterization of wastewater which will be used as a model pollutant. Different parameters will be tested by analytical methods stated in Table 2. The standard methods will be considered for

Sr. No.	Parameters	Unit	Value
1	pH	---	2.7
2	Suspended Solids	mg/L	3402
3	COD	mg/L	45000
4	Chloride	mg/L	1100

Table -2 General Characteristics of Wastewater

The above data shows that the pollutant has a high organic load and low biodegradability means complex to degrade by traditional conventional treatments.

2.3 Method of Bone Char Preparation

Activated carbon can be prepared from raw materials from various natural sources, including cow bones, wood, and Rice Husk which is a readily available and cost-effective starting material.

The preparation process typically involves the following steps:

1. Collection and cleaning: Removing dirt, sand, and other impurities from the raw material
2. Pretreatment: Washing, drying, and grinding into a fine powder; optional chemical treatment may be applied to improve activation efficiency or remove impurities such as silica
3. Carbonization: Heating in an inert atmosphere at temperatures between 400-600°C to drive off volatile compounds and create a porous carbon structure; this step can also be performed using microwave radiation for faster processing times and lower energy consumption
4. Activation: Further heating the carbonized powder in the presence of oxidizing agents (steam or CO_2) to increase surface area and pore volume; chemical activation may also be employed using strong acids or bases as activating agents
5. Post-treatment: Optional modifications to enhance specific adsorption properties or remove residual chemicals from the activation process

Figure -2 Weighing and sieving of Animal Bone char

Figure -2 Carbonized Animal Bone char

2.4 Materials

For FACCO processes, the materials used in this study are:

$FeSO_4.7H_2O$ - Merck Company for chemicals.

Ferric Chloride anhydrous from Sarabhai Chem

Hydrogen peroxide solution - Merck.

Animal Bone char prepared at Indorama Fergonaazot

Distilled water

Sulphuric acid 98%

Sodium hydroxide 99% - Merk Company

Figure -2 Materials used in the FACCO

2.5 Selection of Ratios and Molar Concentration

The two ratios which play a major role in the entire FACCO process are:

1. COD: H2O2 2. H2O2 : Fe+2

These ratios are decided from the literature and the extremes are also considered.

The following table indicates the different ratios of COD: H2O2 that are used on H2O2 : Fe+2 molar Concentration. For individual COD: H2O2 ratio all the two H2O2 : Fe+2 molar concentrations are used individually.

<table>
<tr><th>COD: H2O2</th><th>H2O2 :Fe+2</th></tr>
<tr><td>10:1</td><td rowspan="3">10:1</td></tr>
<tr><td>6:1</td></tr>
<tr><td>2:1</td></tr>
<tr><td>10:1</td><td rowspan="3">20:1</td></tr>
<tr><td>6:1</td></tr>
<tr><td>2:1</td></tr>
</table>

Table -3 Experimental Ratios

2.6 Fenton Treatment using JAR apparatus with FeSO4

The jar Test is the best approach to determining the treatability and optimum parameters. Effective coagulant, dosage pH. Fenton's oxidation experiments were carried out under optimal conditions in the environment laboratory. Experiments were carried out in 1000ml beakers with a solution volume of 500 ml. The procedure then starts with the addition of FeSO4.7H2O crystals and then slowly adding H2O2 dropwise with stirring of 1 hr. in the JAR apparatus. The dosage of H2O2 added is based on a COD/H2O2 molar ratio of 10:1, 6:1, and 2:1. And the FeSO4dosage based on the H2O2:Fe2+ ratio10:1, 20:1. The experimental setup is placed in the JAR apparatus shown in Figure 2.

Figure -2

2.7 Fenton Treatment using JAR apparatus with FeCl3

This treatment is for the comparison of the two different Iron catalysts FeSO4 and FeCl3. After giving the treatment with FeSO4 now the Treatment is given with FeCl3. In this above-all process goes the same adding PAC then agitating for 1 hr then adjusting the pH 2.5 and 3.5 with sulphuric acid. Then the FeCl3 is based on the ratio 10:1 and 20:1. And H2O2 is added based on the ratio of 10:1, 6:1, and 2:1. After stirring is given for at least 1 hr.

