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EFFLUENT TREATMENT OF ELECTROPLATING UNIT

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Abstract:

The Electroplating industry is one of the top polluting industries. The effluents discharged have high concentrations of toxic heavy metal ions. Our project is an effort to reduce the toxicity of the effluent discharged from an electroplating unit. The project aims to reduce heavy metalion concentrations in the effluent discharged by employing a combined effect of precipitation and adsorption. These methods have been successfully applied and tested by us on a laboratory level and can be easily adapted at an industrial level economically. The project suggests other more sophisticated and new methods of treating effluent from an electroplating unit. We have analyzed our method of treatment from all angles and also recommended solutions to rectify its minor short comings. The report includes an adsorption bed prototype which can be used on a bigger or industrial scale. This method of treatment is simple, effective, practical and most importantly cost effective.

Key Words: Electroplating Effluent, Precipitation Method, Adsorption & Heavy Metal Ions

Introduction:

Electroplating is one of the varieties of 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, luster, color, aesthetics, value addition etc. The base metals involved may be copper, ferrous alloys, including stainless steels and alloys of copper, zinc, aluminum, magnesium, and lead. Non-metallic base materials (such as plaster of Paris and plastics) may also be electroplated. Acids and alkalis, both concentrated and diluted, are used in the preparation of the base surfaces for the various finishes. The plating baths may be acid or alkaline and are almost without exception water solutions of salts of the metals to be deposited. Electroplating operations form part of large scale manufacturing plants (e.g. automobile, cycle, engineering and numerous other industries) or performed as job work by small and tiny units. They are mainly in small scale sectors with over 3,00,000 small scale units in India. On one hand, the process has number of applications but, simultaneously it has been included among 17 major polluting industries in India by Central Pollution and Control Board, government of India. Electroplating is considered a major polluting industry because it discharges toxic materials and heavy metals through wastewater (effluents), air emissions and solid wastes in environment. Any or all of the substances used in electroplating (such as acidic solutions, toxic metals, solvents, and cyanides) can be found in the wastewater, either via rinsing of the product or from spillage and dumping of process baths. The overall wastewater stream is typically extremely variable (1 liter to 500 liters per square meter of surface plated) but is usually high in heavy metals, including cadmium, chrome, lead, copper, zinc, and nickel, and in cyanides, fluorides, and oil and grease, all of which are process dependent.

Precipitation Treatment:

The hydroxide precipitation treatment employs alkaline materials such as caustic soda, soda ash, lime, magnesium hydroxide or a combination thereof. The entire treatment involves precipitation of heavy metal hydroxide(s), flocculation with a polymeric material, settling and discharge of treated effluent. Conventionally, precipitation has been the method most often used to remove heavy metals. Of the few precipitation methods, hydroxide and sulfide are the two main methods currently used, and hydroxide precipitation is by far the most widely used method.

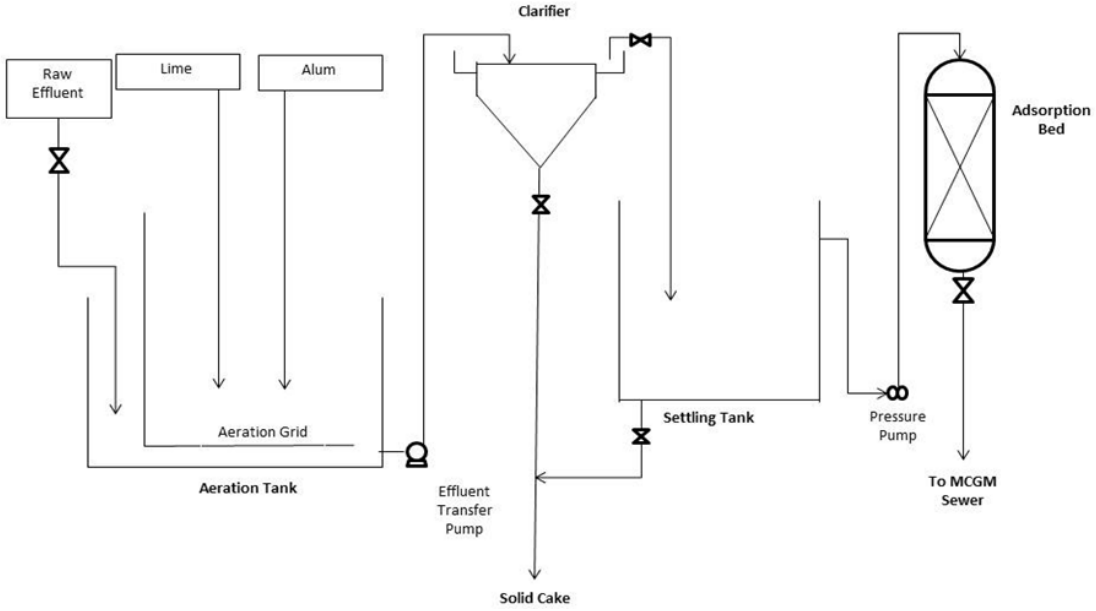
Process Description:

