

## Treatment of Cr<sup>6+</sup> using phytoremediation method in Rante Pond of PT. Vale Indonesia Tbk.

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### ABSTRACT

PT. Vale Indonesia, Tbk is one of the companies that's included in nickel's mining industry in Sorowako village, Nuha District, East Luwu Regency, South Sulawesi Province. The mining method used is an open pit method which in its application is inseparable from water problems. One of its problems is the wastewater of mining activity acquired was not in accordance with the standard of wastewater in the Indonesian regulation number 32 of 2009 regarding environmental protect and management. The amount of Chromium Hexavalent is not less than 0.1 ppm. It will cause the toxic in the body and damage the environment. In Rante pond's research area, the initial concentration of Cr<sup>6+</sup> is so high, that is 0.88 ppm. So, the treatment is needed to reduce the concentration of Cr<sup>6+</sup>. In this study, researcher used phytoremediation method to reduce pollutants of water that utilize plants to transfer, stabilize, or degrade the existing pollutants of water. The plant media used was water-hyacinth. So that, the phytoremediation method had been able to reduce the concentration of Cr<sup>6+</sup> for 7 days from the initial concentration is 0.88 ppm to 0.28 ppm.

**Keywords:** *PT. Vale Indonesia Tbk.; chromium hexavalent; Rante pond; phytoremediation; water-hyacinth.*

### 1. INTRODUCTION

The mining industry both metal and non-metal in Indonesia is one of the largest industries besides agriculture industry. The metal mining industry is particular concern with the rising demand for quality of metal need in this decade [1].

PT. Vale Indonesia Tbk. is the largest nickel mining company in Indonesia. PT. Vale Indonesia Tbk. is located in Sorowako, Nuha District, East Luwu Regency, South Sulawesi Province. Nickel (Ni) is a silvery-white lustrous metal with a slight golden tinge, hard and ductile, and corrosion resistant, as well as retains its mechanical and physical properties

even when placed at very high temperatures [2].

The mining business takes into account the income and expense of the company as the mining business which wants to gain the maximum profit, as well as the wastewater treatment of mining business to meet the quality standards of waste water listed in the Law Number 32 of 2009 concerning Environmental Protection and Management [3].

PT. Vale Indonesia Tbk. has a concentration value of Cr<sup>6+</sup> 0.88 ppm, so it is necessary to do the treatment to meet the quality standard of waste water listed in the Indonesian Government Regulation Number

32 of 2009 concerning Environmental Protection and Management. In the processing of Chromium Hexavalent ( $\text{Cr}^{6+}$ ), PT. Vale Indonesia Tbk. has met the quality standard by using ferro-sulfate ( $\text{FeSO}_4$ ) as a medium of decreasing the concentration of  $\text{Cr}^{6+}$  to 0.1 ppm. However, it requires a very large cost and if excessive use of  $\text{FeSO}_4$  will increase the concentration of Fe in water, so it needs another treatment as the alternative treatment. One of the processing offered is phytoremediation method which is the process of decreasing the contaminant level by using the plant as its indicator. In this case the plant is Water-Hyacinth. Water-Hyacinth is expected can reduce the concentration of  $\text{Cr}^{6+}$  that exist in the mining area.

The purposes of the study are knowing the characteristic of  $\text{Cr}^{6+}$  in waste water of mining activities, the phytoremediation method, and the effectiveness of phytoremediation method of  $\text{Cr}^{6+}$  concentration.

## 2. METHODOLOGY

The research stages consist of literature study and field observation by collecting primary and secondary data. Field observations are conducted to collect informations on preliminary studies. It is conducted to find the issues that must be investigated and the initial recognition in the research sites. The research sites is Rante Pond PT. Vale Indonesia Tbk. Sorowako. This research only discussed about the value of water reduction containing  $\text{Cr}^{6+}$  concentration

by using phytoremediation method of water hyacinth. This research also includes the control of factors that affect to concentration of  $\text{Cr}^{6+}$  after using the phytoremediation method for 7 days.

Primary data are data taken directly in the field by researchers, such as data concentration of  $\text{Cr}^{6+}$ , length of plant roots, and weight of plants. Primary and secondary data that have been obtained then processed and analyzed using phytoremediation method. Data processing is a change of raw data taken from the field which then compiled and calculated by phytoremediation method. Furthermore, the acquired results will be used to the next calculation that accordance with the existing problem. Data analysis of this problem is consisted of the characteristics of  $\text{Cr}^{6+}$ , phytoremediation stage, and effectiveness of phytoremediation method. So get a conclusion and recommendation of output for company. Eventually, the conclusion and recommendation output for the company as a problem solving will be obtained.

