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REMOVAL PB^{2+} OF WELL WATER USING PUROLITE C-100 RESIN AND ADSORPTION KINETIC

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ABSTRACT

Lead is one of important pollutants. Well water is polluted in urban society in Pasuruan, East Java, Indonesia. This water is heavily polluted. The aim of this study was studying removal lead from well water using purolite C-100 resin. This research focused on adsorption kinetics of PB^{2+} ion by purolite C-100. The kinetic method was developed using Freundlich and Langmuir isotherm equation. Variable used was resin mass and flow rate air. The result of this research showed that % Removal Lead (II) purolite C-100 resin was able to reduce Pb2+ ion contentat operation condition of resin mass 10-50 g and flow rate air of 0.02-0.04L.s^{-1} was very good, namely 95.78 – 99.57%. The result of Freundlich equation produced constants of n = 0.5456 and K_f = 922.1467 while Langmuir equation produced constants A_s = 0.0067 and K_b = 298.8661.

KEY WORDS : Flow rate, Freundlich, Langmuir, Mass, Purolite C-100

INTRODUCTION

Polluted drinking water sources are becoming a problem to be resolved. This study was very concerned with this problem, especially pollution from heavy metals. Several kinds of the research reported that contaminant often found in groundwater, such as Pb (II) and Cr (III)) (Kusdarini *et al.*, 2019; Kusdarini *et al.*, 2019b), Mn (II) (Kusdarini and Budianto, 2018), radioactive substances(Levitskaia *et al.*, 2020), organic substances (Jamil *et al.*, 2019; Jamil *et al.*, 2020), bromide (Soyluoglu *et al.*, 2020), Sb (III) dan Fe(II) (Moghimi *et al.*, 2020), (Kusdarini *et al.*, 2018; Lalmi and Bouhidel, 2018), Ca(II), Ni(II), Pb(II), Al(III) (Stefan and Meghea, 2014). Lead is one of the contaminants inside of water, which endangers human health because the properties of a hazardous substance are non-biodegradable, so, it will accumulate in the body. Lead can cause disturbance in metabolism, reproduction, growth, activities, and endanger human survival (Chabukdhara and Nema, 2012).

Lead pollutants are also found in an urban area, like in Pasuruan, East Java, Indonesia. Groundwater contained lead and the lead level around 0.15 - 0.23 mg.l^{-1}. This water has not met requirements if the society used this water as drinking water (Menteri Kesehatan Republik Indonesia, 2010). Previous research explained that several low-cost treatment methods could reduce pollutant in the water, like active carbon (Kusdarini *et al.,* 2017; Budianto *et al.* 2019), ion exchangers(Kusdarini and Budianto, 2018; Kusdarini *et al.,* 2018), and filtration(Kusdariniet al., 2019). Previous researcher has studied groundwater treatment using Amberlite IR 120 Na resin. The results showed Amberlite IR 120 Na resin could reduce lead content more than 95% (Kusdarini *et al.,*). Amberlite IR 120 Na resin's abilityto remove Pb^{2+} was excellent, but Amberlite IR 120 Na resin's price is relatively higher than other resins.

The researchers tried to use purolite resin to remove pollutants in the water. A530E purolite resin was able to treat more than 5.38 x 109L of

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contaminated groundwater and manage to remove about 3.78 Ci technetium-99 during four years of operations (Levitskaia *et al., 2020)*. The Br-purolite resin was able to separate Br 93.5 ± 4.5% for an initial Br concentration of 0.25 $mg.l^{-1}$ with anions competition, like Cl^-, NO^{3-}, NO^{2-}, SO_4^{2-}, PO_4^{3-} (Soyluoglu *et al*., 2020). Purolite resin was also able to improve the performance of granule active carbon (GAC) to remove dissolved organic carbon and microorganic carbon (Jamil *et al*., 2020). S957 purolite resin had a maximum adsorption capacity of 46.63 mg/g to Ni(II) and 60.75 mg / g for La (III) (Araucz *et al*., 2020).

Several studies showed that purolite resin had good ability in adsorb some pollutants, but resin's performance has not been tested in Pb^{2+} ion removal, which was contained in groundwater. The research used to test purolite resin performance in overcoming groundwater pollutant, especially removing lead.

MATERIALS AND METHODS

This research was conducted in laboratory experiments using well water, and the well lead was polluted by lead. The resin material used as Purolite C-100 adsorbs with Purolite C-100 resin (characteristics shown in Table 1).

The equipment set-up system in shown in Fig. 1.

