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Depth Treatment of Engineering Applications Wastewater Using a Sequential Heterogeneous Fenton and Biodegradation Approach: Review

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Abstract. After treating industrial wastewater efficiently and adequately to avoid harm from it being reused and disposed of in the past, the majority of countries in the world have moved to integrated planning and sound management to reuse it. The efficiency of water treatment and reuse depends on a set of environmental standards and controls that are connected to the nature of this water and the eventual purpose of treating and reusing it in order to prevent the environmental repercussions of an integrated method. A framework that assures environmental protection must be employed for this treatment and reuse. The emphasis is on developing reusable resources in order to transition from a linear to a circular economy. Finding the primary pathway for heterogeneous and homogeneous catalysis to pollutant degradation, optimizing the layout for integrating Fenton processes into large-scale treatment plants, particularly its coupling with biological treatment, and analyzing or enhancing heterogeneous catalyst lifetime are all important. are some of the main challenges mentioned in this research. This study intends to analyze the efficacy of the Fenton process in treating water in an effective and economical way compared to other conventional techniques.

1.Introduction

Over the course of the last century, wealthy nations have increasingly worried about water contamination. Since every living thing needs water to survive, it naturally has far-reaching consequences for the planet. Therefore, the quality of the effluent that is left over is sufficient for its intended application. With the help of national and international water quality agreements and rules, we have the technology to clean wastewater and release it back into the environment in pristine form. However, research into more cutting-edge and user-friendly technology is required to make wastewater treatment a procedure accessible worldwide with minimal environmental effect and waste. The Fenton process is studied here; this is an Advanced Oxidation Processes reaction, and it has a promising future in this area (AOPs).

In recent years, The Fenton method has drawn increased attention as a means of handling challenging industrial effluent. In a relatively short period of time, chemical engineers have made enormous contributions to modern life. Chemical engineers create and design the processes used to make everything from antibiotics and other medicines to fertilizers, agricultural chemicals, and polymers that are physiologically compatible for use in biomedical devices. Chemical engineers solve issues that emerge in the manufacturing and use of numerous products, including chemicals, fuel, medicines, and meals.**[1]**.

Through the targeted addition of particular substances, chemical wastewater treatment causes contaminants that are dissolved in wastewater to separate more easily. Precipitation transforms a dissolved substance into a dissoluble substance that can be removed from the liquid by filtering. **[2]**

Removing pollutants such as heavy metals, volatile and semi-volatile organic compounds, and pesticides from wastewater requires the use of multiple chemicals in a complex and time-consuming process called wastewater treatment. Industries such as pharmaceuticals, power and paper use wastewater treatment chemicals. The main chemicals used in wastewater treatment and their typical applications are discussed in the next section. Wastewater treatment can be divided into

three distinct stages: primary, secondary, and tertiary. In other cases, further purification is required, and this is where quaternary water treatment comes into play. **[3]**
Chemical precipitation is used to purify water and wastewater by converting dissolved chemicals in water into solid particles. Chemical precipitation is used to remove ionic components from water by adding counter ions to reduce their solubility. Mechanical, biological and chemical processes of wastewater treatment:

- Ion exchange.
- Chemical stabilization.
- Chemical precipitation.
- Chemical oxidation by using oxidation reagents such as hydrogen peroxide, chlorine peroxide and ozone for reduction of residual COD.

Chemicals Used in breaking down pollutants in Wastewater are:

- Coagulants.
- Control of odor.
- Flocculants.
- Deformers.
- Natural Polymers.
- Agent Reduction.
- Conditioners for sludge.
- Degreasing and cleaning agents. **[4, 5, 6]**

1-1- Water organic matter

Organic compounds in water are referred to as "water organic matter" in the scientific literature. The remnants of species such as plants, animals, and microorganisms can be categorized as either non-humid (consisting of protein, carbs, organic acids, etc.) or humid (consisting of humus). Water's physical and chemical properties, as well as its capacity for self-purification, degradation, migration, and transformation, can be affected by the presence of organic matter. **[7, 8, 9]**

