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Hospital Waste Water Treatment By Electro Chemical Process

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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 reaction is commonly used method in waste water treatment. The classical Fenton reagent, consisting of the reactions between homogeneous Fe+2 catalysts and hydrogen peroxide (H2O2), is highly efficient for the reduction of COD due to the hydroxyl radicals generated by the Fenton reactions. Fenton and Electro Fenton(Chemical) both processes are classified under advanced oxidation process (AOP). AOP is wastewater treatment technique in which highly oxidation agents used to oxidize the pollutants in wastewater. Advanced Oxidation Processes (AOP) using ozone, H_2O_2, ultrasound (US), ultraviolet radiation (UV), Fenton's reagent (FeII+H_2O_2) alone or in combination involving hydroxyl radicals are considered as possible methods of clean and ecologically safe remedial treatment for the degradation of organics. The treatment of distillery effluent was investigated experimentally by various advanced oxidation processes such as Fenton and ozone with different combination of UV and H_2O_2 system.
Fenton's Reagent is used to treat a variety of industrial wastes containing a range of toxic organic compounds dyestuffs, pesticides, wood preservatives, plastics additives, and rubber chemicals. Fenton reaction is commonly used method in waste water treatment. The classical Fenton reagent, consisting of the reactions between homogeneous Fe+2 catalysts and hydrogen peroxide (H_2O_2), is highly efficient for the reduction of COD due to the hydroxyl radicals generated by the Fenton reactions. The effect of operating parameters such as hydrogen peroxide 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 per order was also calculated for the advanced oxidation process. AOP promising future for the treatment of wastewater containing organic compounds those are not easily removable. All AOPs are designed to produce hydroxyl radicals. It is the hydroxyl radical that reacts to disintegrate organic compounds. AOP combine ozone, UV, hydrogen peroxide and/or catalyst to offer effective wastewater treatment solution for the reduction and/or removal of residual organic compounds that are measured by COD, BOD.Fenton process is an advanced oxidation process that uses the ferrous ion and hydrogen peroxide. Many metals have special oxygen transfer properties which improve the utility of hydrogen peroxide. The most common of these is iron which, when used in the prescribed manner, results in the generation of highly reactive hydroxyl radicals (OH). The reactivity of this system was first observed in 1894 by its inventor H.J.H. Fenton. Fenton's reagent is the result of reaction between hydrogen peroxide (H_2O_2) and ferrous iron (Fe2+), producing the hydroxyl radical (OH). The hydroxyl radical is a strong oxidant capable of oxidizing various organic compounds

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Keywords
Hospital wastewater, Electrocoagulation, RSM, Optimization.

1. 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 which generated from the Municipal and hospital 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 from the contains solids, 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 bacterial 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.
- Laundry.
- Chemical and biological laboratories.
- Medical services.
- Research activities.

2. ENVIRONMENTAL & 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.
- It proves that the waste generated from dangerous to the ecological balance and public health.
- 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.

3. HOSPITAL WASTE AS TOXICITY TO SEWER NETWORKST

- 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.
- The presence of chlorinated molecules in high concentrations and presence of heavy metals like mercury and silver has very toxic in nature.
- 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.
- Low chemical consumption.
- Good settling capacity of sludge.
- Low time consumption.
- There no gaseous or residue releases from treatment.
- There is not addition of catalyst.

Fenton's reagents (Fenton's process) cause the dissociation of the oxidant and the formation of reactive hydroxyl radicals that destroy organic pollutants to harmless compounds (CO_2, water and inorganic salts).

4. 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 resources 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.

Presence of additional oxidant species using analysis of product distribution, EPR-spin trapping techniques and effect of added substrates as mentioned earlier. 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.

4.1 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 pollutants in water. Iron salt to catalyze Fenton process and aid as the coagulant for coagulation process and also 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 H2O2 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 is easily to run 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. Fenton's reagents (Fenton's process) cause the dissociation of the oxidant and the formation of reactive hydroxyl radicals that destroy organic pollutants to harmless compounds.

