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Electrochemical Waste Water Treatment

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Abstract - *Wastewater got much of our intention these days because wastewater is polluting our lakes, pounds and even sea have a lot of contaminated amount of waste. This water is hazardous for the acute life, dangerous for living things. Wastewater polluted the natural reservoirs. Over the past, the knowledge of the mechanisms of electrochemical wastewater treatment has progressively evolved. A comprehensive understanding of the types of methods and mechanisms of treatment of wastewater is a prerequisite to the understanding of their relativities and elucidation of intermediate products generated during the oxidation process and degradation pathways. The type, nature, and quantity of reactive species generated in electrochemical treatment processes are controlled by many factors, including the type of the treatment technique, electrode/electro catalyst materials, water/wastewater composition, water pH conditions, and operating parameters are to be considered. Multiple methods such as separation, conversion and combined methods are used for treatment. However, basic principle works on the electrochemical mechanism. This article gives the basic idea of electrochemical methods working principles, techniques being considered. It will also help us understand the byproducts recovery of different metal ions and how they converted into useful form. Best methods based on the efficiency and economic value. Feasibility of long term and short term methods for the treatment of wastewater.*

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1. Introduction

With the increase industrialization in the era waste water is increasing day by day. Resulting in the reduction of the clean water. Our society is facing adverse effects, these effects are equally faced by the humans as well as other species on the earth. The need of hour is to overcome the difficulty. For that a lot of efforts were made in past. But these efforts cannot resolve our problems now. For that we are moving from conventional waste water treatment to advance waste water treatments [1].

Electrochemical methods are widely used for the treatment of the domestic waste water as well as for the industrial waste water. These methods are used only if the pretreatment of the wastewater is done. These methods cannot treat waste having large particles like physical objects. Disinfection, removal of pollutants, harmful ions, heavy metals are the main concerns of removal in the electrochemical waste water treatment methods[2]. Another method advantage of this, we can extract heavy metals form the waste water. There are several techniques for accomplishment of the task of removal of biochemical oxygen demand (BOD) and Total Suspended Solids (TSS) in the waste water[3]. We will be discussing the conversion methods, separation methods and combination of these methods to achieve our goals.

2. Separation Methods

2.1 Electrodeionzation EDI

This method is used for high purity of water. It's mainly use semipermeable membranes and ion exchange method for the purification. EDI have special semipermeable membranes that allows specifically charged ions to pass through. [4]

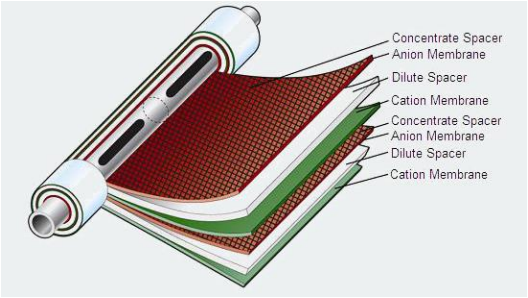

Figure 1. EDI [4]

2.1.1 Working Principle

It simply works on the ion exchange method. It has an anionic membrane and a cationic membrane. Water cannot pass through the membranes, only ions can pass through it. These ions are captured in the specific compartments. They cannot reach the electrode.

2.1.2 Applications

This method is suitable for the economic and continuous removal of impurities. This uses no chemical substances for purification. Reuse of residual water and chemical production.

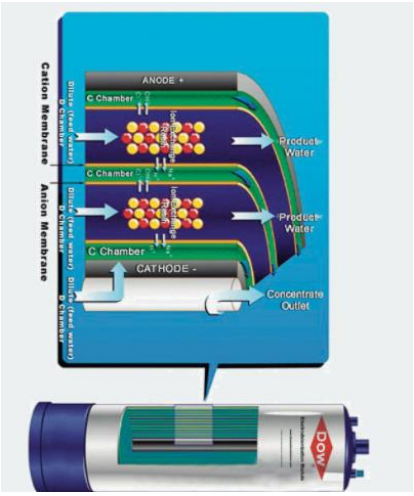

Figure 2. EDI [4]

