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# Advancement in Fenton Process (AOPs) for Wastewater- A review

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*Abstract*— **The development and application of several Advanced Oxidation Processes to destroy many biologically refractory organic contaminants in Industrial wastewater is now a days required. This may includes ozone oxidation method, membrane separation method, activated carbon adsorption method, Fenton oxidation method, etc. Among them, Fenton oxidation ($H_2O_2/Fe^{2+}$) method is considered to be one of the most effective, simple and economical method. This process has advantage of high efficiency but drawback is that it may produce large amount of iron sludge. Fenton oxidation process is used to produce ·OH (hydroxyl radical) and development is made to improved low-sludge wastewater advanced oxidation treatment technology.**

**The aim of paper is to introduce some new advanced technologies in Fenton Process such as Electro-Reduction Fenton Method, Fluidized Bed-Fenton Method.**

*Index Terms*— **Oxidation, Hydroxyl ions, Fenton, Electro-reduction, Fluidized bed.**

## I. INTRODUCTION

Industrial activities are a significant and growing cause of poor water quality. Industry and energy production use account for nearly 20 per cent of total global water withdrawals, and this water is typically returned to its source in a degraded condition.

While industrial production can affect water quality, industrial production can also be negatively impacted by poor water quality. Water is critical to many industrial processes, such as heating and cooling, generating steam, and cleaning, and as a constituent part of some products, such as beverages. Poor quality water may force an industrial facility to relocate, find a new source of water production, or it may decrease the quality of the product.

Much of industrial wastewater is discharged without treatment to open water courses, reducing the quality of larger volumes of water and sometimes infiltrating aquifers and contaminating groundwater resources. Worldwide, it is estimated that industry is responsible for dumping 300-400million tons of heavy metals, solvents, toxic sludge, and other waste into waters each year (UNEP, 2010). While significant progress has been made in many developed nations to reduce direct discharges of pollutants into water bodies, more than 70 per cent of industrial wastes in developing countries are dumped untreated into waters (UN-Water Statistics). Industrial pollutants often alter broad water quality characteristics, such as temperature, acidity, salinity, or turbidity of receiving waters, leading to altered eco systems and higher incidence of water-borne diseases.

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Impacts can be heightened by the synergistic combination of contaminants affecting species communities and structures, wildlife habitats, biodiversity, degradation of other environmental services, and in decreased productivity and simplification of tropic webs.

Industrial pollution is expected to increase in emerging market economies with economic and industrial development. Industries based on organic raw materials are the largest contributors of organic pollution, while oil, steel and mining industries represent the major risk for heavy metal release. Heavy metals from industrial discharges can accumulate in the tissues of humans and other organisms.(4)

Treatment methods vary with the wastewater characteristics. In economic point of view, the most economical and efficient methods are preferable compare to the other. Chemical methods, biological methods and physical methods are the general treatment that are being used and further investigations by researchers proves that chemical methods are the most efficient and economical compare to the other two methods.

The development and application of several Advanced Oxidation Processes (AOPs) to destroy toxic and biologically refractory organic contaminants in aqueous solutions concentrated significant research in the field of environmental engineering during the last decades.

Advanced Oxidative Degradation Processes (AOPs) comprise of techniques such that, under certain conditions, it could transform the vast majority of organic contaminants into carbon dioxide, water, and inorganic ions as a result of oxidation reactions.

Among the different AOPs, several researches have demonstrated that the electro-Fenton process and fluidized bed Fenton process are a technology which can give more better results also economical, efficient, and environmentally friendly to remove organic matter compared with conventional procedures. In electro-Fenton process process, the $H_2O_2$ is produced electrochemically via oxygen reduction on the cathode; then, the addition of ferrous ion into the system analogously generates the radicals in the classical Fenton's reaction. On the other hand, in this process, the ferrous ion is regenerated at the cathode, reducing its addition in comparison to the traditional Fenton's process.(1)

Fluidized-bed-Fenton method is a new technology which generated majority of ferric iron to crystallization or precipitation in fluidized-bed coated surface of Tam body of the plane.