1-2- Resources of organic wastewater

Organic pollutants, which make up the majority of contaminants in wastewater, are just one type. Wastewater contains a variety of organic substances, including polychlorinated biphenyls(PCBs) . Organic wastewater that is harmful to water quality can come from a wide range of human activities, such as the use of phenols, herbicides, pesticides, polycyclic aromatic hydrocarbons (PAHs), aliphatic and heterocyclic chemicals, industrial and agricultural output, and human habitation. **[10]**
Wastewater from the food industry typically contains complex organic contaminants including SS and BOD. The concentration of pesticides and herbicides in farm wastewater may be rather high. Many different polycyclic aromatic hydrocarbons (PAHs) have been found in coke plant wastewater. Heterogeneity chemicals, such as polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs), Oil, food, some dioxins, and other organics have all been found in wastewater from municipal sewage treatment plants. Toxic organic compounds in water supply endanger both aquatic life and human health.**[11].**

1 - 2- 1- Common poisonous substances in organic wastewater

The biological breakdown of the organic contaminants in the wastewater allows for the separation of the pollutants into two classes. Organic pollutants are readily broken down in nature because of their simple structures and high hydrophobicity. It is possible that microorganisms like bacteria, fungi, and algae can degrade organic pollutants like methanol and polysaccharide. On the other hand, if they were to be present in large enough concentrations in wastewater, some of them, like acetone and methanol, might induce acute toxicity.. On the other hand, the metabolism of or other forms of degradation from persistent organic pollutants like DDT, PCBs, and PAHs occur extremely slowly. Some of them, like pesticides, were used extensively for a number of years. Despite the fact that they are less toxic and have a lower concentration in wastewater than soluble organic pollutants, they can persist for years in sediment before moving into the water supply and eventually entering the food chain. The above-mentioned carcinogenic, teratogenic, and neurotoxic properties of many POPs, which are lipid soluble, are present. These organic pollutants draw more attention because they are persistent, easily transported, and toxic **[12]**

The following are the typical poisons found in organic wastewater:

1 - PCBs

PCBs are made by combining biphenyl with anywhere from 2 to 10 chlorine atoms. Water from factories that produce transformers, capacitors, and electric motors often contains PCBs because these fluids are employed as dielectrics and coolants in these devices.**[13]**

2 - Nitrobenzene

With the chemical formula $C_6H_5NO_2$, nitrobenzene is an organic substance. As a precursor to aniline, it is widely produced. It is occasionally used as a solvent in the lab, particularly for electrophilic reagents. Long-term exposure has the potential to seriously harm the central nervous system, impair vision, harm the liver or kidneys, cause anemia, and irritate the lungs**.**Additionally, nitrobenzene has been implicated in recent research as a possible carcinogen.

3 – Oregano -phosphorus pesticide

Oregano phosphorus pesticide may be present in agricultural wastewater due of its persistence in the environment. In addition to inter media manufacturing and degradation processes, this pesticide is frequently found in high concentrations in the wastewater produced by oregano phosphorus pesticide factories. Water contaminated with organ phosphorus pesticides could have devastating effects on the ecosystem if released into the wild. Insecticides containing phosphorus from oregano can be extremely dangerous to your health. Organ phosphorus pesticides are extremely harmful, but they break down rapidly in nature.**[14]**.

4 - Petroleum hydrocarbons

The primary sources of petroleum hydrocarbons in the water system are municipal sewage and industrial wastewater. Different petroleum hydrocarbons from various industries, such as oil exploration, production, transportation, and refining, may be mixed together in the wastewater. Petroleum hydrocarbons are poisonous to aquatic life and can worsen water quality by coating surfaces with an oily film, which reduces the exchange of oxygen between the air and the water. **[15]**

5 - Atrazine

Conservation tillage techniques, which aim to reduce soil erosion, typically involve the application of the herbicide atrazine. This chemical herbicide might prevent and reduce grassy and broadleaf weeds in dry agriculture, increasing the harvest of the primary crops. Atrazine-containing wastewater primarily originates from overburdened farmlands and the chemical industry that produces this product. Despite its propensity to persist in the environment for a very long time, this substance has been found in the drinking water of several countries and in the groundwater of many more. In hot conditions, atrazine has the potential to volatilize, producing harmful chemicals such carbon monoxide and nitrogen oxides that can cause skin, eye, and respiratory irritation. Problems with menstruation, low birth weight, and birth defects have been linked to atrazine exposure below limits allowed by federal rules.

