

# CHAPTER 1

## INTRODUCTION



### 1.1 General

Industry is interested in removing contaminants from waste stream by using hydrous metal oxide (HMO) as an adsorbent. Adsorption and/or coprecipitation of organic and inorganic materials with HMO flocs, followed by additional unit operations such as coagulation, sedimentation, and rapid sand filtration have been utilized successfully in wastewater treatment (Reynolds and Richards, 1982; Dagdigian, 1988).

Industrial wastewater containing inorganic and organic contaminants is frequently treated by co-precipitation. Co-precipitation treatment process includes acidification of the incoming wastewater to induce ionization, mixing of the acidified wastewater with acidic solution of HMO, and precipitating of insoluble species via pH adjustment to the alkaline range. This procedure usually results in efficient removal of insoluble contaminants. The expenditures in this process include the cost of acid to pre-acidify the waste, excess alkaline reagent to neutralize the acid, and handling and disposal of the sludge produced. These and the associated labor, operation, maintenance, and transportation expenses have put financial burden to the industry. The production of sludge also add hidden long-term societal cost associated with the depletion of the limited landfill capacity. Therefore, an improved treatment technology is needed in this area.

Utilizing HMO to remove dissolved and suspended contaminants is based on the principle of adsorption/co-precipitation with iron-based chemical coagulant aids such as  $\text{Fe}(\text{Cl})_3$ . The making of this adsorbent involves the treating of the waste with iron salts, followed by pH adjustment to induce hydrolysis reaction, and subsequently, formation of hydrous ferric oxide (HFO). HFO is an amorphous adsorbent and has particle sizes ranging from 1 to 10 nm. It is highly porous and resembles a swollen gel, rather than a homogeneous solid. HFO has a formula of  $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$  ( $n$  varies from 1 to 3). The density varies from 2.2 to 4.0  $\text{g}/\text{cm}^3$ , with an average of 3.5  $\text{g}/\text{cm}^3$ . HFO removes dissolved contaminants by surface adsorption and co-precipitation, and

through precipitate formation linked to subsequent sedimentation which sweeps material from suspension (sweep flocculation).

HFO, which can also be formed from the beneficial reuse of iron waste, has also been successfully employed to reduce the concentration of hazardous contaminants and potentially valuable metallic elements (As, Se, Ni, Cu, Cr, and Zn) in a variety of waste streams (Benjamin and Leckie, 1981; Benjamin, 1983; Merrill et al., 1985, Brooks, 1990). The advantage of using HMO in waste treatment is its low cost and its ability to modify the treated sludge's characteristics to meet the non-hazardous waste criteria.

Metal plating wastes are generated during the fabrication process. After metals have been fashioned into the appropriate size and shapes to meet customer's specifications, they are finished to final product. Finishing usually involves stripping, removal of undesirable oxides, cleaning and plating. In plating, the metal to be plated acts as the cathode while the plating metal in solution serves as the anode. The total liquid wastes generated are not voluminous, but are extremely hazardous because of their toxic content. The most important toxic contaminants are acids and metals, such as chromium, zinc, copper, nickel, tin and cyanides. Alkaline cleaners, grease, and oil are also found in the waste (Nemerow, and Agardy, 1997).

Nickel is commonly used in metal plating industry. Thus, metal plating wastewater is usually contaminated with high concentrations of nickel. The Department of Industrial Work has requested that the nickel concentration in the waste discharge be less than 1 mg/L.

This study has concentrated on the removal of nickel (Ni) with hydrous ferric oxide column. To reduce the treatment cost, waste iron was selected as the adsorbent. The process uses minimum chemicals and does not produce sludge; hence, no sedimentation tank is required. The goal of this work was to study and develop an effective wastewater treatment technology for the metal plating industry.

## **1.2 Objectives of the study**

The objective of this work was to study and develop a technology for the treatment of metal plating industry wastewater. In order to achieve this goal, the following tasks were performed:

1. To determine the optimum conditions for removal of nickel from metal plating wastewater by using iron scrap columns,
2. To study factors affecting the removal of nickel from metal plating wastewater with iron scrap columns, and
3. To investigate the effect of nickel loading on the performance of iron scrap columns.

## **1.3 Hypothesis**

Iron waste columns can remove nickel from metal plating wastewater

## **1.4 Scopes of the study**

### **1.4.1 Wastewater collection**

Wastewater used in the experiment was collected from the metal plating industry, mainly from rinsing operations, in Samutprakarn province, Thailand. Though there are other contaminants present in the waste stream, this study was concentrated on nickel (Ni) only.

### **1.4.2 Characteristics of wastewater**

The composition of wastewater was analyzed by inductively coupled plasma mass spectrometer (ICP-MS, Varian Ultra Mass 700)

### **1.4.3 Batch experiment**

These experiments were performed to determine the effect of pH on the percentage removal of nickel. The optimum pH obtained in this experiment was then used in the next continuous flow column study.

#### **1.4.4 Continuous flow experiments**

The continuous flow study was conducted by fabricating a bench-scale column with an acrylic pipe filled with iron scrap. This column was used to study the effect of column height, influent flow rate, and nickel concentration on nickel removal.

#### **1.4.5 Nickel analysis**

Nickel was analyzed with an Atomic Absorption Spectrometer (Perkin Elmer, AA Model 2380). Analytical procedure was in accordance with the Standard Methods (APHA, 1998) and manufacturer's recommendation.

#### **1.4.6 X – Ray Diffraction (XRD)**

Structure of iron material was analyzed with X-Ray Diffraction Spectrometer (Jeol, JDX- 8030).