Reduction of lead (II) from aqueous solution by biosorbent derivated from lengkeng (euphoria logan lour) shell with batch method

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Abstract. Adsorbent prepared from lengkeng shell was successfully use to reduce lead from aqueous solution in a batch method. Batch experiments were performed as a function of various experimental parameters. They were pH solution, Pb (II) ion contact time, and initial concentration. The research reveal that the optimum pH was at pH 5, with the adsorption capacity was 27,438 mg/g. The optimum concentration was 400 mg/L with the adsorption capacity was 30,543 mg/g, and the optimum contact time was 75 minutes with adsorption capacity was 34,740 mg/g. The equilibrium data were analyzed by the Langmuir and Freundlich Isotherms and obtained a maximum adsorption capacity of 58.82 mg / g. Based on the results of the experiment showing that lengkeng shells can be used as an alternative and low-cost biosorbent for the reduction of lead (II) ions from aqueous solutions, when conditions are appropriate.

1. Introduction

Toxic metal ions from various industrial wastes can cause water pollution which is a global problem and attracts worldwide attention [1]. They not only toxic and be poisoned to the most organisms living in water body, but it can also be left behind in the food chain and is harmful to living things [2]. Most of them enters the environment as the result of human activities such as electroplating, mining, petroleum refining at high concentrations [3].

One of the most toxic heavy metals is lead(II). It remains dangerous even at low concentrations. Contamination of lead occurs in drinking water because of the corrosion and leaching of lead pipes. The permissible limit of lead in waste water is 300 μg /L that was setting by the USEPA standard drinking water. Pb (II) is a neutrotoxic metal [4] which cause various diseases such as neurological disorders, anemia, kidney disease, and can cause death [5].

Heavy metals reduction from polluted water has been done by several researchers using a wide variety of techniques. These include chemical precipitation [6] filtration, ion exchange, coagulation, extraction and reverse osmosis. This conventional method was difficult to the processing and costs are relatively more expensive [7].

Now a day, adsorption by bio waste material is an environmentally friendly technique for the heavy metal reduction. Some agriculture waste or forestry biosorbsents that was able to reduce metal ion successfully, such as banana peel [8], durian (Durio zibethinus) seed [9], mahkota dewa [10], Petai...
(Parkia speciosa Hassk) peels, papaya (Carica papaya L) leaves, [11] and stem tree of soybean [7] was reported.

Lengkeng (Euphoria longan lour) shell is one of the agricultural waste products that can be used as biosorbent to remove heavy metals. It contains some functional groups especially hydroxyl and carboxyl groups that responsible to bind the ion metal in aqueous. The use of longan shells as bio sorbent is still not common found in the literature. The newest report was for removing Pb (II) ion with column method [12]. In this present work, bio sorbent were produced from Lengkeng shell used to investigate its ability with batch experiment method, with the aim of reducing ions Pb(II) from aqueous solutions with respect to the variation of pH solutions, contact time, and various concentration.

2. Material and method

2.1. Chemical and Equipment
All chemicals used were analytical reagent classes. 1000 mg / L Pb standard solution was made by dissolving 1.5985 grams of Pb (NO3) 2 in volumetric 1L.. Standard solutions were used to dilute the solution in various concentrations. The solution of HNO3 and NaOH was used to set the pH solution. Equilibrium concentration in the sample was measured by using laboratory glassware. Initial metals ion concentration were measured by Atomic Absorption Spectrophotometer (AAS).

2.2. Sample preparation
Biosorbents were used for Pb (II) uptake in aqueous solutions namely lengkeng shells that collected from the central market of Padang City West Sumatera. The lengkeng shell was cleaned from dirt by washing it in double distillated water, and then dried. The sample was crushed and sieved to size of 106 µm, 150 µm, 250 µm, and 300 µm. A total of 20 grams of longan skin were activated with 80 mL 0.01 M HNO3 for 2 hours. Then washed with distilled water until neutral and air dried [12].

2.3. Batch Method
0.2 grams of a lengkeng shells sample was taken and inserted into a 50 mL flask containing 25 mL of Pb (II). Then were shaken on an electrically Adjustable Reciprocating Orbital Shaker at certain speed and time. The same procedure was carried out for the treatment of the pH, concentration and contact time effect. The Samples were poured on filter paper of Whatman 42, and the Pb (II) ions concentration remaining in the filtrate was analyzed using the AAS GBC 932 AA. The amount of Pb (II) concentration adsorbed per unit of bio sorbent mass was calculated by using the following equation.

\[ Q = \frac{C_0 - C_f}{M} \times V \]

Where Q is metal adsorption capacity (mg / g)
C0 is initial concentration of metal ion solution (mg / L)
Cf is the final concentration of metal ion solution (mg / L)
V is the volume of solution (L)
M is the mass of biosorbent (g)

3. Results and Discussion

3.1. Effect of pH
The solutions of pH can affect the specific surface distribution of areas and hydroxyl groups in terms of providing the ability to bind metal ions [13]. The effect of pH on bio sorption of lead (II) by lengkeng shell (Euphoria longan lour) is shown in Fig. 1. The picture shows that the biosorption of Pb2+ increases from 10,642 to 27,438 when pH increases from 2 to 5. When the pH is low, the biosorbent surface will be surrounded by H+, so the surface is positively charged and this condition
causing repulsion between metal ions and biosorbent. As the pH increases, the hydrogen ion concentration will decrease, so that the bio sorbent surface becomes negatively charged and the interaction between metal ions with biosorben results in a high adsorption capacity [14]. The optimum adsorption capacity occurs at pH 5. And at an increase in pH 5 to 7 there is a decrease in adsorption capacity, because at that pH lead metal ions form precipitates and anionic hydroxide complexes which cause the solution to be unstable.

