Reduction Of Pb And Cr Levels In Paper Industrial Liquid Waste With Ion Exchange Method

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Abstract. Paper and pulp industry factory is a factory that contributes to national economic development because paper needs per year can reach 100 million tons. But not only the positive impact is given, the negative impact is present because it produces considerable waste. The paper industry's liquid waste is one of the many wastes containing a lot of metal, for example hexavalent Pb and Cr heavy metals. It is necessary to reduce according to government standards in order to reduce negative impacts on the environment. One way to reduce Pb and Cr levels is ion exchange using cation resin 500 ml paper liquid waste mixed with cation resin at a volume and weight ratio of 10: 0.0017; 10: 0.0034; 10: 0.0068; 10: 0.0136; and 10: 0.0272. Mixing is done with a 190 rpm stirrer motor and the variation of time used is 10, 20, 30, 40, and 50 minutes. The best treatment at a ratio of 10: 0.0272 with a time of 20 minutes. The results obtained by Pb and Cr decreased by 94% from the initial level.

1. Introduction
Environmental pollution in the last two or three decades has become a problem that is warmly discussed and is of particular concern both from various academics or scientists. The potential source of water pollution is industrial wastewater. [3][17]. Inorganic industrial waste is more difficult to control and has greater potential hazards. Waste Chemical industry usually contains heavy metal compounds that are toxic.[6][14]. One of the industrial wastes containing metals is the paper and pulp industry. This was proven by the author through a preliminary test which found the content of heavy metals Pb2+ and Cr6+ in their wastewater.[2][10][11]. One of the paper mills in Sidoarjo has liquid waste with a Pb content of 43 mg/l and Cr 0.159 mg/l. This metal content is found in liquid waste which has not been through the waste treatment installation process. One way to reduce metal content is the ion exchange method. [1]. The important properties that are expected from ion exchangers are large capture capacity, high selectivity, large exchange rates, resistance to temperature, resistance to ion exchangers that have been burdened can be done easily, because ion exchange is a reversible process. [4][5][7].

1.1. Reaction Ion Exchange Mechanism
This research, methods will be exchanged for Pb2+ and Cr6+ ions in liquid waste, and exchanged for H+ ions using cation resin. [13][16]
Here's one of the reactions:

\[
Pb^{2+} + R-H^+ \leftrightarrow R-Pb^{2+} + H^+ \]
Where the variable carried out in this study is the ratio of the volume of waste with various cation resin weights (volume: weight) and the required variation of stirring time. The conditions specified are the volume of liquid waste and stirring speed.[20]. The processed liquid waste results will be analyzed by AAS (Automic Adsorption Spectrophotometry) Our goal in conducting this research is to find out the cation resin requirements and the time needed so that these levels can be in accordance with established government standards so as to help the paper industry to find out the best treatment for metal reduction in liquid waste.[8][9]

The important properties expected of an ion exchanger are large-capacity retrieval power, large selectivity, large exchange speed, resistance to temperature, resistance to burdened ion exchangers easily, because ion exchange is a process that reversible. [15][19]. Ion exchange can be placed as a unit of operation in equilibrium (equilibrium) chemistry. Ion exchange involves the misplacement of ions given by species from the exchange of insoluble material with different ion species when the last solution is brought to contact or is related / mixed. [18].

Ion exchange can be described with general equilibrium:

\[ B_1^+ + R^- B_2^+ \rightarrow \text{B}_2^+ + R^- B_1^+ \]

**1.2. Factors Influence The Reaction Ion Exchange**

- **pH**
  Ionogenic decomposition ion exchangers do not pay attention to pH, some are strongly influenced by pH according to the acid strength of the base. Phenolic OH groups or carboxylic acids are not elevated at low pH, then the exchange capacity is only optimum at pH of alkaline solutions. The effective pH range of ion exchangers for strong acid cations is 0-14.

- **The concentration of dissolved ions**
  The more concentration of ions to be exchanged, the slower the speed of an ion exchange reaction takes place and the less concentration of ions to be exchanged. This is because the resin has a limited ion capacity.

- **Number of ion exchangers**
  The more the number of ion exchangers in the exchange column, the more the ion concentration will be exchanged.

- **Temperature**
  Ion exchange is influenced by temperature, but practically an increase in temperature is not enough to cause an increase in process rate. New high-temperature surgery is useful if the original solution is at this temperature or if the solution is too thick at room temperature.

- **Flow Speed**
  Flow velocity affects the ion exchange process. The faster the flow rate specified in the ion exchange process, the less the ion concentration can be exchanged. This is due to shorter residence times and contact between seawater and resin. [12]

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**Table 1. Water Quality Standards and Water Pollution Control**

| Parameters       | Class I Quality Standard | Unit |
|------------------|--------------------------|------|
| Chromium (VI)    | 0.05                     | mg/l |
| Lead             | 0.03                     | mg/l |

(Source: Government Regulation Number 82 of 2001)
2. Research Methods
The procedure in this study can be explained that Take 500 ml of waste water to be put into a glass beaker and mixed with an ion exchange resin according to a predetermined weight (the variable being run), then the mixture is stirred using a stirring motor at a speed of 190 rpm during the time predetermined (variable executed). Then the solution is filtered with filter paper to separate the sediment from the filtrate. In this study, using a fixed condition the volume of liquid waste was 500 ml, stirring speed 190 rpm and ph 6 at room temperature. Variables used are variations in resin weight 10: 0.0017; 10: 0.0034; 10: 0.0068; 10: 0.0136; and 10: 0.0272. Then use variations of time 10, 20, 30, 40, and 50 minutes.