2.2 Capacitive Deionization (CDI)

It's the latest technique used for the purification of saline water and brackish desalination. It uses direct current DC power source. When current passes through saline water ions are absorbed at cathode and anode. After that ions are de-absorbed form electrodes. So it works on the absorption and de-absorption principle for the purification of water. It is most feasible in case of energy consumption, high purity rates, however its commercial use-age is limited due to its electrodes. They are made of mossad and Zou, porous electrodes used typically for CDI.[5]

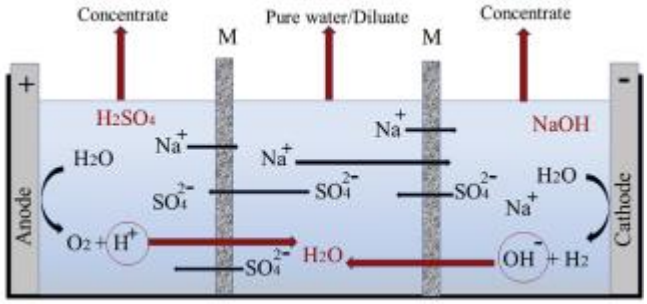

Figure 3. CDI [5]

2.3 Electro flotation

It is gravity separation process, it's the cost efficient process for the separation of many inorganic as well as metals. It is used throughout the world. Removal of hydrophobic ions from the solution.[6] Today it is widely used for the collection of particulate metals from the waste of industries.

2.4 Electro Dialysis

This method we use ion exchange membrane for the separation of electrolytes form the water. A constant source of DC is required for the fulfillment of the task. It works on the principle of potential gradient method. It also helps us to select the ions that we wanted to pass through the membranes.

Ion exchange membranes are of two types based on the function and the purpose of usage. One is the anion exchange membrane and the other is cation exchange membrane. Cation membranes have negatively charged ions like SO3-,COO- , anion have positive charge such as NH3+, ...[7].

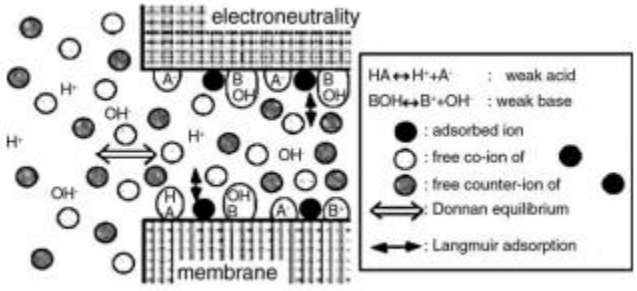

Figure 4. Electrodialysis [7]

2.4.1 Advanced Amphoteric membranes

These membranes are future, having the feature of control over PH of the outer solution and potential of fouling materials such as organic as well inorganic to stick on the surface.[8]

2.5 Electro Deposition

It's an economical and a feasible approach used for the treatment of wastewater. It's widely used for the treatment of water having Ag, Cu and COD. Its works on the oxidation mechanism. We introduce the electrodes in the in the presence of electrolyte. Pass the DC though it I will

automatically started to deposit on the electrodes. First of it is treated with the choline for the removal of Ag, next step is to deposit Cu and finally oxidized to remove COD.[9]

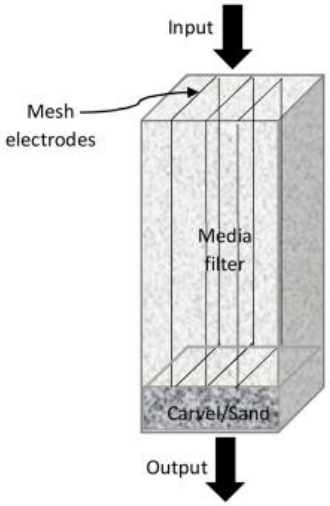

Figure 5. Electro Deposition [9]

2.6 Electro Filtration

Filtration media is being used in almost every water and wastewater treatment. It is used for the removal of solid suspended particles. This is upgraded by using an electrical field across it for removal of dissolved organic carbon DOC.