3.2. Effect of initial Pb (II) ion concentration
The capacity of Pb (II) metal ions adsorbed per unit of mass of a lengkeng shell increases with an increase in the initial concentration of Pb (II) ions and then decreases as shown in Fig. 2. When the concentration is low, Pb (II) metal ions are bound less to the active site on the bio sorbent surface [11]. It can be seen from the Fig. 2 that the optimum concentration of Pb (II) metal ion adsorption by lengkeng shell occurs at a concentration of 400 mg /L with an adsorption capacity of 30,543 mg /g. At the concentration of Pb (II) 500 mg / L, there was a decrease in adsorption capacity to 20,618 mg / g. It is assumed that at this concentration the adsorption capacity of the longan shell against lead metal ions reaches the maximum level. Because at high concentrations, the number of metal ions is not proportional to the number of available lengkeng shell particles so that the surface has reached a saturation point which results in reduced adsorption efficiency.

![Figure 1](image_url)

**Figure. 1.** Effect of pH solution on bio sorption of lead (II) by lengkeng shell (Euphoria longan lour)
Experimental condition: Initial concentration = 250 mg/L, particel size = 106 μm, dose of biosorbent = 0.2 g, contact time = 60 min and speed of string = 150 rpm
3.3. Effect of Contact Time
The duration of contact time treatment was done in order to find out at what time the biosorption process reaches equilibrium. Equilibrium occurs between biosorbents and metal ions. The optimum time occurs at 75 minutes with 34.740 mg / g of the adsorption capacity. With increasing contact time the adsorption capacity decreases, this is because the chemical bonds in the biosorbent have broken up. It seen in fig. 3 that the Pb (II) adsorption by the lengkeng shell does not significantly affect the contact time variation. At minute 30 the adsorption capacity has shown uptake value of 33.52 mg /g. This adsorption value is not too different from the adsorption at the optimum time.

Figure. 2. Effect of concentration on bio sorption of lead (II) by lengkeng shell (Euphoria longan lour)
Experimental condition: pH of solution = 5, particel size = 106 μm dose of biosorbent = 0.2 g, contact time = 60 min and speed of stirring = 150 rpm

Figure. 3. Effect of contact time on bio sorption of lead (II) by lengkeng shell (Euphoria longan lour)
Experimental condition: pH of solution = 5, initial concentration = 400 mg/L, size of particel = 106 μm dose of biosorbent = 0.2 g, contact time = 60 min and speed of stirring = 150 rpm
3.4. Biosorption Isotherm Models

The equation for Langmuir and Freundlich isotherms will be used to determine the maximum biosorbent capacity in adsorbing metal ions by revealing the surface properties and affinity of a biomass [13].

Figure 4. Isotherm Adsorption of Pb(II) onto Lengkeng shell adsorbent

The test of Langmuir adsorption equation and also Freundlich adsorption equation is proven by a good linearization graph and has the price of the coefficient of determination $R^2 \geq 0.9$ (close to number 1). From Fig. 4 shows that the lead (II) ion adsorption equation by lengkeng shell fulfilling the Langmuir adsorption equation with $R^2 = 0.929$ and also Freundlich adsorption equation with $R^2 = 0.804$. This shows that the equation Langmuir and Freundlich could be applied to the adsorption process of Pb (II) metal ions by lengkeng shell. The Langmuir $Ce / Qe$ equation $= 0.0171Ce - 2.0992$ and the equation are obtained Freundlich $\log (Qe) = 2.7639\log Ce - 2.1844$ and the constant price of the two equations such as shown in Table 1 below.

| Isotherm   | Constants | Value  |
|------------|-----------|--------|
| Langmuir   | a         | 58,82  |
|            | b         | 0,008  |
|            | n         | 0,3619 |
| Freundlich | k         | 0,006  |

The Freundlich equation model assumes that there are more than one surface layer (multilayer) and the side is heterogeneous, namely the difference in binding energy on each side where the adsorption process on each side of the adsorption follows the Langmuir isotherm. Therefore, the determination of the maximum adsorption power of lengkeng shell in the process of metal adsorption of lead (II) is calculated using the Langmuir adsorption equation. Because it is carried out on a single layer of substances adsorbed from lead (II) metal ions on each longan skin surface in units of mg of adsorbed metal ion / gram lengkeng shell. Final calculation show that the maximum adsorption capacity is 58.82 mg / gram.
4. Conclusion
Adsorption process of Pb (II) metal by Lengkeng shell reaches its optimum value at pH 5, concentration of 400 mg / L and contact time of 75 minutes. Equilibrium data is more suitable with Langmuir isotherm with $R^2 = 0.929$ mg / g. The final results of this study could be concluded that Lengkeng shell able to use to adsorb lead (II) ions in aqueous solution with a large adsorption capacity.

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