## II. THEORETICAL CONTENTS

### *A. Fenton Process:*

Fenton process requires the usage of hydrogen peroxide ($H_2O_2$) as the oxidation agents. However, hydrogen peroxide alone is still not enough to conclude the reaction because of high concentration of certain refractory contaminants and the low rate of reactions at reasonable $H_2O_2$ concentration. Oxidation process that use $H_2O_2$ and metal salts are classically known as Fenton process. The reaction between $H_2O_2$ and iron salts it will results in the formation of hydroxyl radicals, HO•. This advances oxidation techniques [E. Neyens et. al., 2002] with the presence of HO•, will nonspecifically oxidize target compounds at high reaction rates. (2)

Typically a stirred batch reactor is used where the pH is controlled commonly within the 3–3.5 range. $Fe^{2+}$ is most frequently added as ferrous sulphate and $H_2O_2$ is usually fed as 35% aqueous solution. The process usually works at ambient temperature and pressure. The reactor vessel must be coated with an acid-resistant material, because corrosion can be a serious problem. Addition of reactants is performed in the following sequence:

Waste-water, followed by dilute sulphuric acid (for maintaining acidic conditions), the catalyst ($Fe^{2+}$ salt) in acidic solution, base or acid for pH adjustment and finally hydrogen peroxide.

The discharge from the Fenton reactor passes to a neutralization tank and after flocculants addition the Fe $(OH)_3$ and other accompanying solids are separated by settling. If necessary, a final sand-filtration stage can be used. (3)

### *B. Electro-reduction-Fenton method*

Electro-reduction-Fenton method is the use of electrolytic reduction method. $Fe^{3+}$ in the cathode is reduced to $Fe^{2+}$catalyst, required pH is adjusted. This is particularly suitable for treatment of high COD and hard biodegradable organic waste.

During the reaction process, $H_2O_2$ is added directly and continuously to electrolytic reduction cells which produced the electrolysis reaction of $Fe^{2+}$ for the oxidation of organic matter in waste water, while the $Fe^{3+}$ produced by the reaction can also directly reduced to $Fe^{2+}$ in the cathode and the steady flow of participation in response to so that the oxidation of $H_2O_2$ efficiency elevates, reducing the dose of $H_2O_2$ and reducing the operational costs. In addition, the anode electrodes may also remove part of the organic matter. Reaction after the completion of $Fe^{2+}$ and $Fe^{3+}$ mixed solution can be used as an iron-based coagulant.

The electro-reduction-Fenton method of waste water treatment effect is usually better than Fenton method for high concentration of COD of waste water (COD> 1000mg / L), this may be due to post-Fenton Oxidation of organic intermediates segment which is more than a simple organic acids (such as the acetic acid, oxalic acid, formic acid),·OH (hydroxyl radical) that has lower reaction rate to molecular state of these organic acids, especially when there is water, inorganic ions (such as Cl-, $HCO_3^-$), the inorganic ions will be in competition with ·OH (hydroxyl radical), which lowers the COD removal rate.(5)

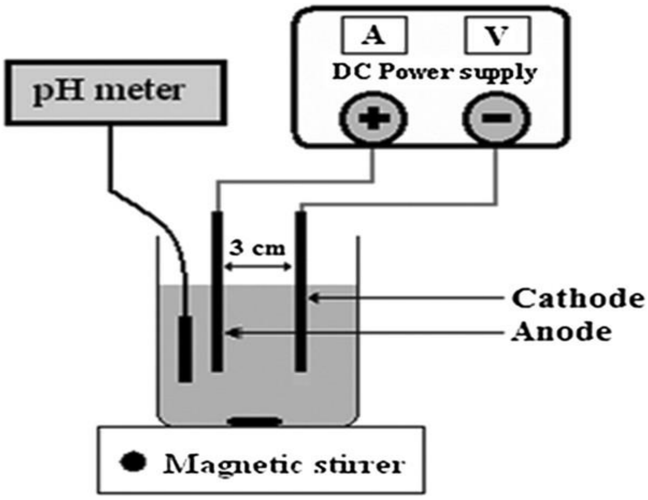


**Fig no.1 :- Experimental setup for Electro reduction Fenton method**

The experimental set-up used in the study is presented in Fig 1. Experimental studies were performed in a glass-made reactor, equipped with a cathode and anode, both of which made of iron and installed in parallel. Distance between the electrodes was 3.0 cm. Electrodes were plunged into the beaker containing of samples of wastewater. The electrodes were connected to a DC power supply. The experiments were carried out at room temperature. As the optimal pH value recognized for the Fenton oxidation is around 3, the initial pH of the solution was adjusted to 3. Then in each run of the experiments, hydrogen peroxide in different concentrations was applied drop wise with the electrical currents of different mA for each of the concentrations. Samples were taken in each reaction time as the process was terminated by turning the DC power supply off. (6)

### *C. 3. Fluidized Bed-Fenton method*

Fluidized-bed-Fenton method is a new technology which generated majority of ferric iron to crystallization or precipitation in fluidized-bed coated surface of Tam body of the plane is a combination of chemical oxidation (Fenton method).