Water treatment equipment consisted if an input, a pump, exchanger cation, and output water tank. Exchanger cation column was a cylinder, the diameter was 4 inches, and the height was 16 inches. The distance of resin support was 3 inches from the exchanger cation column base. The step in this study was pumping polluted water, which has known Pb content in the exchanger cation with a certain flow rate. Flow rate feed water was 0.02 $L.s^{-1}$, 0.03 $L.s^{-1}$, and 0.04 $L.s^{-1}$. Exchanger cation used contained Purolite C-100 resin of 10 g. Water from the adsorption process and exchanger cation was accommodated in output tank. Furthermore, the researchers analyzed water quality by pH measuring, temperature, and lead (II) content. In the water, testing of Lead (II) ion content used atomic absorption spectrophotometry (AAS) method.

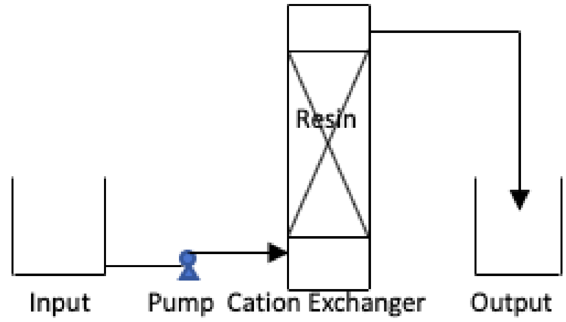

Fig. 1. A series of water treatment equipment

These experiments conducted over and over in the same way, but the researchers just changed the content of Purolite C-100 resin exchanger cation, such as 30, 40, and 50 g. The researchers conducted three times for each experiment to obtain average data. They processed analysis data result of water process by calculate % removal and get adsorption kinetics equation using Freundlich and Langmuir equation.

Purolite C-100 resin ability to remove Pb^{2+} ion in the water was expressed in % Pb removal (equation 1).

$$\%\ \text{Removal Pb}\ (\eta) = \frac{CPb\ Feedwater - CPb\ output)}{CPb\ feed\ water} \times 100\% \quad (1)$$

C_{Pb}feed water is Pb content in the feed water, and C_{Pb} output is Pb content in treated water by equipment series.

Table 1. Purolite C-100 Resin Characteristics

Polymer Structure	Gel polystyrene crosslinked with divinylbenzene
Appearance	Spherical Beads
Functional Group	Sulfonic Acid
Ionic Form	Na^+ form
Total Capacity	2.0 $eq.L^{-1}$ (43.7 $Kgr.ft^{-3}$) (Na^+ form)
Moisture Retention	44 - 48 % (Na^+ form)
Particle Size Range	300 - 1200 µm
< 300 µm (max.)	1 %
Uniformity Coefficient (max.)	1.7
Reversible Swelling, $Na^+ \rightarrow H^+$ (max.)	8%
Specific Gravity	1.29
Shipping Weight (approx.)	800 - 840 g/L (50.0 - 52.5 lb/ft^3)
Temperature Limit	120 °C (248.0 °F)

Removal of Pb^{2+} ions from well water is carried out through an adsorption process. In the adsorption process, exchange reaction took place, and adsorption occurred was physical adsorption, electrolyte molecule adsorption, complex formation between central ion and functional complex, and hydrates formation in the surface or in the absorbent pores. In the adsorption process, concentration and temperature system affected resin ability to absorb metals. If the adsorption process took place at a constant temperature, the numbers Pb^{2+} ion which was able to be adsorbed described in isothermal adsorption equation. This research used Freundlich and Langmuir equation for the adsorption equation.

Freundlich equation was explained in equation (2).

$$\frac{x}{m} = K_f C_e^{\frac{1}{n}} \quad .. (2)$$

Adsorbent capacity ($\frac{x}{m}$) is the numbers of Pb^{2+} ion adsorbed per unit mass of resin (ppm/g), Ce is Pb^{2+} io concentration in adsorbate after desorption (ppm), K_f and n are empiric constants (Kusdarini *et al.*, 2018). K_f and n constant can be found by equation (3)

$$\text{Log}\frac{x}{m} = \log K_f + \frac{1}{n}\log C_e \quad (3)$$

Plotting data used Freundlich equation, and Langmuir equation obtained constant data which had function as lead adsorption kinetics equation using that resin.

RESULTS AND DISCUSSION

Removal Pb

Analysis result of Pb^{2+} ion content at feed water was 0.23 $mg.L^{-1}$ in the temperature of 27.5°C and pH 8.1. This content has not met the quality standard of Pb content for maximum drinking water of 0.01 $mg.l^{-1}$(Menteri Kesehatan Republik Indonesia, 2010), and maximum clean water was 0.05 $mg.l^{-1}$(Menteri Kesehatan Republik Indonesia, 2017). It showed that feed water has not met as drinking water requirements and clean water. Furthermore, the analysis result for Pb^{2+} ion content of output water process used Purolite C-100 resin with resin mass, and flow rate (Q) variables and the continuous system was presented in Table 2.