6 – Phenols

The chemical compound class known as phenols is created when an aromatic hydrocarbon group and a hydroxyl group (-OH) are physically linked. The coking plant, refinery, insulating material manufacture, paper manufacturing, and phenolic chemical factory are the principal producers of phenol in the wastewater. Even in small doses, phenol is a serious health risk because it is a known human carcinogen. Phenol may also have the ability to reduce aquatic organisms' capacity for growth and reproduction.

1-2- 2- Environmental hazards of organic wastewater

A significant amount of soluble oxygen could be consumed by organic pollutants with a high hydrophilic content, such as oil and organic matter. Due to the acute toxicity and high oxygen demand, the aquatic biological system might sustain severe damage that would degrade the water quality. They could easily be broken down by microorganisms, so their negative impact on the environment won't last long.
Environmental elements (such as temperature and PH value) and ageing processes, as well as the properties of the contaminants, can all have an impact on how harmful organic wastewater is. Further research should be done on these elements as well as their long-term implications on the ecosystem. **[16]**

1- 3- Monitoring analysis method of poisonous substances

Common methods for measuring the concentration of organic compounds in wastewater include the chemical oxygen demand (COD), biological oxygen demand (BOD), and total organic carbon (TOC) tests.
The chemical oxygen demand (COD) test is predicated on the idea that given an acidic environment with an aggressive oxidizing agent, nearly all organic compounds can oxidize to carbon dioxide. Considering that the COD value is typically determined using the acidic potassium permanganate and potassium dichromate processes, it is probable that the results of this approach accurately reflect the level of pollution caused by reducing matter in water, such as ammonia and reducing sulfide. Therefore, wastewater with a high concentration of reducing matter will have a COD value that significantly underestimates the true concentration of organic pollutants.**[17]**
The BOD value is the concentration of dissolved oxygen in a water sample over a specified time period at a specified temperature at which aerobic biological organisms can decompose organic material.
A standard and reliable proxy for assessing the concentration of organic contaminants in water is the BOD value, which is typically represented in milligrams of oxygen utilized per liter of sample over five days of incubation at 20°C. Though it's commonly employed as a quantitative indicator of the organic matter in water, this test does not produce a definitive result on its own. **[18]**
The TOC measurement is used to determine how much total carbon is present in the water (both soluble and suspended). More correctly reflecting the amount of organic matter than BOD or COD is this approach, which during the evaluation might oxidase all organic contaminants utilizing combustion.
The COD, BOD, and TOC tests can swiftly identify organic pollution in wastewater, but they cannot distinguish between different forms of organic matter or the nature of the water, which means they cannot identify the total quantity of the same total organic carbon pollution caused by varied impacts **[19].**

1 – 4 - Chromatography-mass spectrometry method

The organic pollutants in wastewater can be identified and separated using a cutting-edge method called chromatography-mass spectrometry. "Spectrometry" refers to a class of analytical methods used to purify substances in labs. Differential partitioning between the movable and stationary phases allows for the separation to take place. Retention on the stationary phase might vary depending on the structural features of the individual wastewater constituents, hence altering the separation.
It was feasible to ionize the organism and put it via an electric field using the mass spectrometer. Because lighter molecules' paths (trajectories) could be bent by the electric field more than heavier molecules', organic matter with different masses would strike the detector at various positions (each organic matter's position is fixed). The organic pollutants could be located and measured using this technique. The types of organic contaminants contained in a sample and their amounts might be fully described by combining chromatography and mass spectrometry.**[20]**

2 - Chemical Oxidation Technologies Under Normal Temperature and Pressure

A growing number of molecules in today's wastewater streams are resistant to microorganisms, meaning that they cannot be adequately treated using traditional biological methods. As a result, it is essential that novel technologies be developed to convert these molecules into less harmful or lower chain compounds that can be treated biologically. Chemical oxidation is a modern method for reducing the harmful effects of chemical oxidants (such H_2O_2, O_3, ClO_2, K_2MnO_4, K_2FeO_4, and others) by breaking them down into less dangerous components.**[21,22]**, figure 1 showed the advanced oxidation.