However, as shown in figure 3.9 shows that in the treatment with FeCl3, the sludge generation ratio is high as compared to the sludge generated with FeSO4. FeCl3 gives better results for COD degradation but it generates a high amount of sludge. FeSO4 gives a reduction and less amount of sludge. So, as a better performance with H2O2 FeSO4 is a good option rather than FeCl3.pH is also playing a role in the treatment. The 2.5 pH value is the best result given. The highest Sludge generated from the use of FeSO4 was 339.74 ml/g. The highest Sludge generated from the use of FeCl3 was 503.30 ml/g.

Figure -3 Comparison of sludge generation by both the iron catalyst

2.8 Factors Affecting FACCO Treatment

2.7.1 Effect of Fenton dosages:

The hydroxyl radical generation depends on H2O2 and Fe2+ amounts. The COD removal efficiency increases with increasing the dosage of reagents. Higher dosages resulted in lowered COD removal. The increase in the ferrous unutilized quantity of iron salts, contributed to an increase in the total dissolved solids content of the effluent.

2.7.2 Effect of H2O2 dosage

The concentration of hydrogen peroxide plays an important role in the process. Hydrogen peroxide generates hydroxyl radical it is a strong oxidant. It applies to various inorganic and organic pollutants. However, hydrogen peroxide alone is not effective for high concentrations. Hydrogen peroxide oxidizes both the organic and inorganic pollutants as a result COD removal efficiency increases with an increase in the H2O2 dosage. But at the excess amount, the COD removal efficiency decreases.

2.7.3 Effect of Fe2+ dosage

Fe2+ is used as a catalyst for oxidation.H2O2 alone is not effective in wastewater treatment so iron is required to increase the efficiency. At pH 2 to 4, Fe+2 increases the COD removal % with OH radical. But at the higher dose of Fe +2, the removal efficiency decreases. Fe2+ at higher concentrations hindered the organic pollutant. Fe2+ as hinders speeding up the formation of hydroxyl radicals.

2.7.4 Effect of pH

pH plays an important role in the Fenton process. The production of hydroxyl radical and the concentration of the ferrous ion are controlled by the pH. The Fenton process strongly depends on the pH of the solution due to iron and H2O2 speciation factors. Research says that the oxidation potential of hydroxyl radicals decreases with increasing the pH. COD removal depends on the initial pH of the solution. Hydroxyl radical consumed by the presence of H+. It is also influenced by the concentration of Fe ions. So the efficiency of the Fenton process increases and decreases at the optimum pH.[24]