4.1.1 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.

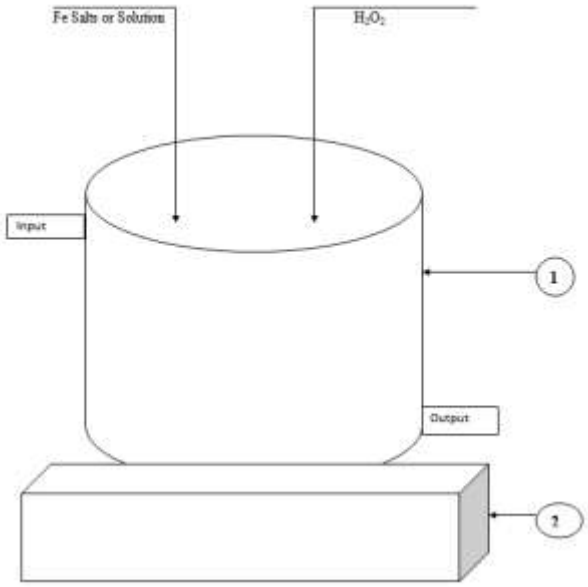

Fig.1 Schematic digram for Fenton Process

4.1.2 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 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.

4.1.3 Acid or Alkali

H2SO4 acid or NaOH alkali to be used for Ph maintain of waste water. The optimum Value of pH necessary for the Fenton process.

4.1.4 Reaction Mechanism Fenton Process

The reaction of Fenton reagent and oxidizing agent H_2O_2.The generation of hydroxyl radicals following the chain reaction.

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

$OH^{\bullet} + Fe_2^{+} \longrightarrow OH^{-} + Fe^{3+}$ (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 decompose hydrogen peroxide in water and oxygen (forming ferrous ions and radicals)

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

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

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

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

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

The organics (RH) are oxidized by hydroxyl radicals proton abstraction ending with the production of organics radicals (R•).

Effects of various parameters on the Fenton Oxidation Process

- Mass Ratio & Dosage of H2O2/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.

5.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 dioxygen reduction at the cathode.

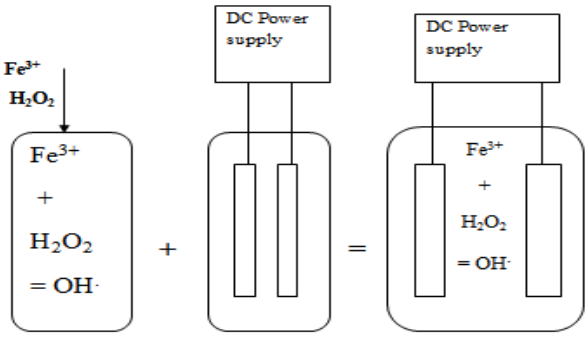

Fig. 2 Electrochemical Process

Advanced oxidation process used in wastewater treatment technology which is Electro Fenton process. This process is modification of conventional Fenton process. It consists of electrolysis cell that regenerates Fenton reagent by electrochemical 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

$O2 + 2H^{+} + 2e^{-} = H_2O_2$

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 H2O2
- 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

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

5.1 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

5.2 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
- Toxicity reduction
- Biodegradability improvement
- BOD / COD removal
- Odor and color removal

5.3 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.

6. 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.

Table No. 1 Results 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

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.

Table.2 Results Analysis Effect of 12 V DC current on waste water

Time Min	Current (Voltage)	% COD Reduction	% SS Reduction	% TDS Removal
30	12	32	24	28
45	12	42	34	38
60	12	58	46	50
75	12	68	60	64
90	12	72	66	68
105	12	84	74	78
120	12	96	88	92

CONCLUSION

- There is complete mineralization of organic matter.
- There is no need for any processing units on the surface.
- This process reduces organic loading in terms of chemical oxygen demand 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 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.
- 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.

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