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Electro chemical process for effective treatment of Hospital waste water

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ABSTRACT

Advanced Oxidation processes are used to oxidize complex organic constituents found in wastewaters that are difficult to degrade biologically into simpler end products. Fenton and Electro Fenton (Chemical) both processes are classified under advanced oxidation process (AOP). The classical Fenton reagent, consisting of the reactions between homogeneous Fe^{+2} catalysts and hydrogen peroxide (H_2O_2), which is highly efficient for the reduction of COD due to the hydroxyl radicals generated by the Fenton reactions. AOP is waste water treatment technique in which highly oxidation agents used to oxidize the pollutants in wastewater. Advanced Oxidation Processes (AOP) is considered as best possible methods of clean and ecologically safe remedial treatment for the degradation of organics by using ozone, H_2O_2, ultrasound (US), ultraviolet radiation (UV), Fenton's reagent ($Fe^{+2}H_2O_2$) alone or in combination. Fenton's Reagent is used to treat a variety of industrial wastes like dye stuffs, pesticides, wood preservatives, plastics additives, and rubber chemicals. The effect of operating parameters such as concentration, initial effluent pH and Fe^{+2} concentrations on Fenton system for the percentage color and chemical oxygen demand removal has been studied. The energy was also calculated for per order in the advanced oxidation process. Some metals have a special oxygen transfer property which helps in improving the utility of hydrogen peroxide. The most common metal of these is iron which, when used in the prescribed manner, results in the generation of highly reactive hydroxyl radicals (OH).

Key words : *Hospital wastewater, Advanced oxygen process, Fenton reagent, Hydrogen peroxide*

Introduction

Major concern with the hospital wastewater is that, it is been discharged into the sewage network without any primary treatment or there is no any conventional wastewater treatment facility provided for the treatment of collected wastewater is not able to meet Wastewater originate from domestic, industrial, commercial, agriculture activity may create threat to human life. Waste water generated from the Municipal and hospital and from other domestic usually conveyed in combined sewer or sanitary landfill and treated at wastewater treatment plant. This type of human activity may create heavy load to the wastewater treatment units. Waste which generated contains toxic pollutants, metal oxides, hazardous liquid waste from various units, pharmaceuticals, radioactive waste, bacteria, viruses, blood, and fluid which has high BOD and COD are due to presence of solids and bacteria in it and think if not treated properly, it may create threat to human life as well as environment. So there is necessity to treat wastewater before discharge in to natural stream.

Sources of the hospital waste

- Drug treatments.
- Surgery.
- Radiology.

- Operation room.
- Chemical and biological laboratories.
- Medical services.

Environmental and Health Risk

- Waste generated from hospital contains infectious, pathogens, biodegradable and radioactive contaminants that cause pollution and health related problems.
- It also contains harmful pollutant, such as: pathogenic microorganisms (bacteria, viruses), residual of medicine and laboratory chemicals (antibiotics, phenol and chloroform) and biodegradable organic material (protein, fat, carbohydrate).
- Contaminants can easily reach the water resources causing environmental aquatic pollution and human health problems.
- Hazardous from hospital waste like pathological, radioactive, chemical, infectious and pharmaceutical wastes, if left untreated, lead to outbreaks of communicable diseases, water contamination and radioactive pollution.

Hospital Waste as Toxicity to Sewer Networks

- Main environmental problems concerning hospital waste effluents are its discharge into the urban sewer network without any preliminary treatment.
- Need for hospitals treatments use a variety of chemical substances such as pharmaceuticals, radionuclide, solvents and disinfectants for medical purposes as diagnostics, disinfection and research.
- After treatment or application some of these substances and excreted non-metabolized drugs by the patients enter into the hospital waste streams which are finally conducted into the municipal sewer network without treatment.
- Expired medicines and unused medications sometimes are also disposed into the hospital drains.
- So the hospitals may represent an incontestable release source of many toxic substances in the aquatic environment destroying the diversity of the system.
- Hospital waste has Significant concentrations of COD: 1900 mg/L, BOD: 700 mg/L are measured in the hospital effluent. As we can compare to urban domestic effluent, hospital waste effluent are more polluted and toxic.

