# A REVIEW ON STUDIES OF EFFLUENTS IN ELECTROPLATING INDUSTRY

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**Abstract**

Electroplating is one of the several techniques of metal finishing. It is a technique of deposition of a fine layer of one metal on another through electrolytic process to impart various properties and attributes, such as corrosion-protection, enhanced surface hardness, lustre, colour. They also add to the aesthetic value of object. Electroplating is the process of depositing a coating having a desirable form by means of electrolysis i.e. by the use of electricity. Its purpose is generally to alter the characteristics of a surface so as to provide improved appearance, ability to withstand corrosive agents, resistance to abrasion, or other desired properties or a combination of them, although occasionally it is used simply to alter dimensions. In this paper review of research work is done and problems are implemented in future.

Keywords: - electro, gold, DC, current etc.

## INRTODUCTION

Electroplating is known as electro deposition because the process involves depositing a thin layer of metal onto the surface of a work piece, which is referred to as the substrate. An electric current is used to cause the desired reaction.

Here's a simplified explanation of how electroplating works: Let's suppose that a layer of gold is to be electrodeposited onto metal jewelry to improve the appearance of the piece. The plating metal, or coating, (gold) is connected to the anode (positively charged electrode) of the electrical circuit, while the jewelry piece is placed at the cathode (negatively charged electrode). Both are immersed in a specially developed electrolytic solution (bath).

At this point, a DC current is supplied to the anode, which oxidizes the metal atoms in the gold and dissolves them into the bath. The dissolved gold ions are reduced at the cathode and deposited (plated) onto the jewelry piece. Factors that impact the final plating result include:

- the chemical composition and temperature of the bath
- the voltage level of the electric current
- the distance between the anode and the cathode
- the electrical current application's length of time

Electroplating is the application of electrolytic cells in which a thin layer of metal is deposited onto an electrically conductive surface.

A cell consists of two electrodes (conductors), usually made of metal, which are held apart from one another. The electrodes are immersed in an electrolyte (a solution).

When an electric current is turned on, positive ions in the electrolyte move to the negatively charged electrode, called the cathode. Positive ions are atoms with one electron too few. When they reach the cathode, they combine with electrons and lose their positive charge.

At the same time, negatively charged ions move to the positive electrode, called the anode. Negatively charged ions are atoms with one electron too many. When they reach the positive anode, they transfer their electrons to it and lose their negative charge.

### The Anode and Cathode

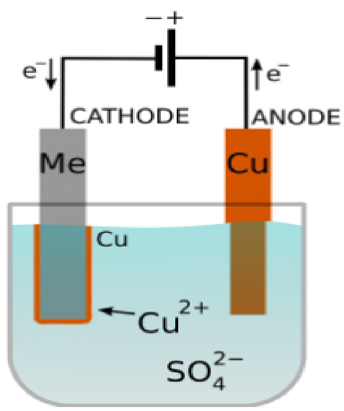
In one form of electroplating, the metal to be plated is located at the anode of the circuit, with the item to be plated located at the cathode. Both the anode and cathode are immersed in a solution that contains a dissolved metal salt—such as an ion of the metal being plated—and other ions that act to permit the flow of electricity through the circuit.

Direct current is supplied to the anode, oxidizing its metal atoms and dissolving them in the electrolyte solution. The dissolved metal ions are reduced at the cathode, plating the metal onto the item. The current through the circuit is such that the rate at which the anode is dissolved is equal to the rate at which the cathode is plated.

## USES OF ELECTROPLATING

Talking about the uses of electroplating, apart from enhancing the appearance of the substrate it is used in various other purposes as well. The major application is to optimize a material's resistance towards corrosion. The plated layer often serves as a sacrificial coating which reveals that it dissolves before the base substance. Some of the other common applications of electroplating involve:

- Improving wear resistance.
- Improving the thickness of the metal surface.
- Enhancing the electrical conductivity like plating a copper layer on an electrical component.
- Minimizing Friction.
- Improving surface uniformity.