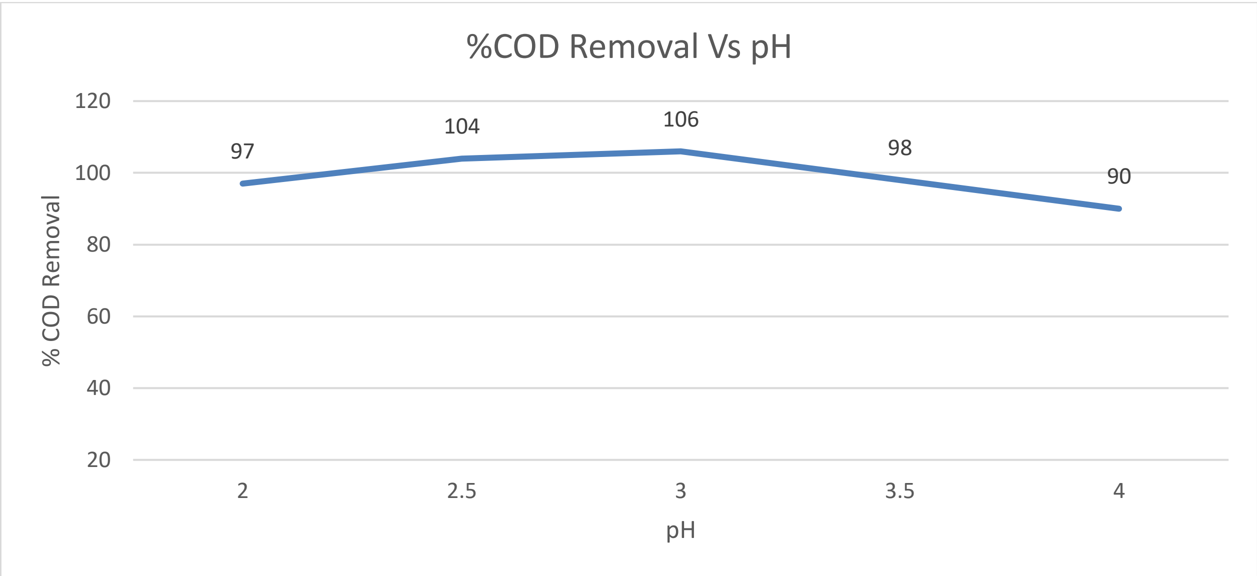

Figure -4 %COD removal Vs pH

2.9 Analytical Methods

Sets of examinations were performed keeping in mind the end goal to assess the productivity of the procedures explored and the working of the pilot plant. Moreover, to the online estimations, tests were pulled back at standard time intervals and a few disconnected factors were additionally estimated keeping in mind the end goal to think about the advancement of the procedure under various process operational conditions. All the more particularly, parameters, for example, COD, specific concentrations of contaminant, and hydrogen peroxide were estimated along the examined treatment traverse. The analyses of pH, COD, SS, and TDS will be conducted by the Standard analytical Methods These analytical methods are presented in the table with their references.

Parameters	Method to be used
pH	Electrometric Method
COD	5220 B, Open Reflux Method
TSS	2540 , Total Suspended Solids Dried at 103-105°C

Table -4 Analytical Methods

4. RESULT & DISCUSSION

4.1 Initial Characteristics of Wastewater

Wastewater sampling was carried out on different days and their characteristics are shown in the below table.

Sr. No.	Parameter	Unit	Sample Results				
			A	B	C	D	E
1	pH	-	2.7	2.8	2.77	2.74	2.8
2	COD	mg/l	40320	40464	40900	40600	40510
3	TSS	mg/l	1580	1546	1540	1548	1545

Table -5 Initial characteristics of wastewater

From the above table, it's clear that the pH ranges between 2.7 to 2.8, COD from 40320 to 40900, and TSS from 1540 to 1580. Further study is carried out to determine the dosages of Hydrogen peroxide, Ferric chloride, and ferrous sulfate.

4.2 Chemical Dosage for Fenton's Treatment

The following table shows the description of the chemical dosage given to the wastewater after the charcoal treatment for the Fenton treatment.

Sr. No	H2O2 /Fe+2 ratio	COD/H2O2 ratio
1	10:1	10:1
2		6:1
3		2:1
4	20:1	10:1
5		6:1
6		2:1

Table -6 Chemical Dosage for Fenton's Treatment

4.3 COD Tests

The test work is arranged to concentrate on the most extremely effective treatment for COD expulsion by contrasting Fenton's procedure. Quantities of COD tests were performed including tests treated by both the strategies i.e., Fenton-activated carbon catalytical oxidation. COD tests were finished by Standard Analytical Methods.

4.4 Results of FACCO Treatment

The results of the FACCO process are shown in the following tables. In cases where the maximum removal was obtained at COD: H2O2 is 6:1 and the H2O2: Fe 20:1 the % COD removal is a maximum of 62.08. The sample volume considered in the procedure was 500ml. The open Reflux Method was utilized to test the COD. The dilution ratio used in the COD test was 1:20.

COD Removal with H2O2 : Fe+2=10:1 and 20:1 Molar Concentration at pH 2.5 for FeSO4

This section includes the results of COD removal for H2O2 : Fe+2=10:1 and 20:1 molar concentration with different COD: H2O2 molar ratios with charcoal treatment.

The following table shows the results for COD: H2O2 =10:1,6:1 and 2:1 H2O2 : Fe+2 ratio= 10:1 at pH-2.5.

Sr. No.	COD: H2O2	H2O2 : Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:1	10:1	40900	22930	43.94
2	6:1	10:1	40900	20000	51.10
3	2:1	10:1	40900	32080	21.56

Table -7 Results for COD: H2O2 =10:1,6:1,2:1 H2O2 : Fe+2 molar ratio= 10:1

The following table shows the results for COD: H2O2 =10:1,6:1 and 2:1 H2O2 :Fe+2 ratio= 20:1 at pH-2.5.