- ✓ The effluent from the process flows under gravity into the Aeration Tank
- ✓ Solution preparation:
  - Lime Slurry: Approximately 5 kg of crushed commercial lime is slowly added to the agitation tank which is already filled with 75% water. It is stirred manually to mix the contents. This prepares a 20% solution.
  - Alum Solution: About 70 grams of commercial crushed alum is added to the agitation tank which is previously filled with effluent. It is manually stirred to mix the contents thoroughly.
- ✓ After the process tank is completely filled with raw effluent, lime slurry is added to the tank and the air sparging is turned on to provide agitation. Metals present in the effluent form their respective insoluble hydroxides upon reaction with lime.

- ✓ The Alum solution is then added to flocculate the particles. After further mixing with the help of compressed air, the air spargingis turned off. The treated effluent is then pumped into the clarifier, where it is allowed to settle.
- ✓ After allowing the effluent to settle for 45-60 minutes, the sludge settled at the bottom of the tank is solid cake and is disposed. The overflow is clear effluent. This overflow still has some solid particles.
- ✓ The overflow is sent to a settling tank where the particles are allowed to settle at the bottom of the tank. The clear effluent is pumped to the top of an adsorption bed.
- ✓ The clear effluent trickles down through the bed – heavy metal ions get adsorbed as it moves down the bed.
- ✓ The bottom product of the adsorption bed is then sent to the MCGM sewer.

The sand for the adsorption bed was collected from a beach. It had not been washed. The presence of $Na^{+}and\ Cl^{-}$ ions in the unwashed sand resulted in the increased Chloride ion value in the test result of the treated sample.

Flow Sheet for Precipitation Treatment:



Cost Analysis

Average price of Lime = 8.7 INR/Kg[1]

Average price of Caustic Soda = 62 INR/ Kg[2]

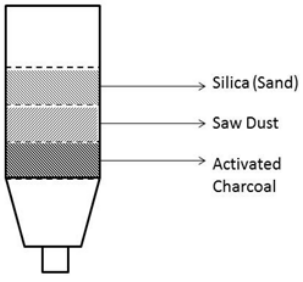
The cost of raw materials involves costing of two main ingredients Lime and Alum.100g of Lime is used per litre, 50L of effluent requires at least 5000g (5Kg) of lime. Assuming the average cost of lime is INR 8.75/Kg, the pH of lime used is 3, if it is lesser then more quantity of lime is required per litre thus increasing costs. It costs INR 43.750 for 50L of effluent. A litre of effluent requires 10g of Alum. Assuming the average cost of alum to be INR 14/ Kg, we need 500g of alum for 50L effluent costing INR 7. Total cost of precipitation treatment will be INR 50 (approx.).

Adsorption Bed Prototype:

The adsorbents that are generally used in wastewater treatment by most environmental agencies are:

- ✓ Activated Carbon
- ✓ Silica (sand) or Gravel
- ✓ Saw Dust

It is known that activated carbon has excellent water clarifying properties and has been in use since ancient times. Also, it is very easy to produce as it is just the steam heating of any allotrope of carbon to about 400 degrees Celsius. Silica (sand) and gravel are easily available in any part of the world, free of cost. Saw dust is a waste obtained from wood and furniture industries and can be bought at very cheap prices.