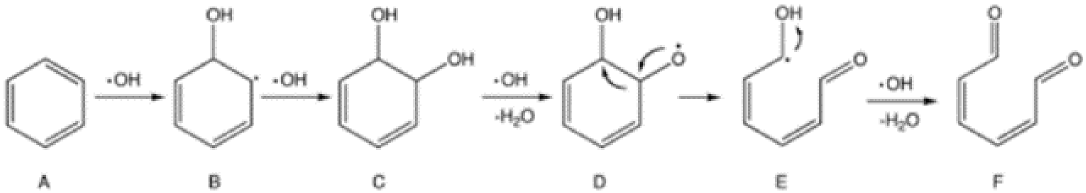

Fig. 1. The advanced oxidation process **[22]**

On the other hand, chemical oxidation methods employ oxidizing chemicals like ozone and hydrogen peroxide, and their rates of deterioration are far more manageable. As a result, researchers have developed advanced oxidation processes (AOPs) that utilize the high reactivity of hydroxyl radicals to promote oxidation as a potential strategy for treating wastewaters containing refractory organic compounds. Where these radicals originate is the primary distinction between procedures like Fenton, photo-Fenton, moist oxidation, zonation, and photo catalysis.
The main advanced oxidation process highlighted in this section, Fenton's chemistry, operates under ambient conditions (belonging to the class of AOPs).

3 – Fenton Process

The Fenton's process, shown in Figure 2, was initially described in 1894 after it was discovered that the oxidation of tartaric acid by hydrogen peroxide is much enhanced in the presence of ferrous ion. In certain academic works, the intricate mechanism of Fenton's process is described with a large number of equations. However, the steps can be summarized as follows: Acidic solutions containing ferrous iron and hydrogen peroxide produce hydroxyl radicals, which subsequently react with organic molecules already present in the solution.**[23]**

$$Fe^{2+}+H_2O_2 \rightarrow Fe^{3+}+HO^{-}+HO^{\bullet} \quad (1)$$

The following mechanism appears to be responsible for the regeneration of iron (II) as a catalyst:

$$Fe^{3+}+H_2O_2 \leftrightarrow Fe\text{-}OOH_2^{+}+H^{+} \quad (2)$$

$$Fe\text{-}OOH_2^{+} \rightarrow Fe^{2+}+HO_2^{\bullet} \quad (3)$$

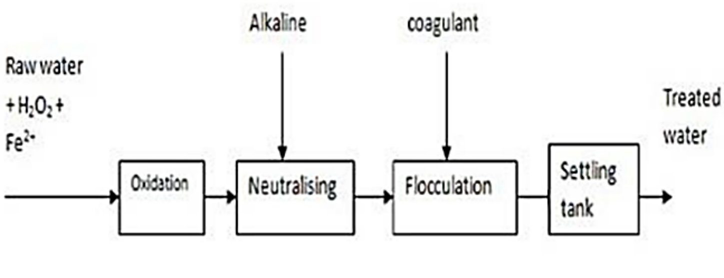

Fig. 2. Fenton Process **[23]**

A crucial part of the Fenton reaction's process is the creation of hydroxyl radicals and hydroxide anions as a result of a single electron transfer from Fe^{2+} to H_2O_2 in the outer sphere. Fluorine atoms and hydroxyl radicals are the two chemical species that are most oxidizing. They are very powerful species that can absorb one electron from any other species in the media or from an organic substrate that is rich in electrons to create a hydroxide anion.. At pH 0 and pH 14, respectively, the hydroxyl radical's oxidation potential has been calculated as +2.8 and +2.0V. Because of HO•'s high reactivity, a variety of organic compounds can be attacked by it. The Fenton reaction converts the carbons and heteroatoms of the organic substrate to inorganic species while also producing CO_2 and the accompanying oxygenated species, such as NO_x, SO_x, and PO_x, which are formed by the heteroatoms. The cyclic reactions of Fenton chemistry, which occur in air, can be mathematically represented.