Sr. No.	COD: H2O2	H2O2 : Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:1	20:1	40900	29036	29.0
2	6:1	20:1	40900	15509	62.08
3	2:1	20:1	40900	27340	33.15

Table -8 Results for COD:H2O2 =10:1,6:1,2:1 H2O2 :Fe+2 molar ratio= 20:1

COD Removal with H2O2 : Fe+2=10:1 and 20:1 Molar Concentration at pH 3.5 for FeSO4

This section includes the results of COD removal for H2O2 : Fe^{+2}=10:1 and 20:1 molar concentration with different COD: H2O2 molar ratio with charcoal treatment.

The following table shows the results for COD: H2O2 =10:1,6:1 and 2:1 H2O2 :Fe^{+2} ratio= 10:1 at pH-3.5.

Sr. No.	COD:H2O2	H2O2 :Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:01	10:01	40900	20705	44.37
2	6:01	10:01	40900	29210	28.58

3	2:01	10:01	40900	26520	35.16

Table -9 Results for COD:H2O2 =10:1,6:1,2:1 H2O2 :Fe+2 ratio= 10:1

The following table shows the results for COD:H2O2 =10:1, 6:1 and 2:1 H2O2 : Fe+2 ratio= 20:1 at pH-3.5.

Sr. No.	COD:H2O2	H2O2 :Fe+2	COD before treatment (mg/l)	COD after treatment (mg/l)	%COD removal
1	10:01	20:01	40900	25195	38.39
2	6:01	20:01	40900	23510	42.52
3	2:01	20:01	40900	24416	40.30

Table -10 Results for COD: H2O2 =10:1, 6:1, 2:1 H2O2 : Fe+2 molar ratio= 20:1

COD Removal with H2O2 : Fe+2=10:1 and 20:1 Molar Concentration at pH 2.5 for FeCl3

This section includes the results of COD removal for H2O2 : Fe+2=10:1 and 20:1 molar concentration with different COD: H2O2 molar ratio with charcoal treatment.

The following table shows the results for COD: H2O2 =10:1, 6:1, and 2:1 H2O2 : Fe+2 ratio 10:1 at pH-2.5.

Sr. No.	COD: H2O2	H2O2 :Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:01	10:01	40900	26080	36.23
2	6:01	10:01	40900	21220	48.12
3	2:01	10:01	40900	19020	53.50

Table -11 Results for COD: H2O2 =10:1, 6:1, 2:1 H2O2 : Fe+2 ratio= 10:1

The following table shows the results for COD: H2O2 =10:1, 6:1, and 2:1 H2O2 : Fe+2 ratio 20:1 at pH-2.5.

Sr. No.	COD: H2O2	H2O2 : Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:01	20:01	40900	23220	43.23
2	6:01	20:01	40900	23750	41.93
3	2:01	20:01	40900	21021	48.6

Table -12 Results for COD: H2O2 =10:1, 6:1, 2:1 H2O2 : Fe+2 molar ratio= 20:1

COD Removal with H2O2 : Fe+2=10:1 and 20:1 Molar Concentration at pH 3.5 for FeCl3

This section includes the results of COD removal for H2O2 : Fe+2=10:1 and 20:1 molar concentration with different COD: H2O2 molar ratio with charcoal treatment.

The following table shows the results for COD: H2O2 =10:1, 6:1 and 2:1 H2O2 : Fe+2 molar ratio= 10:1 at pH-3.5.

Sr. No.	COD:H2O2	H2O2 :Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:01	10:01	40900	22510	44.96
2	6:01	10:01	40900	18080	55.79
3	2:01	10:01	40900	27520	32.71

Table -13: Results for COD: H2O2 =10:1, 6:1, 2:1 H2O2 : Fe+2 ratio= 10:1

The following table shows the results for COD:H2O2 =10:1,6:1 and 2:1 H2O2 :Fe+2 ratio= 20:1 at pH-3.5.

Sr. No.	COD:H2O2	H2O2 :Fe+2	Before COD(mg/l)	After COD(mg/l)	%COD removal
1	10:01	20:01	40900	20795	49.16
2	6:01	20:01	40900	21920	46.40
3	2:01	20:01	40900	23220	43.23

Table -14: Results for COD:H2O2 =10:1,6:1,2:1 H2O2 :Fe+2 ratio= 20:1

4.5 Wastewater Characterization after Treatment

There is a reduction in wastewater after treatment. The COD, pH, and TSS values get reduced up to some extent. The maximum % COD removal is 62%.