The schematic fig 2 of this method is as shown below.

A fluidized-bed reactor is a cylinder vessel which consists of the outlet and inlet.At the beginning, adjusted pH of sample after that, a calculated amount of ferrous sulfate was added in the wastewater. Hydrogen peroxide was finally added and the reaction was simultaneously started.

This technology outshines the traditional Fenton oxidation method significantly. It can reduce a large number of chemical sludge productions of Fenton method as Tam body formed on the surface of ironoxide has the effect of heterogeneous catalysis, and while the fluidized bed method also facilitated the chemical oxidation reaction, mass transfer efficiency, and enhance the COD removal rate.(5)

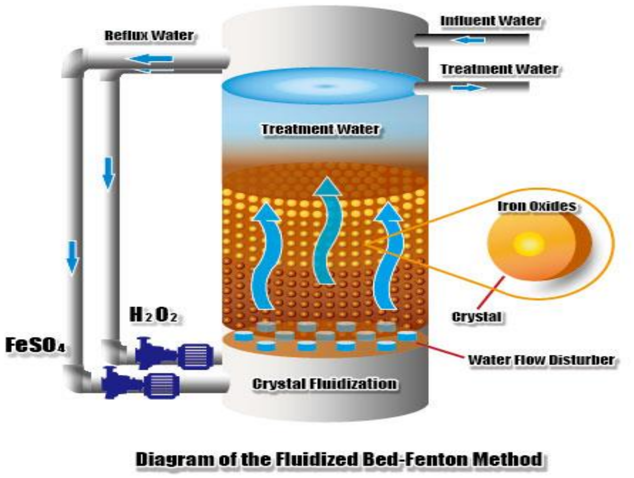


**Fig no.2:- Experimental setup for Fluidized Bed-Fenton method**

**Comparison of characteristics of Fenton Method with Electro reduction Fenton Method and Fluidized Bed Fenton Method:**

| Name of technology | Applicable COD(mg/lit) | Technology character |
|---|---|---|
| Traditional Fenton method | 50-1000 | Much iron sludge, easily to be disturbed by the pollutant. |
| Electrolytic-Fenton method | 1000-50000 | Electro-reduction Fe to reuse iron, reducing 80% of iron sludge |
| Fluidized bed -Fenton method | 50-1000 | Reducing 70% of iron sludge. |

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## III. Application:

Fenton technologies can be applied to numerous industries such as:

1. Waste water in petrochemical industry: mainly used in biological pre-treatment.
2. Waste water in chemical industry: it can be used for all kinds of stream having high COD,Wastewater containing color.
3. Waste water in man-made fibers, textile wastes: can be used in biological pre-treatment and biological treatment of water quality checks, effluents is up to standard.
4. Waste water in dyeing and finishing industry: mainly used for biological treatment of the color, Foam and COD removal.
5. Waste water in the printed circuit board (PCB) industry: it can be used for all kinds of stream of high COD wastewater such as cleaning agents.
6. Waste water in papermaking: mainly used for biological treatment of color and COD removal.
7. Waste water in synthetic resin industry: mainly used for biological treatment of water quality checks.
8. Waste water in pharmaceuticals, leather industry: it used in biological pre-treatment.(5)

## IV. Conclusion

The application of Fenton Method which applies the electrolytic reduction-Fenton method for high concentrations of bio-refractory wastewater (COD> 1000mg / L) treatment. It can be used as biological pre-treatment to improve water quality, and enhance the follow-up bio - processing capacity.

Fluidized bed-Fenton method is also applicable for low concentrations of biological decomposition of waste water (COD <1000mg / L) are generally used for (COD <500mg / L) treatment. It can be used for biological post-treatment to enhance and release stream, which ensures the quality of the discharge water quality.

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