$$RH + HO\bullet \rightarrow R\bullet + H_2O \quad (4)$$

$$R\bullet + Fe^{3+} \rightarrow R^+ + Fe^{2+} \quad (5)$$

$$R^+ + H_2O \rightarrow ROH + H^+ \quad (6)$$

$$R\bullet + Fe^{2+} \rightarrow \text{products} + Fe^{3+} \quad (7)$$

$$R\bullet + O_2 \rightarrow ROO\bullet \quad (8)$$

$$R\bullet + \bullet OOH \rightarrow RO\bullet + \bullet OH \quad (9)$$

$$ROO\bullet + RH \rightarrow ROOH + R\bullet \quad (10)$$

$$ROO\bullet + Fe^{2+} \rightarrow \text{products} + Fe^{3+} \quad (11)$$

$$ROO\bullet + Fe^{3+} \rightarrow \text{products} + Fe^{2+} \quad (12)$$

Operating pH, number of ferrous ions, hydrogen peroxide concentration, initial pollutant concentration, buffer type used to regulate pH, operating temperature, and chemical coagulation were utilized to determine the efficacy of applying Fenton oxidation to the treatment of wastewater. It's been established that a pH of 3 is ideal.. The efficiency of pollutant elimination increases when the dose of ferrous ions and hydrogen peroxide is raised. However, because to the risks to the environment and high costs of therapy associated with excessive doses, care should be used while deciding the dosage. The optimal dose must be established in comparable laboratory scale experiments or can be obtained in the open literature. **[23],[17]**

The traditional Fenton reaction, which generates high fluxes of hydroxyl radicals by combining hydrogen peroxide with an iron (II) salt, is a homogeneous catalytic reaction. As a result, issues like catalyst separation, regeneration, etc., that is common to homogeneous catalysis make the application of the traditional Fenton reaction difficult. Iron hydroxide must not precipitate, so pH must be carefully controlled. As a result, heterogeneous catalysts for the Fenton reaction have been created and evaluated using materials containing transition metal cations, especially iron ions. **[24]**

The Fenton process dramatically reduces hazardous and resistant chemical molecules while also improving the biodegradability of organic compounds. Following Fenton treatment, the leachate's quality can be markedly enhanced in terms of its level of organic matter, odor, and color. Leachate from the composting of various wastes has been treated and pre-treated quite successfully using Fenton's reagent. According to leachate characteristics and Fenton reagent dosages, reported final BOD_5/COD ratios can increase from initial values of less than 0.10 to values ranging from 0.14 to more than 0.60. The reported range of COD elimination efficiency is 45 to 85%. Leachate's color and smell can also be significantly diminished. In the Fenton treatment of a mature leachate, the decolorization efficiency can reach 92 percent **[25].**At $[Fe^{2+}]/[COD] = 0.1$, the ideal Fenton reaction conditions were discovered. Under these circumstances, there was a significant oxidation of both leachates, with a COD removal of 75-75% and a BOD_5 removal of 90-98%. It was discovered that Fenton's reagent oxidized leachate's preferably biodegradable organic matter. **[23]**

The capacity of EDTA, N-bis [2-(1,2-dicarboxyethoxy)ethyl]glycine (BCA5), and N-bis]2- (1,2-dicarboxyethoxy) ethyl]aspartic acid (BCA6) to breakdown complexing agents was investigated in bleaching wastewater. At a concentration of 76 mM, it was claimed that almost all of the EDTA had been removed.**[17]**

Due to its high COD value and low BOD 5 value, the wastewater from Paper Recycling Plants is considered to be environmentally harmful and intractable for biological treatment. Fenton Process is regarded as the most effective method for treating this wastewater. Studying the main factors influencing this oxidation, such as the doses of H_2O_2 and Fe^{2+} and the dosing strategy of H_2O_2 at a pH value of about 3, helped treat this water by oxidizing it with Fenton Fe^{2+} H_2O_2. The Fenton method demonstrated its efficacy by achieving a COD removal efficiency of 78.5 percent at a total peroxide dose of 2.2 g/l with a dosing strategy intermittently into four batches at 15-minute intervals. Additionally, it has been demonstrated through experimentation that intermittent dosing in four batches is superior to intermittent dosing in one batch in two aspects: the effectiveness of COD removal and the ratio of BOD 5 to COD. We achieved this ratio through intermittent dosing, which qualifies the water that has completed the oxidation process for biological treatment, at approximately 0.32. With the need to maintain chlorine mixing basins to ensure the absence of sediments that lower the sterilization process' efficiency, the four-stage system with twice as much recovery for water treatment helps to raise treatment efficiency to about 99 percent. **[26]**

3 – 1 – Advanced Fenton Process

The advanced Fenton process is a type of advanced chemical oxidation process that is used to break down complex organic compounds that are hard to biodegrade into simpler end products.
Advantages of using cutting-edge Fenton process technology

- Decomposition of organic substances
- toxicity reduction
- Better decomposition of complex compounds
- Remove color and odors