**Electroplating**

Electroplating Example

A simple example of the electroplating process is the electroplating of copper in which the metal to be plated (copper) is used as the anode, and the electrolyte solution contains the ion of the metal to be plated ($Cu^{2+}$ in this example). Copper goes into solution at the anode as it is plated at the cathode. A constant concentration of $Cu^{2+}$ is maintained in the electrolyte solution surrounding the electrodes:

Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2\ e^-$

Cathode: $Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$

Common Electroplating Processes

| Metal | Anode | Electrolyte | Application |
|---|---|---|---|
| **Cu** | **Cu** | **20% $CuSO_4$, 3% $H_2SO_4$** | **electrotype** |
| Ag | Ag | 4% AgCN, 4% KCN, 4% $K_2CO_3$ | jewelry, tableware |
| Au | Au, C, Ni-Cr | 3% AuCN, 19% KCN, 4% $Na_3PO_4$ buffer | jewelry |
| Cr | Pb | 25% $CrO_3$, 0.25% $H_2SO_4$ | automobile parts |
| Ni | Ni | 30% $NiSO_4$, 2% $NiCl_2$, 1% $H_3BO_3$ | Cr base plate |
| Zn | Zn | 6% $Zn(CN)_2$, 5% NaCN, 4% NaOH, 1% $Na_2CO_3$, 0.5% $Al_2(SO_4)_3$ | galvanized steel |
| Sn | Sn | 8% $H_2SO_4$, 3% Sn, 10% cresol-sulfuric acid | tin-plated cans |

## BRIEF OVERVIEW OF EFFLUENTS RELEASED DURING ELECTROPLATING OF METALS

A wide variety of processes (physical, chemical and electrochemical) are used in electroplating industry leads to effluents which may not be very complex in chemical composition from a single process but becomes complicated chemically when they are present in a sewerage system. Wastes generated during these operations are associated with the solvents and cleansers and mental-ion-bearing aqueous solutions used in plating tanks.

- A variety of chemicals ad substances are used, depending upon the surface properties of the object to be electroplated. Some of the chemicals are unknown for the users, because they are marketed as proprietary items manufactured by the chemical companies. The main source of electroplating effluents are identified as drag out losses, concentrated liquid wastes, spent acid bath, spent alkali baths, spent passivation dip and rinse water.

Electroplating effluents are generally acid, with up to 200 to 300 mg/L of suspended solids, copper mickel and zine in verying amounts. The characteristics of the waste stream from electroplating industries are so toxic and corrosive due to presence of these metals.

## IMPACTS OF ELECTROPLATING EFFLUENTS ON ENVIRONMENT, SOIL, WATER AND HUMAN BEINGS

Environmental contamination due to man-made and natural sources in increasing day by day because of increase in population, industrialization and urbanization. Industrialization has led to discharge of effluents, which in turn pollute the ecosystem. The wastewater discharges from effluents from industries such as electroplating pose a threat as these effluents are usually dumped into natural water resources like rivers, lakes and ponds and make it unfit human, animal, irrigation as well as for industrial use. Some of their harmful effects are:-

➢ The most adverse effect is on the workers who are exposed routinely. Over a period of time such exposures are known to cause diseases and various infirmities.

➢ Higher concentration of Nickel from electroplating effluents causes poisoning effects like headache, dizziness, nausea, tightness in chest, vomiting, shortness in breadth, rapid respiration and extreme weakness.

➢ Electroplating effluents constitutes important source of have metal pollution in water such as chromium, nickel, serious effects on human health, aquatic life and plants.

➢ Exposure to chromium during electroplating may cause asthma. The workers of electroplating industries which are exposed to chrome and nickel fumes may develop asthma in them.

➢ By mixing of electroplating effluents in plants, the germination of plants in delayed with the increase of effluent concentration.

➢ In Delhi, an important part of pollution load to the river Yamuna is contributed by electroplating units.

➢ Industrial effluents, often used for irrigation in developing countries like India has developed soil pollution by toxic metals.

➢ Repeated use of waste water for agriculture reduces the soil capacity to retain heavy metals.

➢ Metals when introduced into aquatic system through discharge of effluents from electroplating industries are capable of causing phytoxicity, bio concentration and biomagnifications by aquatic organisms.