Secondary data obtained from archives and data that already exist in the company. The data used as completeness in accomplishing the research are map of research location, tools and materials used, water discharge of Rante Pond for one month.

### A. Characteristic of $\text{Cr}^{6+}$

In this stage, the researchers look at the general characteristics of the water appearance that has been contaminated with  $\text{Cr}^{6+}$ . It conclusion is based on the water of Rante

Pond before phytoremediation method with water-hyacinth as the media is conducted.

### **B. Stages of Phytoremediation Method Cr6+**

Phytoremediation method is one method to decrease Cr6 + concentration based on several considerations and testing. In this research, researcher has used phytoremediation method by using hyacinth plant media. Here are the test steps:

Water sampling contaminated with Cr6 +. At this stage, researcher takes water samples at the research site of Rante Pond. the initial concentration of Cr6+ is 0.88 ppm before using the phytoremediation method. at the time of water sampling, the researcher used a shelter with 15 liters of water for each sample.

At the stage of sampling of plant media, the researcher obtained a sample of water-hyacinth plant at the location of the tourist spot located in Sorowako, namely the Matano Lake with the weight and the phase of the plant taken at random.

Measurement of plant weight. at the time of determining the weight of the sample plants, the researcher used a trial method in each sample. for weight measurement, the researcher uses analytic scales so that the experimental study has the plant weight. sample A has a 900 gram plant weight, sample B has a plant weight of 840 grams, sample C has a weight of 780 grams of plant.

Measurement of Length of plant roots. At this stage, the measurement uses a ruler with centimeters (cm). the aim is to know the presence or not of influence Root length in the

study. In sample A has a phase of water hyacinth plant. it is a medium phase with a thick roots and the root length is 17 cm. sample B has a phase of water hyacinth plant. it is the phase of medium and old, and the root length is 22.3 cm. sample C has a phase of water hyacinth plant. it is a medium phase that has a thick roots, and has a root length of 23 cm.

### **C. Effectiveness of Phytoremediation Method**

At this stage the researchers determine the concentration of water contaminated Cr6+ for 7 days through phytoremediation method. its aimed for showing the value of change of Cr6+ concentration. The ways to determine the concentration value of Cr6+, that are:

Add water contaminated by Cr6+ in a cuvette of 25 ml and 1 pack of chromaver powder. Cover the cuvette bottle, and blend (chromaver + water) until powder cromaver is not visible by shaking it. After mixed well, wait for 5 minutes. Determine the Cr6+ concentration value on the calorimeter tool, and note the result into the books.

After knowing how to determine the concentration of Cr6+, then the researchers record the level of reduction of Cr6+ concentration. Its way is calculating the value of Cr6+ concentration per day, which has used water-hyacinth on phytoremediation method. Thereafter, conclude the factors affecting the reduction of Cr6+ concentration values, as well as conclude the effectiveness of the phytoremediation method when the weight of the plant does not match with the expected

absorption of Cr6+ concentration. The formula used is as follows:

$$BT_{lab} = \left[ \frac{E1}{E2} \right] \times RB \quad (1)$$

Where:

$BT_{lab}$  = Ideal plant weight (gr / L)

E1 = expected effectiveness (%)

E2 = Actual effectiveness (%)

RB = Mean of actual plant weight (gr/ L)

The equation above (1) to know the ideal plant weight expected to reach the appropriate concentration of waste water quality standards. For that effectiveness is expected. actual effectiveness and average actual plant weight need to modify the equation to determine the ideal plant weight. So the similarities equation used to be:

$$E1 = \left[ \frac{Co - Cbk}{Co} \right] \times 100\% \quad (2)$$

Where:

E1 = Expected effectiveness (%)

Co = Initial concentration (ppm)

Cbk = Concentration according to standard quality (ppm)

$$E2 = \left[ \frac{Co - Clab}{Co} \right] \times 100\% \quad (3)$$

Where:

E1 = Actual effectiveness (%)

Co = Initial concentration (ppm)

Clab = The final concentration of the test (ppm)

Average Weight Plants in the experiment used a 900 gram plant weight for 15 liters has a level of Cr6 + absorb well, so the weight of the plant for 1 liter using 60 grams.