The factors due to this Electrochemical Process becomes popular are follows

- Low cost.
- Easy in operation
- Low sludge production
- Low operational and maintenance cost.
- High efficiency
- Less chemical consumption
- Good settling capacity of sludge
- Less time consumption.
- There no gaseous or residue releases from treatment.
- There is not addition of catalyst.

Fenton's reagents (Fenton's process) cause the formation of reactive hydroxyl radicals that destroy organic pollutants to harmless compounds.

Fenton Chemistry

Fenton's reagent (hydrogen peroxide in the presence of a ferrous salt) based oxidation system has been used for the treatment of both organic and inorganic substances under laboratory conditions as wells real effluents from different areas like chemical manufacturers, refinery and fuel terminals, engine and metal cleaning etc. The formation of reactive oxidizing species, able to efficiently degrade the pollutants of the wastewater stream but the nature of these species and its formulation is a subject of controversy. At this stage that both hydroxyl as well as ferryl complexes co-exist in Fenton's mechanism and depending on the operating conditions, one of them will predominate.

A. Fenton's Process

Treatment of waste water by Fenton process the main chemical used is hydrogen peroxide (H_2O_2). Due to the Hydrogen peroxide (H_2O_2) is a strong oxidant and its application in the treatment of various inorganic and organic pollutants is well established. For some cases H_2O_2 not effective for high concentrations of certain refractory contaminants because of low rates of reaction at reasonable H_2O_2 concentrations. So for such cases improvements can be achieved by using transition metal salts (e.g. iron salts) which are strong oxidants that is the Fenton's process. By using iron salts oxidation processes utilizing activation of H_2O_2 and classically referred to as Fenton reagent is known to be very effective in the destruction of many hazardous organic pollut-

ants in water. Iron salt to catalyse Fenton process aid as the coagulant for coagulation process so known as reducing agent.

Iron and hydrogen peroxide are two major chemicals determining operation costs as well as efficiency for Fenton AOP. Reaction time for Fenton AOP is short comparing with other and it has other important advantages. There are two major chemicals Iron and H_2O_2 are cheap and non-toxic, there is no mass transfer limitation due to its homogenous catalytic nature, there is no energy involved as catalyst and the process are easy to operate and control.

This is the most important and promising method of AOPs in terms of cost effectiveness and ease of operation. This is also effective method in the removal of many hazardous organic pollutants from wastewaters and can also be an effective pre treatment step by transforming constituents to by-products that are more readily biodegradable and reducing overall toxicity to microorganisms in the downstream biological treatment processes.

Hydrogen Peroxide (H_2O_2)

This is the strong oxidant and its application in the treatment of various inorganic and organic pollutants is well established. H_2O_2 consist of two hydrogen molecules and two oxygen molecules.

Fenton's Reagents (Fe salt/ $FeSO_4$ Solution)

Metal salts (e.g. iron salts) which are strong oxidants that is the Fenton's process. Fe^{+3} and Fe^{+2} are used to

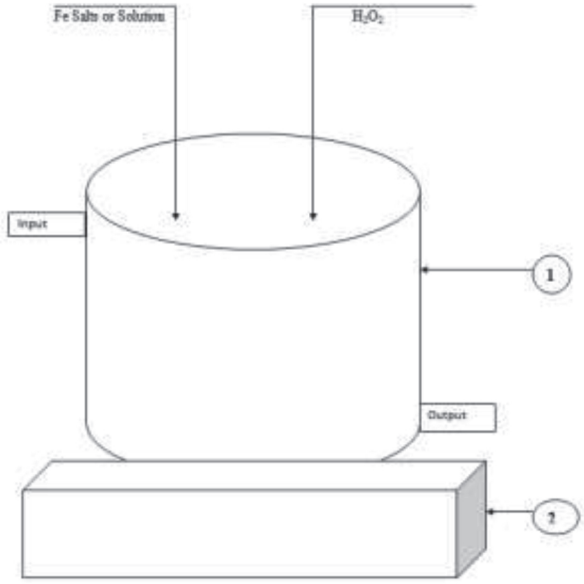

Fig. 1. Schematic diagram for Fenton Process

oxidation of H_2O_2 which decompose or cause of degradation of waste water. The amount of this Fenton reagent is based on the amount used of H_2O_2.