## LITERATURE REVIEW

Adhoum N. *et al.* (2004) have been proposed the performance of electrocoagulation, with aluminium sacrificial anode, in the treatment of metal ions ($Cu^{2+}$, $Zn^{2+}$ and Cr(VI)) containing wastewater, has been investigated. Several working parameters, such as pH, current density and metal ion concentrations were studied in an attempt to achieve a higher removal capacity. Results obtained with synthetic wastewater revealed that the most effective removal capacities of studied metals could be achieved when the pH was kept between 4 and 8. In addition, the increase of current density, in the range 0.8–4.8 A $dm^{-2}$, enhanced the treatment rate without affecting the charge loading, required to reduce metal ion concentrations under the admissible legal levels. The removal rates of copper and zinc were found to be five times quicker than chromium because of a difference in the removal mechanisms. The process was successfully applied to the treatment of an electroplating wastewater where an effective reduction of ($Cu^{2+}$, $Zn^{2+}$ and Cr(VI)) concentrations under legal limits was obtained, just after 20 min. The electrode and electricity consumptions were found to be 1 g $l^{-1}$ and 32 A h $l^{-1}$, respectively. The method was found to be highly efficient and relatively fast compared to conventional existing techniques.[1]

Kaur A. *et al.* (2006) have been proposed Sublethal toxicity of nickel-chrome electroplating effluent on blood plasma protein and cholesterol was investigated in the fish Channa punctatus(BI). The fish was most sensitive to stress during the spawning phase followed by preparatory and prespawning phase of the reproductive cycle. An increase in the concentration of biomolecules corresponding to a decline in GSI clearly indicates that the metabolism of the fish is affected and the biomolecules are not taken up by the body under the stress of the effluent.[6]

Pandey P. *et al.* (2007) have been present work was to investigate the removal of Ni(II) by the fresh biomass (FBM) and chemically treated leached biomass (LBM) of Calotropis procera. The scope of the work included screening of the biosorbents for their metal uptake potential, batch equilibrium, column mode removal studies and kinetic studies at varying pH (2-6), contact time, biosorbent dosages (1-25 g/L) and initial metal ion concentration (5-500 mg/L). The development of batch kinetic model and determination of order, desorption studies, column studies were investigated. It was observed that pH had marked effect on the Ni(II) uptake. Langmuir and Freundlich models were used to correlate equilibrium data on sorption of Ni(II) metallic ion by using both FBM and LBM at 28o C and pH 3 and different coefficients were calculated. It was found that both biomasses were statistically significant fit for Freundlich model. The biomass was successfully used for removal nickel from synthetic and industrial effluents and the technique appears industrially applicable and viable. Electroplating has a long history in India. Like many other industrial activities, it gained momentum after independence. Modern techniques in electroplating started in early sixties in India, but the first semi automatic plant was set up in 1976 in Mumbai. Since then, the industry has grown steadily without facing any recession. Currently there are more than 600 automatic plants in the country International Metalworkers Federation, 2002 have been although official figures are not available, and estimates indicate that in 1970, electroplating industry was of Rs. 100 million. During the period 1970-85, the government policy on the restriction import in force led to high growth of this industry. [12]

Huang *et al.* (1997) developed a software MIN-CYANIDE, that contained various solutions and algorithm for waste minimization of cyanide levels produced in electroplating plants. This software also provided Waste Minimization opportunities based on the inputs and also recommended high prioritized measures for source reduction (chemicals). However, the software was restricted to cyanide-containing waste streams only, and was incapable of providing any decision for the support for the minimization of many other chemicals, metal and non-metal containing waste streams. [4]

Huang Y.L. *et al.* (1991) made an intelligent decision making approach (software called WMEP- advisor) for waste minimization decision support system. But, the program was based on fuzzy linguistic concepts of LOW, MEDIUM and HIGH etc which were related to inputs of electroplating process. So, it was not able to quantify precisely the LOW, MEDIUM and HIGH inputs, for e.g. EXCESSIVE drag out, HIGH temperature etc.[5]