In this, to avoid membrane fouling by using direct current electrical field across the filtration system. Except ions, almost all colloidal particles, suspended solids, microorganisms. Have either positive or negative charges are deviated. Electric field is applied in such a way to accumulate undesired particles with the help of the electrical field.[10]

3. Electro Dialysis

3.1 Electrochemical Destruction

It's much of our concern to treat wastewater. Therefore, new methods have been generated by which we can destruct the wastewater. Use electrolyte for accomplishment of the concern. The ions that we needed to remove from the water are captured at anode and the cathode. This make the water free of ions that we have to remove. Membranes are being used to remove particulate matters from water.[11] Now I am show a model of removal from the water.

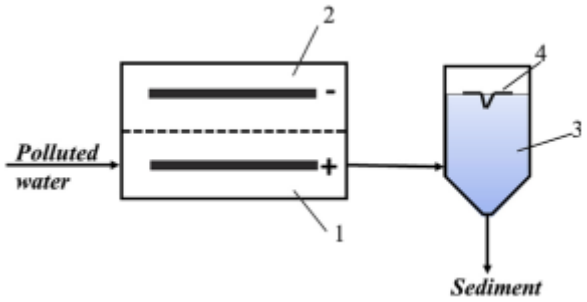

Figure 6. ED [11]

The polluted water is forced to pass through the membrane. We have an anode compartment 1 and a cathode compartment 2, being used for ion exchange.3 represents the sedimentation and at the last 4 presents the oil trap.

3.2 Electrochemical Oxidation

The chemical reaction in which an atom or a molecule losses electron or electrons. This happens at anode that is made of the catalytic material being used in the conversion. This all done during the passage of electric current.[12]

3.2.1 Two types off oxidation

a. Anodic Oxidation

It is possible at low potential differences but main drawback of it is deposition of polymeric layer on the surface of anode. That why its not viable until evolution of oxygen.[12]

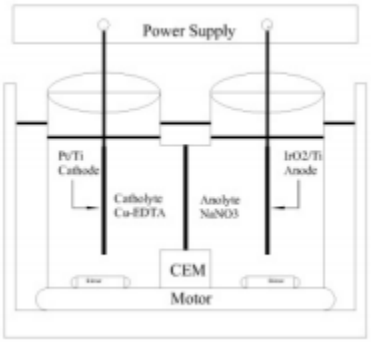

Figure 7. Electrochemical Oxidation[12]

b. Indirect Oxidation

This prevents the fouling of anode of organic particulate. No direct electrons transfer between the anode and the organic matter. It works on the principle that oxidization of pollutants is done in the bulk of the solution. Choline is most active specie in this category.[13]

3.3 Electrochemical Reduction

In this one or more electron of an atom or molecule is deposited on the surface of the cathode due to passage of electric current in the electrochemical system. ER can be used for organic and heavy metals like Pb, Hg,… and similar

ones. Its cost effective but process efficiency is very sensitive to wastewater ingredients.

Electrochemical reduction is usually done for the toxic metals, using electrocoagulation technique. Water treatment for heavy metals like Pb , Hg is carried out in acidic conditions as cathode is made of sulfur.[14]

4. Combined Methods

4.1 Electro Coagulation

Wide range of pollutants can be removed from wastewater using this technique. These are usually negatively charged such as microorganisms, inorganic colloidal particles, cyanobacteria, organic bacteria and clay. Usually electrodes of aluminum used for the treatment of water having oil concentrations.

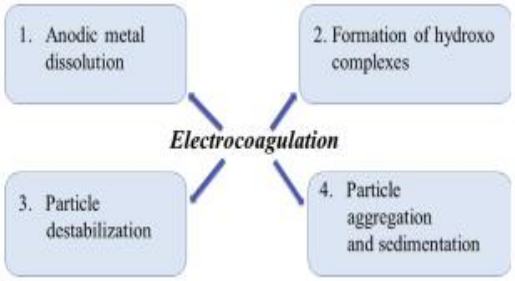

Figure 8. Electrocoagulation [6]

This method is usually used in the textile industry for treatment of dyes wastewater before releasing to any lake or canal.