Starting with hydrogen peroxide and iron, the Advanced Fenton Process relies on the high reactivity of the hydroxyl radical to fulfill its goals under controlled temperature and temperature settings. In particular, hydroxyl radicals OH can be synthesized by reacting 35% hydrogen peroxide (H2O2) with ferrous sulfate (FeSO4) in an acidic environment (pH 2.5 - 3), with the acidity maintained by a dosage of sulfuric acid, and using the following equation::

$$Fe\ 2++H2O2 \rightarrow Fe\ 3++OH+OH^- \qquad (13)$$ **[7]**

According to chain processes, the OHO radical interacts in aqueous solution with the majority of aliphatic and aromatic compounds. This causes the CC bonds to break, which results in the degradation of pollutants. A retention period of around two hours is needed for this response. Hydrated lime or soda is introduced to the second tank, which also has a slow electric stirrer, to neutralize the drains and minimize the surplus of H_2O_2. A pH meter is used to measure the pH and adjust the amount of the reagent. A retention time of around an hour and a half is necessary during this second stage. **[27]**
The flocculation tank, a third step required by the Fenton reactor, is where the electrolytic dosage accelerates the separation of sludge flakes from the treated water. A minimum 15-minute contact time should be guaranteed by the flocculation tank. The water needs to be transported to a sedimentation tank after finishing Fenton's oxidative treatment in order to separate the cleared water from the sediment sludge. If it is essential to obtain a greater sludge density, a sludge thickening tank must also be provided because the sludge at this stage has a thickness of 1-2 %. The Fenton method, a biological treatment to remove nitrogen and phosphorous to improve water properties, was used to increase the effectiveness of water generated from some industrial and sewage treatment plants. Since it has been discovered that leaving nitrogen and phosphorous in waste water causes more environmental issues, especially when it is drained into drains, where it promotes the growth of a wide variety of plants, weeds, and fungi, reduces the amount of dissolved oxygen in the water, which kills fisheries, and causes the water to enter an anaerobic state, this method is particularly useful for industrial wastewater from carpet and textile factories.**[17,26]**

3 -2 - Typical reactor used for Fenton oxidation

A batch Fenton reactor consists of an unpressurized stirred reactor equipped with metering pumps for the addition of acid, base, a ferrous sulfate catalyst solution, and industrial grade (35-50 percent) hydrogen peroxide. The reactor vessel should be coated with an acid-resistant material to protect it from the Fenton reagent's severe abrasiveness and the potential for significant corrosion.. Bringing the pH of the solution up to 6 will prevent iron hydroxide from developing. Many organic contaminants have an optimum Fenton reaction pH of 3–4, and a catalyst to peroxide ratio of 1–5. Hydrogen peroxide is added last to an acidic solution after a pH adjusting agent has been introduced (the pH is adjusted to 3-4) and a diluted sulfuric acid catalyst has been added. The Fenton reactor (Oxidation tank) effluent is sent into the neutralizing tank for pH correction after passing through the stream, a flocculation tank, and a solid-liquid separation tank to remove the precipitate (adjustment of pH at 9). Schematic representation of Fenton oxidation procedure shown in Figure 3. **[16],[28]**