Acid or Alkali

H_2SO_4 acid or NaOH alkali to be used for pH maintain of waste water. The optimum value of pH is necessary for the Fenton process.

Reaction Mechanism Fenton Process

The reactions of Fenton reagent and oxidizing agent H_2O_2 and the generation of hydroxyl radicals are as following.

$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^{\bullet} + OH^-$ (chain initiation) (1)

$OH^{\bullet} + Fe^{2+} \rightarrow OH^- + Fe^{3+}$ (chain termination) (2)

As per reaction (1) and (2) the ferrous iron (Fe^{2+}) starts the reaction and catalyses the decomposition of H_2O_2 in hydroxyl radicals and newly formed ferric ions (Fe^{3+}) may decomposes H_2O_2 in water and oxygen by forming ferrous ions and radicals.

$Fe^{3+} + H_2O_2 \rightarrow FeOOH^{2+} + H^+$ (3)

$Fe\ OOH^{2+} \rightarrow HO^{2\bullet} + Fe^{2+}$ (4)

All of above reactions are the Fenton process which carried out step by step.

$HO^{\bullet} + RH \quad H_2O + R^{\bullet}$

$R^{\bullet} + Fe^{3+} \quad R+ + Fe^{2+}$

The organics get oxidized by hydroxyl radical proton abstraction ending with the formation of organic radical (R•).

Effects of various parameters on the Fenton Oxidation Process

- Mass Ratio & Dosage of $H_2O_2/Fe2^+$
- Iron type (Ferrous $Fe2^+$ – Ferric $Fe3^+$)
- Temperature
- pH
- Reaction Time
- Adding chemicals in steps
- The Reaction is followed by neutralization
- Characteristic of Wastewater treated

Electrochemical Technology (Electro-fenton Process)

In recent year the AOPs are most widely used techniques for the waste water treatment process and the development of the AOPs the new research

study has been developed combined with the AOPs with the Electrical and Chemical treatment process that is called as Electrochemical Technology. Electrochemical reactions include in Electro-Fenton methods situ generation of their agents used for the Fenton reaction and generated reagents depend on solution conditions, cell potential and nature of electrodes. Production of Ferrous ions oxidative dissolution of anodes such as iron metal or by reduction of ferric ions at an inert cathode such as platinum and H_2O_2 may be produced by dioxide reduction at the cathode.

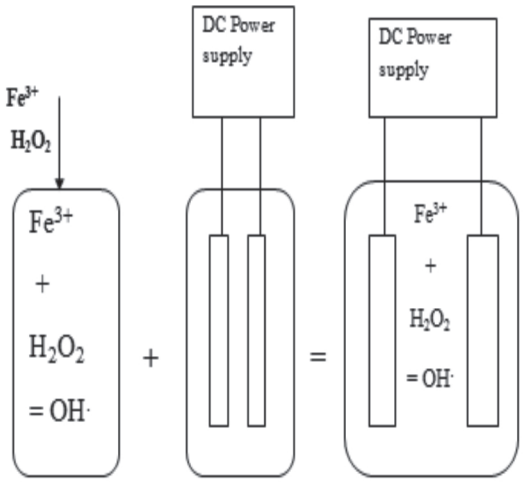

Fig. 2. Electro Chemical Process

Advanced oxidation process used in wastewater treatment technology which is Electro Fenton process. Electro Fenton Process consists of electrolysis cell that reform Fenton reagent by electro chemical reaction between anode and cathode. In this electrochemical reaction which is combination of two reaction Fenton reaction and electrochemical oxidation (EO) and the reaction works in single reaction chamber. EO is electrochemical reaction as Fenton is a chemical reaction who oxidizes the pollutant by electrochemical process.

