OPERATING COST OPTIMIZATION IN INDUSTRIAL WASTEWATER TREATMENT: A CASE STUDY FOR ALUMINUM PLANT

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ABSTRACT

In most of the time, wastewater treatment plants are operated without optimization. As the system is already meets the requirements, it is normally thought that optimization is unnecessary. However, this is not the case. In the current economic situation, it should be focused on reducing operating costs of any wastewater treatment facility. Optimization provides to decide on the most economical method and also ensures that the wastewater treatment facility always meets environmental compliance. The major aim of this study is optimization of the wastewater treatment process of an aluminium plant which produces aluminium profiles by extrusion and anodic oxidation processes. The wastewater from the plant is a mixed wastewater with high sulfate concentration. As a first step of the optimization, it was established that the current method is chemical precipitation which utilized $BaCl_2.2H_2O$. The chemical which can be economically and chemically alternative to $BaCl_2.2H_2O$ were determined and studied by various amounts as the second step. As the result of study, the operating costs were optimized when the treatment process meets the requirements of Water Pollution Control Regulation of Turkey. Besides, the environmental damage of the sludge containing barium was limited.

Keywords: wastewater, sulfate removal, chemical precipitation, optimization, aluminium plant.

1. Introduction

The surface treatment of and by metals dates back to early man using gold decoratively before 4000 BC (EC, 2006). One of the surface treatment mehod is anodic oxidation. Anodic oxidation, or anodizing, is an electrolytic process for producing very much thicker oxide coatings whose improved physical and chemical properties have greatly increased the field of application for aluminium (Henley, 1982). Anodising was first used on an industrial scale in 1923 and was a chromic acid–based process. Chromic acid anodising is still used today in specialised applications (e.g. high strength aluminium alloys for aerospace) Variations of this process soon evolved, and the first sulfuric acid anodising process was patented in 1927. Sulfuric acid soon became and remains the most common anodising electrolyte. It comprises anything from heavy duty black dyed coatings for high-tech instruments to cheap objects. It also includes architectural anodising primarily for protecting aluminium window frames etc from the elements (ESTAL, 2015).

Based on the use of sulfuric acid, anodising wastewaters contains high sulfate concentration. High concentrations of sulfate in drinking water may cause transitory diarrhea (U.S. EPA, 1990). A study of adults found that most experienced a laxative effect above 1000 mg/L, whereas medical case reports indicate that bottle-fed infants develop diarrhea at sulfate levels above 600 mg/L. Acute diarrhea can cause dehydration, particularly in infants and young children who may already have a microbial diarrheal condition. Adults living in areas having high sulfate concentrations in their drinking water easily adjust, with no ill effects (Letterman, 1999). In Turkey, sulfate concentration limit is 250 mg/L (PHI, 2013) in drinking water and 1700 mg/L (MEUP, 2004) for the industrial plants at the organized industrial zones (OZI, industrial park).
Several methods have been employed to treat sulfate-containing wastewater, including crystallization (Tait *et al*., 2009), ion exchange (Haghsheno *et al*., 2009; Guimarães and Leão,

2014), biological treatment (Silva *et al*., 2002), electro-dialysis (Paz-Garcia *et al*., 2013), nano-filtration (Meihong *et al*., 2008), adsorption (Hong *et al*., 2014; Iakovleva *et al*., 2015), and chemical precipitation (Benatti *et al*., 2009).

In this study, operating costs of wastewater treatment facility of a aluminium production and anodic oxidation plant optimized by chemical precipitation depending on the chemical compounds and amount of use of them.

2. Materials and methods

2.1. Materials

In this study, the wastewaters which have asidic and basic characterization were used with 1.18 and 13.5 pH values. Asidic wastewater contains 6000 mg/L sulfate concentration. The wastewaters were provided from aluminium production and anodic oxidation plant at the first organized industrial zone (OZI, industrial park) in the center of Bilecik, Turkey.

The chemicals used in the study are $BaCl_2.2H_2O$ and $CaCl_2$. $BaCl_2.2H_2O$ is the current utilized chemical for the treatment facility in aluminium plant and $CaCl_2$ was selected as an alternative to $BaCl_2.2H_2O$ economically and structural (Table 1).

Table 1: Comparison of the chemicals

	$BaCl_2.2H_2O$	**$CaCl_2$**
Solubility of sulfate salt of the chemical (g/100 mL water)	0.0002448	0.21
Price ($/kg)	0.8	0.2

2.2. Experimental Method

The experimental system is shown in Fig.1 was used for the study. Selected chemicals with different amounts were dissolved in distilled water and added to the acidic effluent. The amounts of the chemicals were in range 0.1 to 0.05 g chemical for 1 L effluent.