Figure 1. The Set Of Stirrer

Figure 2. Research Procedure Block Diagram

3. Result and Discussion
All analyzes in the process of decreasing levels of Cr\(^{6+}\) (hexavalent chrome) and Pb\(^{2+}\) (lead) are analyzed by AAS (atomic adsorbtent spectrophotometry). Based on the analysis of the content of the waste before reducing its metal content, the following data are obtained:
Table 2. Results of Initial Analysis of Plant Waste Content

| Test Parameters                  | Test Results |
|---------------------------------|--------------|
| Copper (Cu)                     | < 0.0223 mg/l |
| Cadmium (Cd)                    | < 0.0078 mg/l |
| Mercury (Hg)                    | < 0.0005 mg/l |
| Lead (Pb)                       | 13.585 mg/l  |
| Hexavalent Chromium (Cr⁶⁺)      | 0.159 mg/l   |
| Nickel (Ni)                     | < 0.0031 mg/l |

In the process of decreasing the levels of Pb²⁺ and Cr⁶⁺ metals from waste looking paper mills using ion exchanges with various variables being carried out, the results of the analysis are obtained, so a more detailed discussion of each test parameter is needed by using the following graph.

Figure 3. The Relation of Pb (lead) levels with stirring time (minutes)

The figure above, it can be seen that there are fluctuations in the Pb level to the time specified. When viewed, the average resin works to absorb Pb well in the range of 10-30 minutes from various additions to the cation resin. Then in the time range of stirring 40-50 minutes the Pb level gradually increases. In the span of 10-30 minutes the resin has absorbed Pb optimally, because of that the capacity of resin in absorbing has been fulfilled. If stirring is continued, a reversible reaction or alternating reaction will occur, so that the absorbed Pb will be released from the resin and H⁺ will be reabsorbed by the resin.

Here is the reaction: 

\[ R-H^+ + Pb^{2+} \leftrightarrow R-Pb^{2+} + H^+ \]

Pb levels decrease gradually. So that it can be concluded that the more resin, the more Pb is absorbed. The best addition of resin and stirring time to be used in decreasing Pb levels was 1.36 g of cation resin with a span of 20 minutes.
Figure 4. The relation of Cr (chrome) levels with stirring time (minutes)

The figure above there is a fluctuating graph. On average, the resin works to absorb Cr well in the range of 10-30 minutes, and when it optimally absorbs Cr at an average time of 30 minutes from various additions to the cation resin. Then in the stirring period of 40-50 minutes the Cr level gradually increases. In the span of 10-30 minutes the resin has absorbed Cr optimally, because of that the capacity of resin in absorbing has been fulfilled. If stirring is continued, a reversible reaction or alternating reaction will occur, so that the absorbed Cr will be released from the resin and H + will be reabsorbed by the resin. Here is the reaction:

$$R-H + Cr^{6+} \leftrightarrow R-Cr^{6+} + H^+$$

Cr level decreases gradually. So that it can be concluded that the more resin, the more Cr is absorbed. The best addition of resin and stirring time to use is 1.36 gr cation resin with a span of 10-30 minutes.

Figure 5. The relation of Pb (lead) levels with weight of cation resin (gram)
Viewed from the graph of adding resin to the Pb level above. On the addition of 0.085; 0.17; 0.34; 0.68; 1.36 gram resin and stirring time of 10 minutes can be seen that the content of Pb content decreases gradually. Where the levels of Pb ion which are highly interchanged occur in the addition of 1.36 gram resin. This also happens when stirring 10; 20; 30; 40; and 50. So it can be said that the more addition of resin the more Pb ions are exchanged with resin. From the graph above it can be concluded that the best addition of resin and stirring time in our study was 1.36 gr of cation resin with a span of 20 minutes.

![Figure 6](image_url)

**Figure 6.** The relationship of Cr (chrome) levels with weight of cation resin (gram)

Viewed from the graph of adding resin to the Cr levels above. On the addition of 0.085; 0.17; 0.34; 0.68; 1.36 grams resin and stirring time of 10 minutes can be seen that the content of Cr content decreases gradually. Where the levels of Cr ions which were highly interchanged occurred in the addition of 1.36 gram resin. This also happens when stirring 10; 20; 30; 40; and 50. So it can be said that the more resin is added, the more Cr ions are exchanged with resin. From the graph above it can be concluded that the best addition of resin and stirring time in our study was 1.36 gr of cation resin with a span of 30 minutes.

4. Conclusion
The conclusions for this research are as follows:

- The best of the addition 1.36 gr of cation resin with a span of 20 minutes Pb levels decreased from 13 mg/l to 0.02 mg/l.
- The best of the addition 1.36 gr of cation resin with a span of 30 minutes Cr levels decreased from 0.159 mg/l to 0.001 mg/l.
- The best treatment of paper liquid waste so that it can pass the quality standard is the addition of 1.36 gr of cation resin in 20 minutes which can reduce Pb levels to 0.02 mg / l and Cr to 0.001 mg / l according to factory waste quality standards.

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