1. Electrode reactions to generate Fe and Al at the anode side while H2 at the cathode.
2. For the treatment of dyes wastewater.[6]

This method shows the feasibility at pilot scale. Its economical, efficient technique for the decontamination. Less sludge is produced, so cost of its disposal is quite low. It is easily operate able. Low energy consumption and operating cost making it economical.[15]

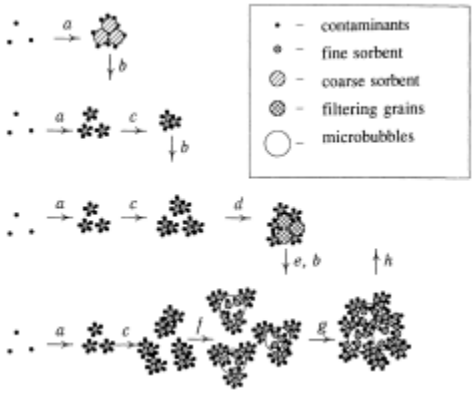

Figure 9. EC [15]

4.2 Electro Floto Coagulation

The issue of purification of water from pollutants ae well fine particles is much of our concern. There is a lot of conventional methods for it but these are inefficient for treatment of water that the main purpose of development of reliable and economical techniques. This especially deals with the particle size, here you can see different bubbles floating on the surface.[16]

4.3 Photo Electro Catalysis

PEC is the process in which we use catalyst and light for the acceleration of the chemical reaction. Catalyst activity is accelerated by using light irradiation. It can efficiently works to treat wastewater containing inorganic ions, organic compounds reduction and for disinfection.

Light has dual properties, showing wave nature as diffraction and as particle while interacting to the particles. PEC is advanced step of treatment of waste water contaminates, CO2, ion reduction and microorganisms deactivation.

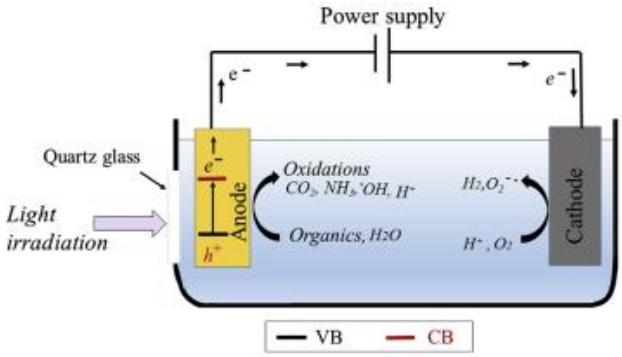

Figure 10. Photoelectrocatalysis [13]

PEC worked on the principle of photoexcitation. Degradation of organic compounds are due to simultaneous action of light and potential difference between the electrodes. Nitrate is found in the surface water, the most efficient way of to remove it. Its becomes more feasible when PEC and RO are combined that gives brilliant results.[13]

5. Sonoelectro Catalysis

One of the major drawback is the polarization and passivation of electrodes due to the poor mass transfer. Due to polarization gas accumulate at electrode and thus result in depletion of pollutants to the surface of electrodes boundary layer. Passivation is due to the accumulation of reactants at electrodes resulting in poor efficiency. Sound waves having frequency 20 kHz to 10^6 kHz used for treatment of water through the series of compression and rarefaction cycles, causing the pressure zone in the medium.

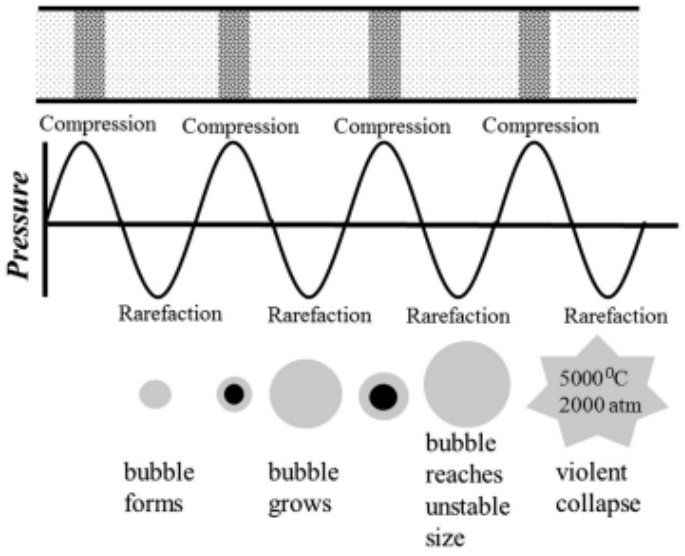

Figure 11. SEC [17]