The mixtures were stirred during 2 hours and basic effluent was added for neutralization. Neutralized effluent was waited one night and was taken water samples.

Figure 1: Experimental steps

The sulfate concentration of the samples was determined by UV spectrometer, according to ASTM standart method (ASTM, 2011).

3. Results and discussion

The utilized chemical compound and the amount of the chemical is $BaCl_2.2H_2O$ with 0.1 g/L effluent. Therefore, the trials were performed from 0.1 to 0.05 g chemical/L effluent.

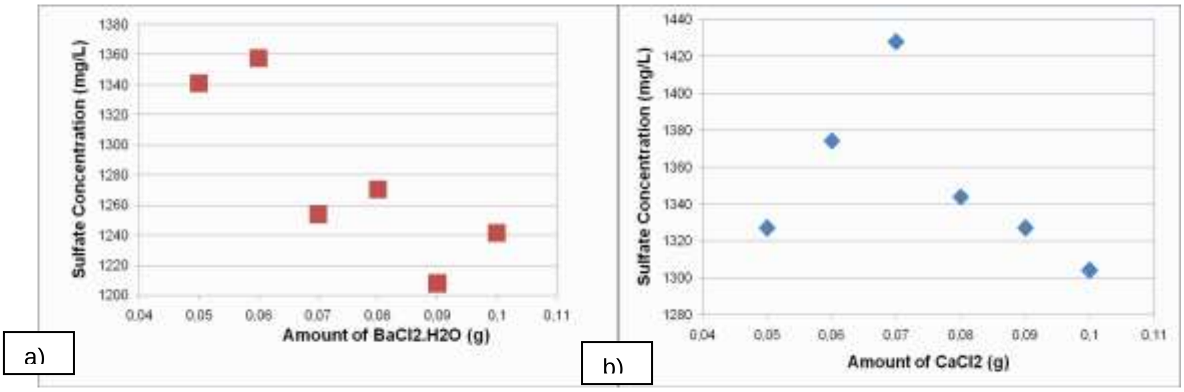

Figure 2: Sulfate concentration of the treated wastewater

Fig.2 shows that sulfate concentration increases while used $BaCl_2.2H_2O$ amount decreases, in range of 1207.65 and 1357.49 mg/L; and changes from 1303.98 to 1427.83 mg/L depending on $CaCl_2$ amount.

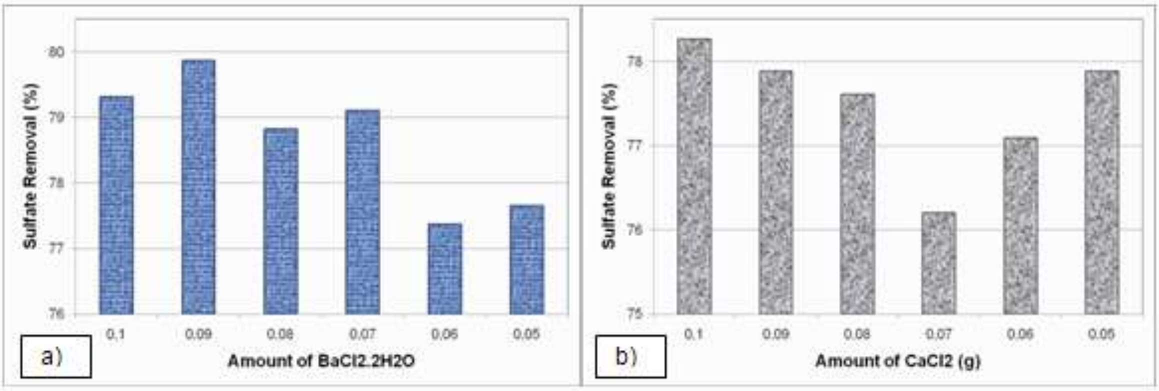

Figure 3: Percentage of sulfate removal

As shown in Fig.3, maximum sulfate removal percentages have almost same value for both of the chemicals.

4. Conclusions

The minimum value, 0.05 g, can be selected as the chemical amount for both of the chemicals, while the treatment process meets the requirements of Water Pollution Control Regulation of Turkey. Also, the results show that $CaCl_2$ can be selected as alternative to $BaCl_2.2H_2O$, based on effectiveness and the prices. Besides, the sludge that occured at the end of the treatment process will be limited during the use less chemical amount.

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