After getting the expected effectiveness, then we can know the amount of weight of the plant in Rante Pond. At this stage the researcher calculates the weight of water hyacinth plant as a medium of phytoremediation method which is inserted into Rante Pond to reach Cr6 + concentration according to the quality standards of nickel mining waste water by using the formula:

$$J = \left[ \frac{Q}{Q_{lab}} \right] \times BT_{lab} \quad (4)$$

Where:

J = Total weight of plant that meets the standard of Cr6+ (kg)

Q = Volume of Rante Pond (L / h)

$Q_{lab}$  = Water discharge at laboratory (L / h)

$B_{tlab}$  = Weight of plants to meet the quality standards in the laboratory (kg / L).

### 3. RESULTS AND DISCUSSION

#### A. Characteristics of Cr6+

Cr6+ or better known as hexavalent or hexavalent chromium is an element that is toxic to humans and damage to environment. In general, the presence of the lowest chromium concentration is in the top soil layer and gradually the concentration increases in the limonite layer, medium grade limonite, and

the highest accumulation in the layer transition zone [3], [5]. Chromium is in nature combined with some elements such as Iron (Fe) [5], [6]. Nickel ore containing Cr6+ of Aluminum (Al) and Magnesium (Mg) in the form of spinel that is strong and resistant [4]. Water containing Cr6+ has the characteristics of mining waste water, namely: phytoremediation

method using water hyacinth plant media are plant weight, plant growth phase, and dense plant roots. The results of this study are shown in Table 1 and Fig. 1. Furthermore, comparison and variation of decline chart of Cr6+ concentration using water hyacinth as the media in phytoremediation method is illustrated in Fig. 1.

Table 1. The variation of concentration Cr6+ (Chromium Hexavalent) during seven days with initial concentration of Cr6+ 0.88 ppm.

| Vegetation         |               | Water Volume (L) | Initial Cr6+ Concentration (ppm) | Decreased of Cr6+ concentration on N-day (ppm) |      |      |      |      |      |      | Remarks  |
|--------------------|---------------|------------------|----------------------------------|--|------|------|------|------|------|------|--|
| Species            | Weight (gram) |                  |                                  | 1  | 2    | 3    | 4    | 5    | 6    | 7    |  |
| Water Hyacinth (A) | 900           | 15               | 0.88                             | 0.66   | 0.40 | 0.47 | 0.46 | 0.48 | 0.33 | 0.28 | 1. The medium phase.<br>2. The root length is 17 cm and dense. |
| Water Hyacinth (B) | 840           | 15               | 0.88                             | 0.67   | 0.45 | 0.57 | 0.55 | 0.37 | 0.41 | 0.39 | 1. The old phase.<br>2. The root length is 23.3 cm.            |
| Water Hyacinth (C) | 780           | 15               | 0.88                             | 0.65   | 0.51 | 0.57 | 0.49 | 0.44 | 0.60 | 0.43 | 1. The medium phase.<br>2. The root length is 23 cm and dense. |