Table 2 showed that the content of Pb^{2+} ion at output water withPurolite C-100 resin had met requirements of clear and drink water. Purolite C-100 resin was kind enough to remove Pb^{2+} ion feed water. The calculation result of % Removal lead (II) used Purolite C-100 resin from feed water in resin mass variations, and the flow rate of feed water was presented in Figure 2.

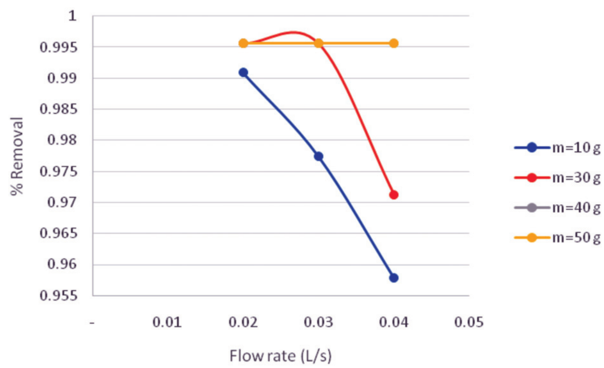

Fig. 2. Removal lead (II) used Purolite C-100 resin in resin mass variations and flow water of feed water

Figure 2 showed that % Removal Lead (II) by Purolite C-100 resin was 95.78 – 99.57%. Lead (II) Removal by resin was stable at a resin mass condition at least 40g. Optimal condition of Pb^{2+} ion removal process in mass by 40g resin with flow rate air 0.04 $L.s^{-1}$ or equivalent to flowrate load /kg resin 1 $L.s^{-1}Kg^{-1}$. The optimal condition of the operating process was also obtained at 60g resin mass user, but the maximum flow rate air 0.02 $L.s^{-1}$ or equivalent flowrate load resin /kg of 0.667 $L.s^{-1} Kg^{-1}$. It was in accordance with %Pb removal chart in the resin load range between 0.4 - 4.0 $L.s^{-1}.Kg^{-1}$ as shown in Fig. 3.

Figure 3 showed that % removal was optimal and stabile in load resin between 0.4 – 1.0 $L.s^{-1}.Kg^{-1}$ and it has decreased in higher resin load. In flow rate resin load 2 $L.s^{-1}$ per Kg resin ($L.s^{-1}.Kg^{-1}$) showed that this rate has experienced on the optimum condition and would go down if the load increased. The research result of Purolite C-100 resin user had an ability to remove lead (II) and show better performance compare with Amberlite IR 120 Na (Kusdarini *et al.*, 2018).

Removal % of Lead (II) by Purolite C-100 resin without eluting substance helping showed similarity

Table 2. The content of Pb^{2+} water output after it was processed using Purolite C-100 resin in various resins (m) and volumetric rate of feed water (Q)

Q ($L.s^{-1}$)	Pb^{2+} ion content ($mg.l^{-1}$)			
	m1=10 g	m2=30 g	m3=40 g	m4=50 g
0.02	0.0021	0.001	0.001	0.001
0.03	0.0052	0.001	0.001	0.001
0.04	0.0097	0.0066	0.001	0.001

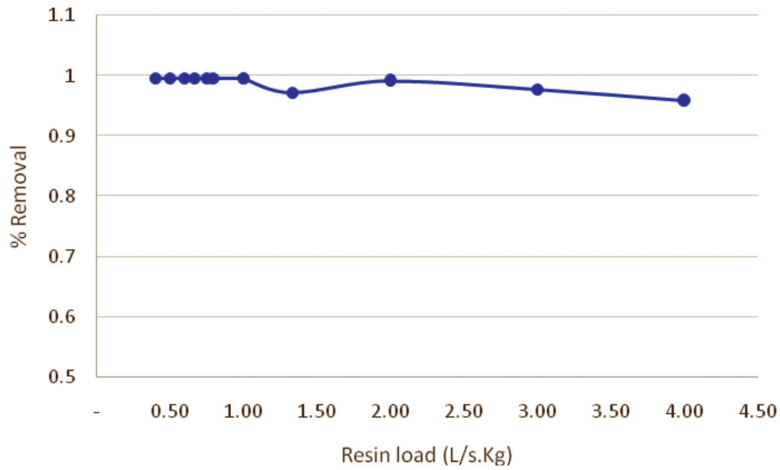

Fig. 3. % Removal Lead (II) in various resin load (L.s^{-1} Kg^{-1})