Koga S. *et al.* (1977) developed a metal plating waste water reclamation system which consisted of reuse of waste water from pre-treatment and post-treatment process with the help of RO plant. The waste water discharged from the electro-plating equipment, contained acidic chromium and alkaline cyanides. However, this study proved to be unsuccessful because of the fluctuation in the quality of inflowing waste water, which made the treatment difficult. Kremen et al., (1977) reported a RO scheme for metal finishing wastewater containing Cu2+, Zn2+, Cr 3+ and Cr 6+, where, 95% of water recovery was found that could be reused in process.[9]

Biomass as an absorbent over use of activated carbon for adsorption, as activated carbon has high cost of recycling which is a drawback for developing countries. The sphagnum moss peat to be an effective adsorbent for hexavalent Chromium. But, the recovery of Chromium was only 50%. Agricultural residues as low-cost adsorbents for heavy metals in wastewater. They received great attention by developing countries. Srivastava et al., used waste slurry from fertilizer plants as an adsorbent for heavy metals from electroplating industry. Biomass can be used as absorbent of chemicals used in electroplating industries, Column operations having sugarcane residue or bagasse as an adsorbent was developed.

Keukeleire *et al.* (2010) demonstrated recovery of Cu2+, Ni2+ and Zn2+ from wastewater (in the absence of cyanide) in an electroplating factory were 95.5%, 96.3.0%, and 97.1%, respectively. A comparison between biomass and Activated carbon was done and established that use of activated carbon was superior of using sugarcane and bio-mass. But, in developing countries low cost of bio mass can be a crucial factor. Going retrospectively, made use of sawdust with several reactive dyes for adsorption of Copper (Cu), Lead (Pb), Mercury (Hg) and Iron (Fe). In highly acidic conditions (pH=2), such as use of chromic acid with sulphuric acid( low pH) .phosphate treated sawdust showed remarkable adsorption behavior in such conditions. Thus, cost of neutralization can be prevented. Ion exchange appears to be a promising technique for the treatment of streams in electroplating process industries.[7]

Kimbrough *et al.* (1999) suggested that separation of heavy metal is based on health concerns (discussed in detail in following chapter-4), since some heavy metals are potentially carcinogenic when inhaled and also due to their commercial value. Sawdust is a widely available in abundance. It has been reported to exhibit Ion-exchange and complexation capacities towards heavy metals.[8]

## PROBLEM FORMULATIONS

After reviewing the literature critically, it has been found that environmental contamination is increasing bay by day because of rapid industrialization and urbanization. Industrialization has led to discharge of effluents, which in turn pollute the ecosystem. The disposal of effluents releasing from electroplating industries has become a serious problem due to rising cost of their disposals. The effluents discharged from electroplating industries pose a threat as they as they are usually dumped into natural water resources like rivers, lakes and punks and make it unfit for human, animals, irrigation as well as industrial use. So the investigator has decided to make a study on the characteristics of the effluents releasing from electroplating industries.

## RESEARCH PROBLEM

Like many industries, electroplating industries gained momentum after independence. Their number is increasing day by day because of increasing demand of finished metals. A wide variety of chemicals and substances are used in electroplating process depending upon surface properties of object to be electroplated. Electroplating effluents released in natural resources have adverse effect on humans, animals and plants. So attempts will be made to study the characteristics of effluents releasing from electroplating industries in city Ludhiana, state Punjab so theta proper way of their disposal or management can be made.

## CONCLUSION

Electroplating is known as electrode position because the process involves depositing a thin layer of metal onto the surface of a work piece, which is referred to as the substrate. An electric current is used to cause the desired reaction. Like many industries, electroplating industries gained momentum after independence. Their number is increasing day by day because of increasing demand of finished metals. A wide variety of chemicals and substances are used in electroplating process depending upon surface properties of object to be electroplated. Electroplating effluents constitutes important source of have metal pollution in water such as chromium, nickel, serious effects on human health, aquatic life and plants. Exposure to chromium during electroplating may cause asthma. The workers of electroplating industries which are exposed to chrome and nickel fumes may develop asthma in them.

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