Sr. No.	Parameters	Unit	Value
1	pH	---	5.7
2	Suspended Solids	mg/L	312
3	COD	mg/L	15509

Table -15 Wastewater Characterization after Treatment

4.6 Comparison of efficiency of COD removal with FeSO4 and FeCl3

The Fenton Activated Carbon catalytical Oxidation (FACCO)process is applied to the wastewater to reduce the COD value. By this FACCO process, we can achieve a maximum 62%5 reduction. Our other aim is to find out the better catalyst between FeSO4 and FeCl3. The result shows that the FeSO4 gives a maximum reduction of about 62%. FeCl3 also gives a reduction of up to 55.81%. But by the use of FeCl3, it gives a high amount of sludge. So, it can increase the cost and require other treatments. The Comparison of the FeSO4 and FeCl3 is shown in figure
4.9 and 4.10 which shows the percentage of COD removal.

Sr. No.	pH	COD: H2O2	H2O2 : Fe+2	Catalyst	%COD removal	Catalyst	%COD removal
1	2.5	10:1	10:1	FeSO4	43.94	FeCl3	36.23
2	2.5	6:1	10:1	FeSO4	51.10	FeCl3	48.12
3	2.5	2:1	10:1	FeSO4	21.56	FeCl3	53.50
4	2.5	10:1	20:1	FeSO4	29.0	FeCl3	43.23
5	2.5	6:1	20:1	FeSO4	62.08	FeCl3	41.93

6	2.5	2:1	20:1	FeSO4	33.15	FeCl3	48.60

Table -5 Comparison Of Efficiency Of Cod Removal With FeSO4 AND FeCl3 At pH 2.5

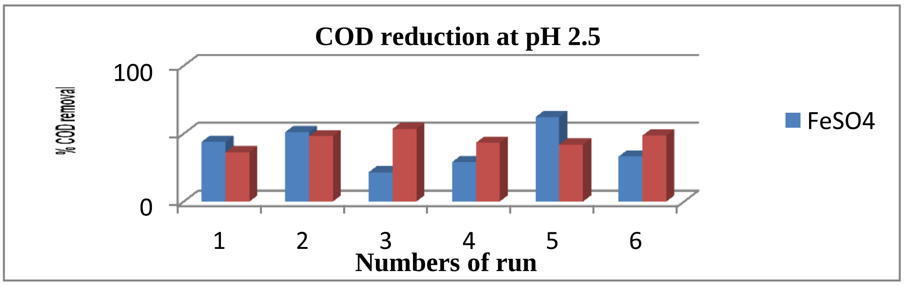

Figure -6 Compression of efficiency of COD removal with FeSO4 and FeCl3 at pH 2.5

Sr. No.	pH	COD:H2O2	H2O2 : Fe^{+2}	Catalyst	%COD removal	Catalyst	%COD removal
1	3.5	10:1	10:1	FeSO4	44.37	FeCl3	44.96
2	3.5	6:1	10:1	FeSO4	28.58	FeCl3	55.79
3	3.5	2:1	10:1	FeSO4	32.71	FeCl3	32.71
4	3.5	10:1	20:1	FeSO4	38.39	FeCl3	49.16
5	3.5	6:1	20:1	FeSO4	42.52	FeCl3	46.40
6	3.5	2:1	20:1	FeSO4	40.30	FeCl3	43.23

