Plumbum Removal by using Chitosan as Absorbent

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Abstract

The study focuses on the potential of chitosan as a natural biopolymer adsorbent for plumbum removal from the simulated waste water by using jar test. When using Chitosan powder the absorption process had occur. The analysis that had been conducted in this experiment were the percentage removal of plumbum by using Inductively Coupled Plasma (ICP) and pH test. The efficiency of Chitosan as natural absorbent was to be determined based on the two paramaters conducted, which were the effect of amount of absorbent and the mixing speed of the jart test. In this research, 5 samples of simulated waste water containing lead (II) nitrate were tested under fixed retention time which was 30 minutes for every parameter. This study showed that 2g of Chitosan could effectively remove 98.65% of plumbum, at the maximum of 200 rpm of the mixing speed. This research also showed that Chitosan gave better removal performance compared to chemical absorbent such as aluminium sulphate.

1. Introduction

Water contamination has turned out to be a common case nowadays due to the industrial activities that cause the release of contaminants in the water. It has been reported that the contaminants are composed of heavy metals, pesticides, pharmaceutical residues and biological species (Xia et al., 2017; Apell & Boyer, 2010). It will become worse if the areas are surrounded by the factories that tend to release the chemical wastes. In other words, industrially heavy areas are usually known as the main reason the water becomes contaminated. In fact, industrialization and urbanization are the contributors to the release of heavy metals into the environment. Some industries that are related to the existence of heavy metal contamination are metal plating, mining operations, tanneries, alloy industries and also storage batteries industries (Hegazi, 2013; Gupta et al., 2001). The release of heavy metals in water should be avoided since they do not degrade into harmless products, are very toxic to many life forms, able to accumulate in the environment and cannot be metabolized and decomposed (Hegazi, 2013). One of the most dangerous pollutants is lead, which exists as cation of Pb(II). Lead has a toxicity level of 1-100 ppm, which is higher than copper (Cu) and mercury (Hg)(Lukum & Djafar, 2012).

There are many technologies that have been developed in the past years to treat the waste water. Wastewater treatment processes are designed to achieve improvements in the quality of the wastewater. The various treatment processes may reduce variety of contaminants. There are some application of waste water treatment that are being used nowadays. Some examples are heavy metal precipitation, pH control and alkalinity adjustment, carbon source augmentation & nutrient addition and the last one is phosphorus removal. For the removal of heavy metal in the waste water, the treatment processes are precipitation, membrane filtration, ion exchange, adsorption and also co-precipitation. However, the most effective technique that can be applied in all industries is adsorption (Al-Manhel et al., 2016; Shahidi et al., 1999). This is because adsorption is very convenient, in term of cost, simplicity and complexity (Mohammad et al., 2017).

Recently, environmentally friendly treatments are widely used in the water treatment process. There are some methods that have been used in waste water treatment by using natural coagulant. *Moringa oleifera* (Sajina), *Dolichos lablab* (beans), and *Cicer arietinum* (dal) seeds are some coagulants that are usually being used for the waste water treatment. Based on the previous study from (Birima et al., 2013), fine powder was achieved from the seed kernel. Physical properties that are tested in their experiment are pH value and turbidity. Another study from (Chikomo & Musaida, 2016) has shown that the treatment of waste water using watermelon seeds (*Citrullus lanatus*) was able to reduce biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), turbidity, pH, total dissolved solids (TDS), electrical conductivity (EC) and trace elements. Based on their experiment, the watermelon seeds are also used to enhance the filtration despite as coagulants.

However, there are also abundant of absorbents being used such as chitosan, and also cellulose, in which they can be proposed as an alternative for waste water treatment (Al-Manhel et al., 2016). Chitosan is the natural biopolymers and are very well-known as part of a strategy for water treatment and environmental protection. Chitosan is a biopolymer of glucosamine that contains high contents of amine and hydroxyl functional groups (Luk et al., 2014). Due to the high deacetilization rate and have free amino group, it is known as an effective pollutant bio-absorbent (Lasindrang et al., 2015). These coagulants are advantageous because they are no toxic for human health, biodegradable, efficient in low dosage and reduce sludge volume (Zemmouri et al., 2013; Guibal & Roussy, 2007). Figure 1 shows the molecular structures of Chitosan.