Length: 6cm
Diameter: 7cm
L/D Ratio = $\frac{6}{7}$ = 0.857

Results:

Untreated Sample Analysis Result:

S.No	Tests	Results	Unit	Method Reference
1	Zince	20	mg/l	By ICPMS
2	Tin	1.5	mg/l	By ICPMS
3	Nickel	53	mg/l	By ICPMS
4	Copper	130	mg/l	By ICPMS
5	Sulphates as SO_4	350.6	mg/l	IS 3025(part24): 1991
6	Chlorides as Cl	389.9	mg/l	IS 3025(part24): 1991

Treated Sample Analysis Result:

S.No	Tests	Results	Unit	Method Reference
1	Zinc	0.01	mg/l	By ICPMS
2	Tin	BLQ<0.01	mg/l	By ICPMS
3	Nickel	0.01	mg/l	By ICPMS
4	Copper	0.02	mg/l	By ICPMS
5	Sulphates as SO_4	139.1	mg/l	IS 3025(part24): 1991
6	Chlorides as Cl	514.0	mg/l	IS 3025(part24): 1991

Discussion:

The effluent sample was treated by metal hydroxide precipitation method and then passed through an adsorption bed for further removal of heavy metal ions, specifically Zn^{2+} , $Ni^{2+,}$ Sn^{2+} and Cu^{2+}. Expected results of precipitation treatment are as shown in the table:

Table 6: Expected results of precipitation treatment [3]

Heavy Metal	Achievable Concentration (mg/l)	Precipitating Agent
Tin	0.3	Caustic, Lime
Copper	0.5	Caustic, Lime
Nickel	0.5	Caustic, Lime
Zinc	0.5	Caustic, Lime

These quantities of heavy metals are highly reduced from the values that are present in untreated effluent but they are significant. These metals tend to accumulate in the food chain through bio-magnification and can be detrimental to human health in the long run. The accumulation of these metals can also lead to collapse of the ecological food chain, especially in water bodies. To improve on the results obtained from the precipitation method, the effluent was passed through an adsorption bed containing three adsorbent layers. The result obtained only by precipitation is as shown above in the table. The test results obtained for treated effluent are significantly lower than those that are obtained only after precipitation. Heavy metal concentrations have been reduced trace quantities, all under 0.02 ppm (Zinc 0.02ppm, Copper 0.01 ppm, Tin less than 0.01 ppm, Nickel 0.01ppm). Since the quantities of metals are so minute, this treated water can be used for industrial uses, washing, etc. but this water is not fit for human consumption.

Conclusion:

Metal hydroxide precipitation is relatively cheap as the raw materials used are very cheap and easily available. Also, only conventional equipments are required unlike other processes that require specialized equipment which is costly. A lot of other processes are also time consuming and labour intensive at times. Precipitation is quick and treatment can be finished over a short period of time as short as one day. The government has taken necessary steps to make effluent treatment compulsory for all industries. The main aim is to release only treated effluent into water bodies. Thus, the installation of an effluent treatment plant is compulsory. Precipitation treatment with an adsorption bed is the cheapest option available. It is not only cheap but also a very effective solution to pollution problems in the electroplating industry. The adsorption bed is easily constructed with the adsorbents hardly contributing to the cost as saw dust is discarded waste and sand is easily available in abundance. Activated charcoal is also easy to make by steam treatment of carbonaceous materials at 400-500 degrees Celsius. The adsorption bed requires regeneration/replacement after about 300-400 cycles (approximately one year), which is the only drawback of this method. From the test results obtained, it is clear that the effluent discharged into sewers after precipitation treatment is not fit for any use as it contains significant amounts of heavy metals. Thus, the passing of effluent through an adsorption bed is absolutely necessary to make the water reusable and prevent wastage by seepage into the ground or as run-off to sewers where it mixes with biological waste and gets contaminated.

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Nomenclature:
ICPMS: Inductively Coupled Plasma Mass Spectroscopy
BLQ: Below Limit of Quantification