Various parts of Electro Fenton process

- Electrolysis cell
- DC power supply
- Magnetic stirrer if required
- Electrodes

Anode Reaction

$Fe^{+3} + e^- = Fe^{+2}$

Cathode reaction

$O_2 + 2H^+ + 2e^- = H_2O_2$

Compared to the classical Fenton process the main advantages of the EF process

- Controlled generation of Fenton's reagent (cost effectiveness)
- Avoiding thus the risks related to transport, storage and handling of H_2O_2
- Elimination of parasitic reactions that wasting OH (very low Fenton's reagent concentration)
- Total master ship of the processing by current or potential control
- Possibility of controlling the degradation kinetics and performing mechanistic studies
- Almost total mineralization of organics including the intermediates.

Electro-Fenton method is used for

- removal of many kinds of recalcitrant pollutants
- treatment of landfill leach ate
- phenol degradation
- Reduction of Turbidity, BOD, COD from various types of wastewater.

A. Advantages of Electro Fenton Process

- Main advantage of this process is environmental compatibility.
- Clean reagent are used
- Can control various parameters like COD, BOD, TDS, Turbidity, Color removal etc.
- Less Effluent produced
- Wastewater can be reuse for process.
- Cost of reagents are lower
- This treatment process can be used at ambient temperature.
- Complete mineralization of organic matter
- Very effective at removing resistant organic compounds
- Produce less harmful by-products
- Less maintenance required

B. Applications of Electro Fenton Process

- Water Reclaim Process of various types of waste water
- Chemical Industry
- Pharmaceutical Industry
- Pulp and Paper Industry
- Textile Industry
- Food Industry
- Landfill Leachates
- Biomedical Application
- Dye-Process Industrial Waste
- Pre-treatment to wastewater, sludge, or contaminated soil
- Organic pollutant destruction

Table 1. Result Analysis Effect of 6 V Dc Current On Waste Water

Time Min	Current (Voltage)	% COD Reduction	% SS Reduction	% TDS Removal
30	6	24	18	20
45	6	32	22	24
60	6	42	30	32
75	6	52	38	40
90	6	60	48	52
105	6	69	58	66

Table 2. Result analysis effect of 12 V Dc current on waste water

Time min	Current (Voltage)	% COD Reduction	% SS Reduction	% TDS Removal
30	6	24	18	20
45	6	32	22	24
60	6	42	30	32
75	6	52	38	40
90	6	60	48	52
105	6	69	58	66

- Toxicity reduction
- Biodegradability improvement
- BOD / COD removal
- Odor and color removal

C. Disadvantages of Electro Fenton Process

- The reactions are efficient at low pH-levels (<6) -which is difficult to maintain.
- In some cases chemical oxidation may even lead to increased toxicity due to the formation of even more toxic oxidation by-products.

Results Analysis

Experiment at current intensity or voltage 6 Volts DC (0.5 amp)-After collecting the samples of waste water and giving treatment from all the three methods for every 15 minutes interval following are results obtained for all the parameters values.

Experiment at current intensity or voltage 12 Volts DC (1 amp)-After collecting the samples of waste water and giving treatment from all the three methods for every 15 minutes interval following are results obtained for all the parameters values.

Conclusion

- There is complete mineralization of organic matter.
- There is no need for any processing units on the surface.
- This process reduces organic loading and done the removal of recalcitrant and toxic pollutants thus allowing for further conventional biological treatment.
- Electro Fenton process is a relatively economical method other AOPs and both iron and hydrogen peroxide are relatively cheap and safe.
- The reactions of this process are more efficient at low pH-levels (<6) - which is difficult to maintain.
- In some cases chemical oxidation may even lead to increased toxicity due to the formation of even more toxic oxidation by-products.
- Electro Fenton Process for waste water treatment shows better results over the conventional method.
- Electro Fenton process can be used as a tertiary treatment to waste water.
- The other parameters such as TDS, COD, BOD shows effective changes over conventional method.
- Waste water samples are collected from industry after giving primary and secondary treatment and Photo Fenton process with any convectional method gives better results.

Future Scope

Electro chemical can be adopted to treat waste water.

- To improve the efficiency of conventional method.
- Electro chemical can be used as an additional treatment to treat waste water.
- Electro chemical process can make waste water for reusable.

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