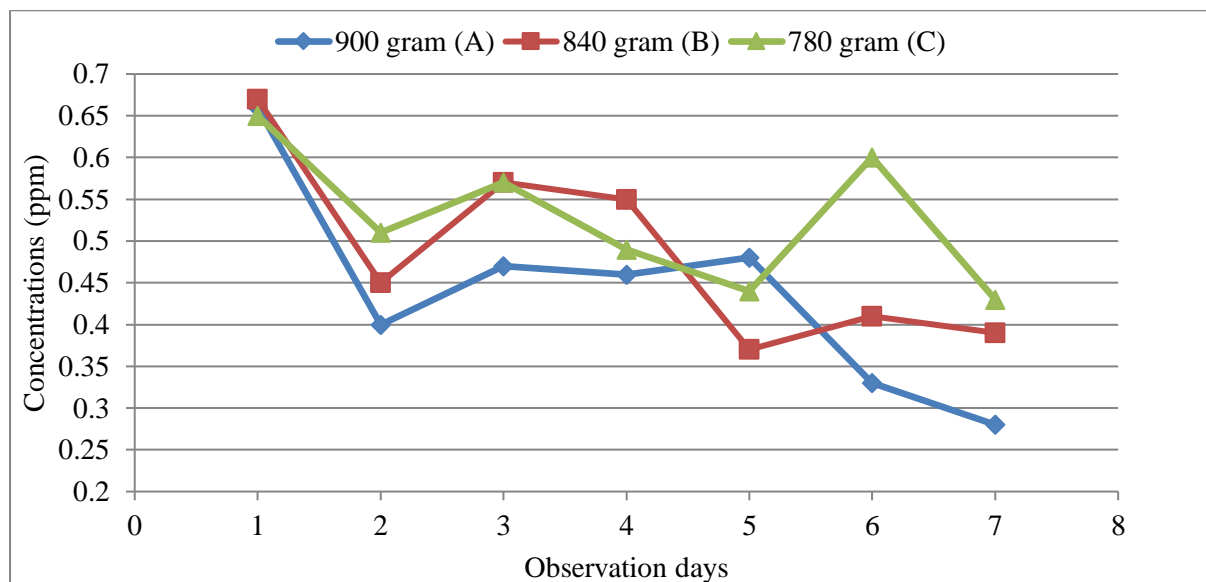


Fig. 1. Comparison of decline chart of Cr6+ concentration using phytoremediation method of water hyacinth Media for 7 days.

### B. Cr6 + Concentration Level

Factors that affect the decreasing level of Cr6+ concentration in the phytoremediation method using water hyacinth plant media are plant weight, plant growth phase, and dense plant roots. While plant roots have no effect at all parameters. Detailed data and information of the concentration level of Cr6+ in this study are shown in Table 1 and Fig. 1.

The graph in Fig. 1 shows the comparison of each sample using the phytoremediation method of water hyacinth. From the graph presented, it has a significant decrease on the 2nd day. It can be seen the level of decrease in concentration per day. In sample A decreased to 0.40 ppm, Sample B decreased to 0.45 ppm, and sample C decreased to 0.51 ppm. So the best concentration decrease of Cr6+ occurred on the 2nd day on laboratory scale. However, on day 5, sample B has a concentration of 0.37 ppm and sample C has a concentration of 0.44 ppm. On day 6, sample B has a concentration of 0.41 ppm and sample C has a concentration of 0.60 ppm. This experienced an increase in the value of Cr6 + concentration caused by the falling roots of the water-hyacinth. so that, the root of plants become one of the factors that affect the level of Cr6+ concentration.

### C. Level of Effectiveness

#### a. Value of Expected Effectiveness

$$E1 = \left[ \frac{Co - Cbk}{Co} \right] \times 100\%$$

$$E1 = \left[ \frac{0.88 - 0.1}{0.88} \right] \times 100\%$$

$$E1 = 88.64\%$$

#### b. Actual Effectiveness Value

$$E1 = \left[ \frac{Co - Cbk}{Co} \right] \times 100\%$$

$$E1 = \left[ \frac{0.88 - 0.28}{0.88} \right] \times 100\%$$

$$E1 = 68.18\%$$

#### c. Average Plant Weight

The experiment uses a 900 gram plant weight for 15 liters of water. This has a well-absorbed concentration of cromium hexavalent (Cr6+), so that the weight of the plant for 1 liter uses 60 grams.

#### d. The weight of Plants to Achieve Quality Standards In 1 Liter

$$J = \left[ \frac{Q}{Q_{lab}} \right] \times B_{Tlab}$$

$$J = \left[ \frac{1.358}{1} \right] \times 77,3$$

$$J = 105 \text{ kg}$$

## 4. CONCLUSION

Characteristics of waste water of nickel ore containing chromium hexavalent (Cr6+) are a clear color, no smell, viscosity in water as usual. On the study of concentration decline of Chromium Hexavalent (Cr6 +) using water hyacinth in phytoremediation method, has several testing steps: water and plant sampling, initial Cr6+ concentration measurement in waste water, plant weight measurement, and measurement of root length.

The effectiveness level of phytoremediation method with water-hyacinth on chromium hexavalent (Cr6+) is 68.18%. The initial concentration value of 0.88 ppm to 0.28 ppm. The effectiveness of the phytoremediation method is strongly influenced by several factors, those are plant

weight, bush roots, and plant growth phase. From the results of the study, it can be concluded that is need for washing and cleaning plants. It aims to eliminate plant pests and can be known to the alive roots that are carried on water-hyacinth plant. The need for special hazardous and toxic materials dumps for Chromaver waste and sample of Chromium Hexavalent (Cr6+) to avoid polluting the environment. The ideal plant weight to achieve the quality standard is 77.3 gr/L. whereas the ideal plant weight to achieve quality when inserted at Rante Pond of PT. Vale Indonesia Tbk., that is 105 kg. Subsequent research should be able to characterize the same parameters. its parameters are length and weight of the same plants.

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