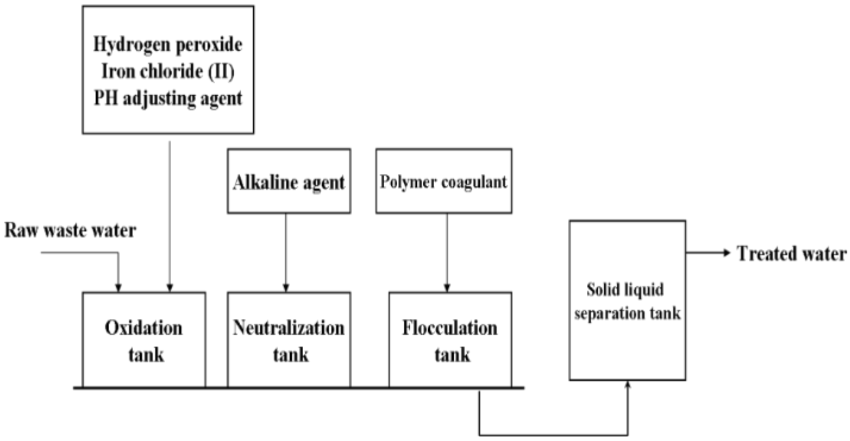

Fig. 3 Typical reactor used for Fenton oxidation. **[16]**

3 – 3 -Sono Fenton

The formation of iron oxide nanoparticles is consistent with the sonolysis or sono chemical approach, which makes use of the physical effects of ultrasound (US) and the sonic cavitation that is formed by it. Sonolysis offers an alternate method for producing iron oxide nanoparticles to utilizing high pressure, high temperature, and prolonged reactions; Fenton and sonolysis can be combined. These techniques take advantage of Fenton's reagent and ultrasound's advantages, which can accelerate the breakdown of organic contaminants. The recombination of hydroxyl radical's results in the production of hydrogen peroxide once more, however UV light treatment increases the quantity of hydroxyl radicals once more. By using sonolysis and photolysis, the intermediate complex that resulted from the interaction of Fe^{3+} with H_2O_2 during the Fenton reaction could be converted to Fe^{2+} **[28, 30]**, figure 4 illustrated mechanism schematic of sono/Fenton-like processes.

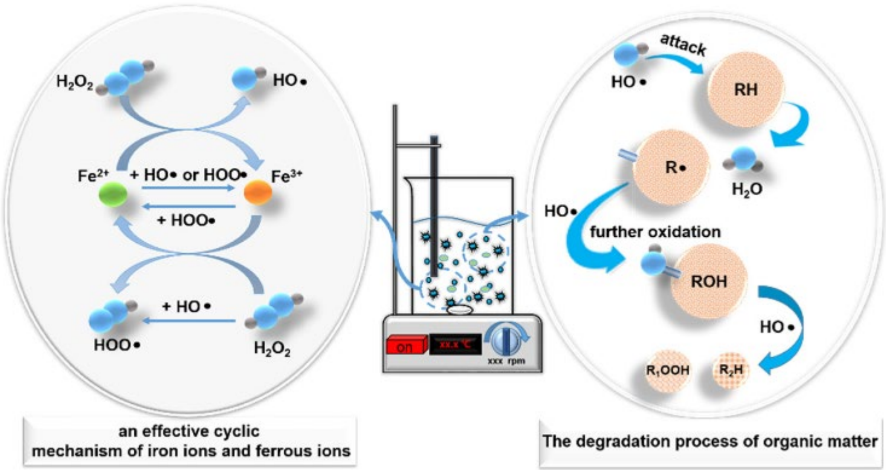

Fig.4. Mechanism schematic of sono/Fenton-like processes. **[28]**

3 – 4 -Electro Fenton

One of the effective and sustainable new methods for the treatment of wastewaters containing organic, particularly aromatic chemicals is electro Fenton. An innovative treatment technology for the treatment of wastewater and water is the electro-Fenton method. By using hydroxyl radicals to oxidase dangerous pollutants, Electro-Fenton is highly effective in treating stubborn substances that are difficult to break down in traditional water and wastewater treatment facilities. Additionally, the electro Fenton process uses a variety of electrolytic reactors, including double compartment cells, bubble reactors, filter press reactors, split double electrode electrochemical cells, and divided three electrode electrochemical cells **([29],[27]**. The Electro-Fenton Process' kinetic modeling was depicted in Figure 5.

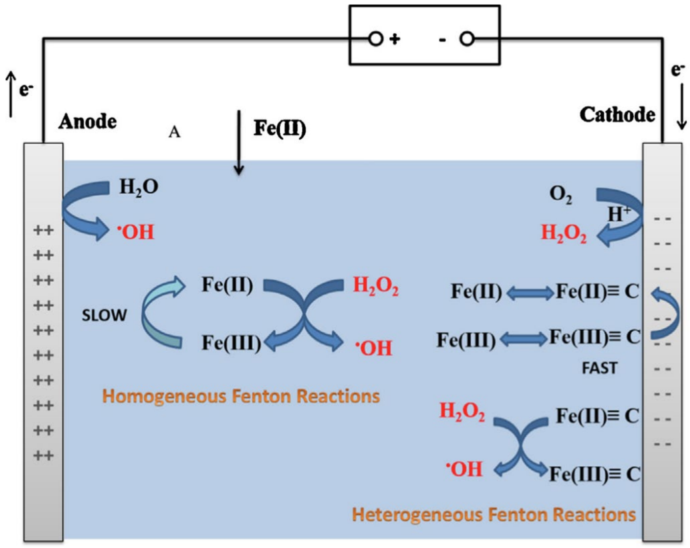

Fig. 5. The kinetic modeling of the Electro-Fenton Process [29]