It can increase the efficiency of the process by rapidly lowering the chemical oxygen demand in wastewater. Further, that by adding catalytic electrode speedup the oxidation reaction. One of its use is in textile industry.[17]

5.1. Electro-Fenton Process

It's advance oxidation process works on the bases of radical reactions. Used for organic pollutants such as pharmaceuticals, pesticides, dyes, phenol and phenolic compounds. Hydroxyl radicals have the high standard reduction potential that the reason for considering as a contributor of most of the degradation of compounds. Fenton reaction is named after Henry John Horstman Fenton, who discovered the transfer of electrons in specific metals.

Electro-Fenton process can be carried out in the cells that can be divided by cation exchange membrane or by not dividing the cell with membrane. The pulp and the paper industry used huge amounts of water and generates larger quantities of wastewater (up to 60 m^3/ton of paper produced). That contains suspended solids, heavy metals, Sulphur compounds along with lignin and its derivatives. Due to these substances wastewater has low degradability that's why we use oxidation process.[18]

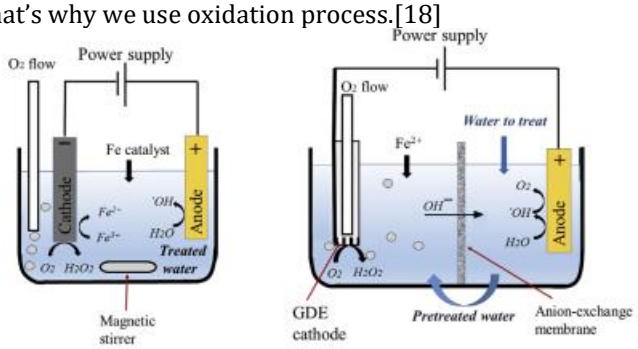

Figure 12. Electro-Fenton Process [18]

5.2 Electro disinfection

It's a bite more efficient method rather than the conventional chemical disinfection method. Its works on the principle of the anodic generation of strong oxidizing agents like O_2,O_3,and hypochlorite during water electrolysis.[19]

Electro disinfection using oxygen gas: formation of anodic oxygen that has capable of killing of germs to some extent. However it is usually recommended for the removal odor of water.

Electro disinfection using chlorine gas and hypochlorite ions: activated chlorine is best for the killing of the bacteria, fungi, spores.

Electro disinfection using O_3 : it has high oxidation potential and diffusion through the cell walls of microorganisms.[20]

6. Conclusion

Give surprising results, removal of organic matter, inorganic matter, and particulate matter relatively convenient. It is viable method and less usage of extra chemical reagents for the extraction of pure metals and organic pollutants. Electrochemical methods give control conditions to treat wastewater having heavy metals. These methods include separation, conversion and combined techniques for the wastewater treatment. In separation, separate the desired particulates from wastewater. In conversion, convert them to suitable matter. The combined method gives you promising results because it has dual characteristics. Membranes are one of the best reliable technique for the removal of desired ions from the solution. Electrodes are used usually for the accumulation of ions according to their charge characteristics. Electrocoagulation is especially used for the collection of by-products and waste materials. Electro-Fenton for organic pollutant efficient degradation. The effect of key parameters on pollutants degradation and mineralization efficiency. The degradation performance was more efficient. It depends upon the pollutant removal and energy consumed. Sono electro catalysis technique uses compression and rarefaction mechanism to remove the pollutants. Increased efficiency, economical feasible, easy operating and control conditions are in electrochemical methods. Due to which, always given preference above the other wastewater treatment technologies.

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