Table-17 Comparison Of Efficiency Of Cod Removal With FeSO4 AND FeCl3 At pH 3.5

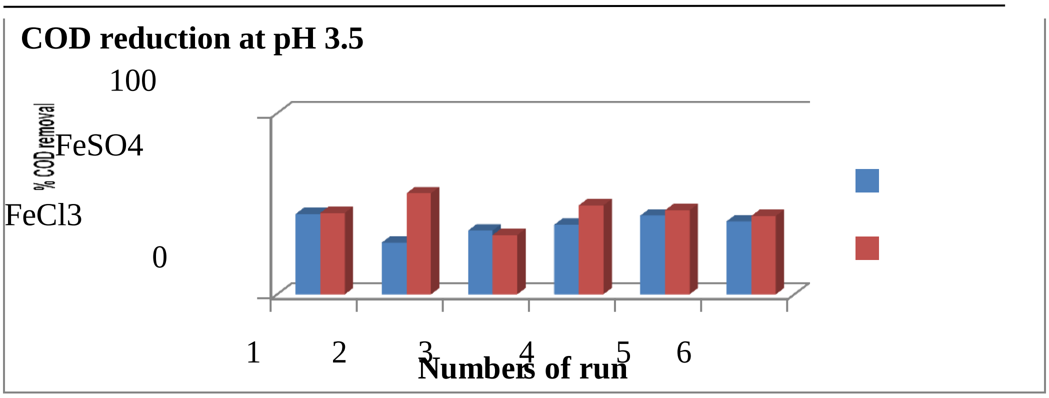

Figure -7 Compression of efficiency of COD removal with FeSO4 and FeCl3 at pH 2.5

4.7 COD Removal with H2O2 : Fe+2=6:1 and 20:1 Molar Concentration at pH 2.5 for FeSO4

Sr. No.	Animal Bone Char gm	COD before treatment (mg/l)	COD after treatment (mg/l)	%COD removal
1	5	40900	8200	79.9
2	10	40900	7000	82.9
3	15	40900	6000	85.3

4.8 Results

The effluent stream pollutes the water stream is the needed a proper treatment method to reduce the pollution level. The characteristics of the wastewater has BOD/COD ratio 0.4 is suitable for the Advanced Oxidation process. Hence treatment of wastewater was done with the Advanced Oxidation process due to its non-biodegradable complex nature. Fenton Activated Carbon Catalytical Oxidation treatment was given to the wastewater without any pre-treatment.

- The examined FACCO treatment was found to be effective as a pretreatment for removing impurities from wastewater when COD is very high.
- The treatment of wastewater results in a substantial % COD removal.
- The H2O2 , FeSO4 FeCl3 Animal bone char dosage should be carefully optimized.
- The COD:H2O2 ratio used in the study were 10:1, 6:1 and 2:1, maximum removal was obtained at 6:1 and minimal removal was obtained at 2:1
- The FACCO treatment with the FeSO4 can achieve up to 62% removal of COD at H2O2 : Fe^{+2} molar concentration of 6:1, COD:H2O2 10:1
- The FACCO treatment with the FeCl3 can achieve up to 55.81% removal of COD at H2O2 : Fe^{+2} molar concentration of 6:1, pH 3.5.
- Sludge generation is a major problem for FeCL3 treatment.
- Animal Bone char with dosage and with an increase in surface area 85.3% removal of COD is observed
- Animal Bone Char is used for further treatment to adsorb impurities of Zn^{2+}, Ca^{2+}, Cu^{2+}
- Animal Bone is eco-friendly replacing activated carbon as well waste to wealth.

5 Conclusions

Wastewater management contributes significantly to the carbon footprint and is necessary concerning environmental issues to think about eco-friendly and sustainable development in planning, performance, and evaluation. With increasing awareness of the environmental effects, the method of upcycling waste material such as animal bones from butcheries for the production of char can be seen as a recovery of a resource.

Animal Bone char with a large content of calcium is viewed as a cheaper carbon material and a plentiful waste. The transportation costs could also be low since it is possible to use cattle bones obtained from local butcher shops in certain very urban or intensive farming areas. Animal bones can be carbonized, thus obtaining bone char cost-effectively

In addition, standard operation should be ensured to reduce operational costs, and for this area, it appears possible to find scale economies because bone char is relatively available all over the world. The initial investment has paid off over the years thanks to low maintenance costs and increased system inlet operations.

Also, promoting a circular economy, bone char directly deposited into aquatic systems or into the soil will enhance water as well as agricultural sustainability. Using animal bone char as an alternative adsorbent in industrial wastewater treatment will have positive results in comparison to traditional and other adsorbents that provide higher removal efficiency at lower operational costs and time. Animal Bone chars can thus explore a wide network of available environmentally based materials.

Significant research progress is needed to bring it to the industrial scale

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