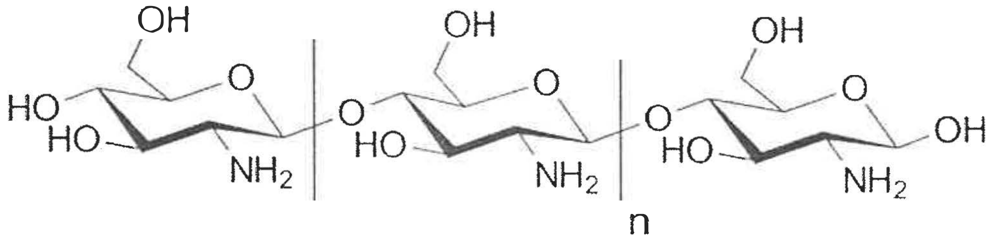

Figure 1: The structure of Chitosan

Therefore, this research focuses on the study of efficiency of chitosan as biopolymer absorbent to treat the waste water from an industry by the process of absorption. The effect of amount of adsorbents and the effect of mixing speed were to be determined.

2. Methodology

2.1 Preparation of simulated Pb

Simulated Pb was prepared by dissolving Lead (II) Nitrate at the concentration of 50 ppm.

2.2 Percentage removal of Pb and pH analysis

The experiment was set up by using jar test followed by Inductively Couple Plasma (ICP) and pH analysis after adding the absorbent.

2.2.1 Jar Test

The jar test for this study was adapted from (Zemmouri et al., 2013). First, the 5 samples of 250ml simulated waste water were placed into 5 beakers of 1L. Next, the beakers had been stirred on the gang stirrer with the paddles positioned identically in each beaker. Before the experiments started, the samples in the beakers had been stirred at 200rpm for 10 minutes to let the samples to be blended.

Table 1 and 2 show the simplification of the experimental procedures by using different absorbents which were Chitosan and Aluminium Sulphate. The parameters that were being considered in this experiment are the amount of absorbents and the mixing speed. The steps were repeated by using Aluminium Sulphate.

Table 1: Different amount of absorbents

Samples	Amount of absorbents (g)
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5

Table 2: Different of mixing speed

Samples	Mixing speeds (rpm)
1	100
2	150
3	200
4	250
5	300

2.2.2.1 The Effect of Amount of Absorbent

After 10 minutes of stirring before the experiment started, different amount of Chitosan were added into each of the beakers that were filled with the waste water. Then, the solutions were being stirred at 200 rpm for 30 minutes and the mixer was turned off to allow the settling to occur for 10 minutes. The solutions were being filtered by using filter paper to ensure there was no residue in the solution.

2.2.2.2 The Effect of Mixing Speed

After 10 minutes of stirring before the experiment started, 2 g of Chitosan were put into each of the beakers that contain the waste water. The solutions were being stirred at different mixing speed for 30 minutes and the mixer was turned off to allow the settling to occur for 10 minutes. The solutions were being filtered by using filter paper to ensure there was no residue in the solution.

2.3 Percentage of Pb removal

All of the solutions of waste water after adding the absorbents were tested by using inductively coupled plasma (ICP) to analyse the removal of heavy metal. From that, the percentage can be identified by using equation 1.