4 - Biological Treatment Technology of Organic Wastewater

Biodegradation employs microorganisms, fungi, green plants, and their enzymes to remove or neutralize environmental pollutants. Biodegradation, which can occur naturally and is now used in wastewater treatment, is one environmentally benign and cost-effective solution to the problem of dirty water.. The organic components in wastewater have been removed using chemical, physical, and biological approaches, with the biological method receiving the most attention due to its superiority on both an economic and ecological level. The characteristics of the organic material have some bearing on the pace and degree of biodegradation. Some organic pollutants, such as organic matter and organic phosphorus insecticides, are readily accessible and simple to breakdown because of their relatively high water solubility and low acute toxicity**[30].** Drugs have greater bioaccumulation, biomagnification, and biotoxicity, and are slow to biodegrade in the natural environment compared to many POPs and xenobiotic organic pollutants.. Organic material can decompose either anaerobically (without oxygen) or aerobically (with oxygen). **[31]**

4 – 1 - Combination of the aerobic and anaerobic biodegradation

Organic pollutants are more effectively degraded by the anaerobic and aerobic reactor when they are combined than when they are done separately. Some advantages of the integrated system include the following:

(1) In some cases, the anaerobic process can decrease the organic load on aerobic degradation and the creation of aerobic sludge, get rid of the organic materials and suspended solid in wastewater, and cut down on the overall size of the reactors..

(2) Anaerobic pretreatment of wastewater results in more stable wastewater, which suggests that anaerobic procedure might lessen wastewater load variability and, as a result, lower the oxygen demand for aerobic degradation.
(3) The next aerobic process might be more effective by altering the biochemical characteristics of the wastewater through the anaerobic process. Investigations revealed that the wastewater produced by aerobic-anaerobic mixed reactors is more stable and prepared for degradation, demonstrating the enormous potential for use of this technology.
Traditional aerobic-anaerobic reactors include the oxidation ditch, A/O reactor, A2/O reactor, artificial wetland, and A/O reactor**;[32], [33].**

5 - The Cost Accounting of Different Organic Wastewater Treatment

The construction expense and the operating expense make up the two components of the cost of treating organic wastewater. The properties of the influent, the technique we used, the effluent's qualities, and the time spent treating them all, etc. all have an impact on the overall cost. Degradable and resistant pollutants are separated in this section.

5 – 1 - The degradable organic pollutants

Sewage from homes, industries dealing with food and livestock, etc. are common sources of wastewater containing organic pollutants that can be degraded. In a natural setting, the high BOD in this effluent may break down over time. Degradable organic contaminants can be remedied using a wide variety of methods, but biological treatments are favored because of their efficacy and practical advantages.[34]

5 – 2 - The reluctant organic pollutants

The paper industry, chemical industry, printing and dyeing wastewater, mechanical manufacturing industry, agriculture, pharmaceutical intermediates, pesticides, etc., are major contributors to the benzene series and other persistent organic pollutants. [35] Due to the fact that this wastewater is poisonous or too solid to break down naturally, its disposal costs are typically higher than those of degradable wastewater..
Some studies hypothesized that the cost may be decreased without compromising the effluent quality by combining the flocculation approach with other procedures, such as the Fenton biological process. In general, if the contaminants are biodegradable, the biological procedure is the least expensive of all the methods.
The wastewater might be disposed of using flocculation and adsorption procedures at a reasonable cost, but the flocculants and adsorbent need additional processing before being repurposed. Pollutants might be effectively removed through membrane separation and advanced oxidation, but they are expensive.

6- Conclusions

Several advancements in the Fenton process have been made in recent years, largely as a result of research efforts. Investigating hybrid approaches like photo-Fenton, electro-Fenton, and sono-Fenton is important for the Fenton process to be considered practicable for industrial treatment facilities. At the moment, regenerating Fenton sludge is crucial for continuing studies. In most cases, the Fenton process has been studied after thermal regeneration and acidic re-dissolution of iron-containing materials.
More research on the development of the Fenton process is necessary to show its economic and commercial feasibility. Because charcoal is so inexpensive, the Fenton process is one of the most cost-effective ways to treat industrial and sewage water over time. It is one of the most effective methods for eliminating chemical and biological pollutants that are resistant to decomposition and contributes to a roughly 99 percent treatment efficiency.

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