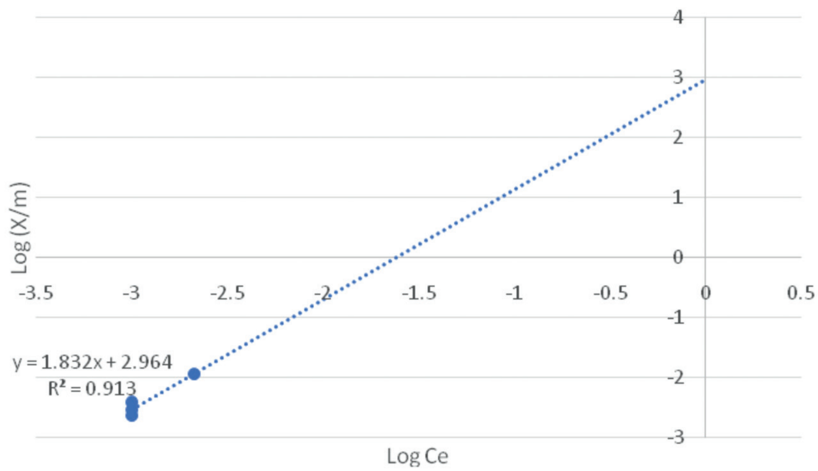

Fig. 4. Relationship of log (X/m) vs log Ce at Freundlich equation

result with lead adsorption research using purolite C-100 resin, and it needed the help of HNO_3 2 – 4 M eluting agents. Lead recovery total was 95.59 - 99.9%, and CH_3COONH_4 1 – 4 M eluting agents helped with recovery lead total was 99.4 - 100% (Badawy *et al.,* 2009).

Isotherm Adsorption Kinetics

Freundlich Equation

The graph to explain the Freundlich equation produced by this research is shown in Figure 4.

This research produced graph of log (X/m) vs log Ce from the Freundlich equation (Fig. 4). The calculation result of this equation (3) and Figure 4 showed that the cost for 1/n was 1.8329, so n was 0.5456. Then, log K_f was 2.9648, so the K_f value was 922/1467. Freundlich equation from isotherm adsorption kinetics of purolite C-100 resin to Pb^{2+} ion contained in well water was explained in equation (4).

$$\frac{x}{m} = 922.1467\ C_e^{1.8329} \quad .. (4)$$

Figure 4 showed the Freundlich equation, which was produced was accurate because correlation R coefficient close to 1 was 0.9558.

Langmuir Equation

Langmuir equation presented in equation (5).

$$\frac{C}{q} = \frac{1}{Kb} + \frac{C}{As} \quad .. (5)$$

A_s and K_h were q coefficient. Q was Pb^{2+} ion load adopted at per unit weight of the resin (ppm.g^{-1}), and C was Pb2+ ion concentration in well water after passed (ppm) (Jasper and Sumithra, 2020;

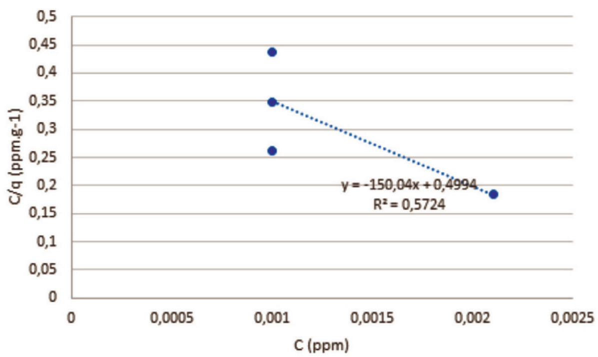

Fig. 5. Relationship C/q vs C at Langmuir equation

Kusdarini *et al.*, 2018). Figure 5 was a graphic for the Langmuir equation.

This study produced graphic pf C/q vs C from Langmuir equation. The Langmuir equation constants at equation (5) could be found in Figure 5. Calculation result showed the value of $\frac{a}{As}$ = 150.04, so, A_s= 0.0067 while the value of Term $\frac{1}{KbAs}$ (was 0.499, so, K_b was 298.8661. Isotherm adsorption kinetic of purolite C-100 resin to the Pb^{2+} ion could be formulated using Langmuir equation, namely equation (6).

$$\frac{C}{q} = 0.4994 \quad \frac{C}{0.0067} \qquad (6)$$

Correlation (R) coefficient from the Langmuir equation obtained in Figure 5 of 0.7566, so, the Langmuir equation received was accurate enough.

CONCLUSION

The ability of purolite C-100 resin at Pb^{2+} ion removal from well water was excellent. In operation condition, flow rate air load was 0.5 – 0.4 $L.s^{-1}$ per kg, and the resin was able to reduce Pb^{2+} ion content in well water about 95.78 – 99.57%. Lead content in water output has met drink water requirement based on *Permenkes* RI Number 492-Year 2010. Then isotherm adsorption kinetic resin used Freundlich equation producing constant n = 0.5456 and K_f = 922.1467. Whereas, kinetic adsorption testing used Langmuir equation and it produced constants A_s = 0.0067 and K_b = 298.8661. Freundlich equation produced was more accurate in prediction of isotherm adsorption kinetic than Langmuir equation based on correlation coefficient value.

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