

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of The Research**

The rapid growth of industries such as electroplating and leather tanning has resulted in wastewater with high concentrations of chromium, which recorded at 141.06 mg/L in electroplating industry and 754 mg/L in leather tanning industry (Izzulhaq, 2022). These levels exceed the permissible limit established by the Indonesian Ministry of Environment Regulation No. 5 of 2014 on Wastewater Quality Standards, which limited to 0.5 mg/L. Chromium discharged into aquatic environment poses serious ecological and health risks. Due to its toxic nature and resistance to degradation, chromium can accumulate in aquatic organisms and subsequently threaten human health (Kadim & Risjani, 2022). Therefore, wastewater or raw water containing high chromium concentrations requires effective strategies to mitigate its adverse impacts on living organism.

Treatment of hexavalent chromium (Cr (VI)) can be carried out through physical, chemical, and biological approaches. Physically, electrocoagulation using iron electrodes has proven effective, achieving removal efficiencies of more than 90% (Islam et al., 2023). Chemically, photocatalytic treatment using Resin Immobilized Photocatalyst-  $\text{TiO}_2$  (RIPT-  $\text{TiO}_2$ ) has demonstrated a degradation efficiency of 70.67% for real wastewater after 180 minutes of treatment (Hidayah et al., 2026). Biologically, the use of *Pseudomonas aeruginosa* has shown the ability to degrade Cr(VI) up to 93% (An et al., 2020).

Photocatalysis is a catalytic oxidation process that utilizes light as an energy source to generate electron-holes pairs, which will be used on the degradation of various pollutants in water (Oladimeji et al., 2024). The application of photocatalysis in wastewater treatment has demonstrated high effectiveness, with relatively low operational costs, since the process requires minimal energy input and the photocatalysts themselves are reusable. However, repeated use of photocatalyst eventually leads to saturation, as the active sites on their surfaces become progressively covered by pollutants. This surface fouling reduces their

ability to adsorb and oxidize contaminants, thereby diminishing performance after several treatment cycles.

In the study conducted by Katoch et al., (2024), the photocatalytic efficiency of anatase  $\text{TiO}_2$  in degrading  $\text{Cr(VI)}$  declined from 95% to 50% by the ninth cycle, primarily due to the accumulation of  $\text{Cr(III)}$  on the  $\text{TiO}_2$  surface. A similar phenomenon is likely to occur on the Resin Immobilized Photocatalyst-  $\text{TiO}_2$  (RIPT-  $\text{TiO}_2$ ). Consequently, a desorption step is required to release the  $\text{Cr(III)}$  species that accumulate on the RIPT-  $\text{TiO}_2$  surface, thereby restoring its active sites and enhancing its pollutant degradation capacity in subsequent cycle.

Desorption is the process by which pollutants are released from the active surface of a photocatalyst (Sati, 2023). This process can be carried out through ion binding using acidic solutions, chelating agents, or by exchanging with other ions. During desorption, chemical reactions occur between the desorbing solution and the photocatalyst, resulting in the release of ions from its surface. Such chemical interactions may alter the surface characteristics of the material, including changes in functional groups and the morphology of the photocatalyst structure. These modifications can influence the ion release capacity and affect the overall effectiveness of the photocatalyst in subsequent treatment cycles.

A study by reported that the release of  $\text{Cr(III)}$  from the surface of  $\text{TiO}_2$  can be achieved using organic acids, such as citric acid, with desorption efficiencies reaching up to 90.13% (Djellabi et al., 2016). Nevertheless, research examining the material characteristics following desorption remains limited, particularly in relation to Resin Immobilized Photocatalyst-  $\text{TiO}_2$  (RIPT-  $\text{TiO}_2$ ). Based on this gap, this study was conducted to analyse the influence of different desorbing solutions, such as deionized water, citric acid, and sulfuric acid on the functional groups and morphology of RIPT-  $\text{TiO}_2$ , as well as its capacity to release  $\text{Cr (III)}$ . Artificial  $\text{Cr(VI)}$  wastewater was employed to ensure controlled concentrations, thereby allowing for more accurate analysis. This research is expected to provide insights into the effectiveness of desorption in maintaining the stability and performance of RIPT-  $\text{TiO}_2$  in degrading  $\text{Cr(VI)}$ , supporting the application of photocatalysis in accordance with environmentally friendly principles and sustainable energy.

## 1.2 Problems of the Study

Based on the background of the study, this study is conducted to answer this following questions :

1. How does desorption solution (deionized water, citric acid 0,1 M, and sulfuric acid 0,1 M) affect the changes in functional groups on Resin Immobilized Photocatalyst-TiO<sub>2</sub> (RIPT-TiO<sub>2</sub>)?
2. How does the capacity of Resin Immobilized Photocatalyst-TiO<sub>2</sub> (RIPT-TiO<sub>2</sub>) to release Cr (III) during the desorption process?
3. How does the desorption cycle influence the changes in the mass distribution of Cr (III)?

## 1.3 Objectives of the Study

Concerning the problems of the study above, the objectives of this astudy are as follows :

1. To analyze the effect of desorption solution (deionized water, citric acid 0,1 M, and sulfuric acid 0,1 M) on the changes in functional groups on Resin Immobilized Photocatalyst-TiO<sub>2</sub> (RIPT-TiO<sub>2</sub>)
2. To analyze the capacity of Resin Immobilized Photocatalyst-TiO<sub>2</sub> (RIPT-TiO<sub>2</sub>) to release Cr (III) during the desorption process
3. To analyze the influence of desorption cycle on the mass distribution of Cr (III).

## 1.4 Significance of the Study

Based on the objectives and problems above, this study is expected to provide significance impact to :

1. Researchers, as both experience and knowledge related to photocatalyst desorption processes and mass balance analysis.
2. Academition, as a reference in the field of catalysis, particularly about desorption processes and the effectiveness of photocatalysts.
3. Readers, as a source of information on wastewater treatment technologies, especially for wastewater containing heavy metals such as hexavalent chromium (Cr(VI)).

### **1.5 Scope and Limitation**

The scope of this study includes :

1. The wastewater of this research is artificial wastewater containing hexavalent chromium (Cr(VI)).
2. The photocatalyst applied is an anion resin immobilized on TiO<sub>2</sub>.
3. Both the photocatalysis and desorption processes are conducted in a batch system
4. This study is carried out on a laboratory scale at the Research Laboratory of the Department of Environmental Engineering, Faculty of Engineering and Science, UPN “Veteran” East Java.