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$$\frac{\text{Initial concentration of Pb} - \text{Final concentration of Pb}}{\text{Initial concentration of Pb}} \times 100 \qquad \text{Equation 1}$$

3. Results and Discussion

3.1 Lead removal by different amount of absorbents

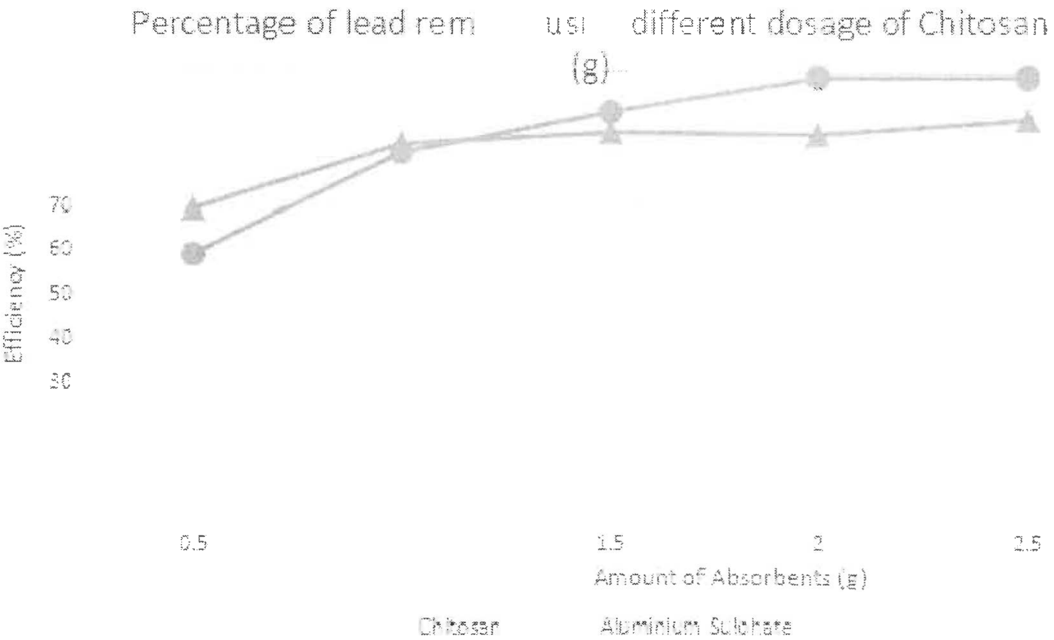

Figure 2: Percentage removal of lead by using different amount of absorbents

Figure 2 shows the graph of percentage removal of lead by using different amount of absorbents. From the graph, it can be seen that in the beginning, Aluminium Sulphate became more efficient compared to Chitosan which the percentage removal of lead by using Aluminium Sulphate was 69.11% while Chitosan was 58.90% .This happened because a higher dose provided larger number of binding sites which eventually caused enhanced removal of Pb^{2+} (Zhang, Zeng, & Cheng, 2016; Saha & Sarkar, 2012). Therefore, the percentage removal of the lead was highly increasing as the amount of Chitosan increased meanwhile for the Aluminium Sulphate, the result showed that the percentage removal was just slightly increasing as the amount of Aluminium Sulphate used increased. Then, the optimum amount of Chitosan that showed the highest percentage removal was at 2.0g which it managed to remove 98.65% of the lead while the highest percentage of lead being removed by Aluminium Sulphate occurred at its maximum mass at 2.5g which is 89%. The effectiveness of the natural absorbent amount has been exemplified in other researcher finding a similar optimum adsorbent dosage (Alhogbi, 2017). The 10% different of percentage removal of lead between Chitosan and Aluminium Sulphate were already showing that Chitosan was more efficient to be used as an absorbent. The concentration at the highest percentage removal of lead when using Chitosan was 0.688 ppm which it successfully removed 49.312 ppm of lead in lead (II) Nitrate and for the Aluminium Sulphate, the concentration of lead was 5.605 ppm. In overall, in the beginning the percentage removal of lead by using Chitosan was lesser than when using Aluminium Sulphate but then the percentage removal of lead by using

Chitosan was constantly increasing meanwhile the percentage removal of lead by using Aluminium Sulphate was just slightly increasing and it can only reach until 89%. removal of lead. Thus, by comparing the concentration, a big difference can be seen. This proven that Chitosan was the most efficient to be used as a low cost absorbent in removal of lead from the waste water.

3.2 Lead removal by different mixing speed

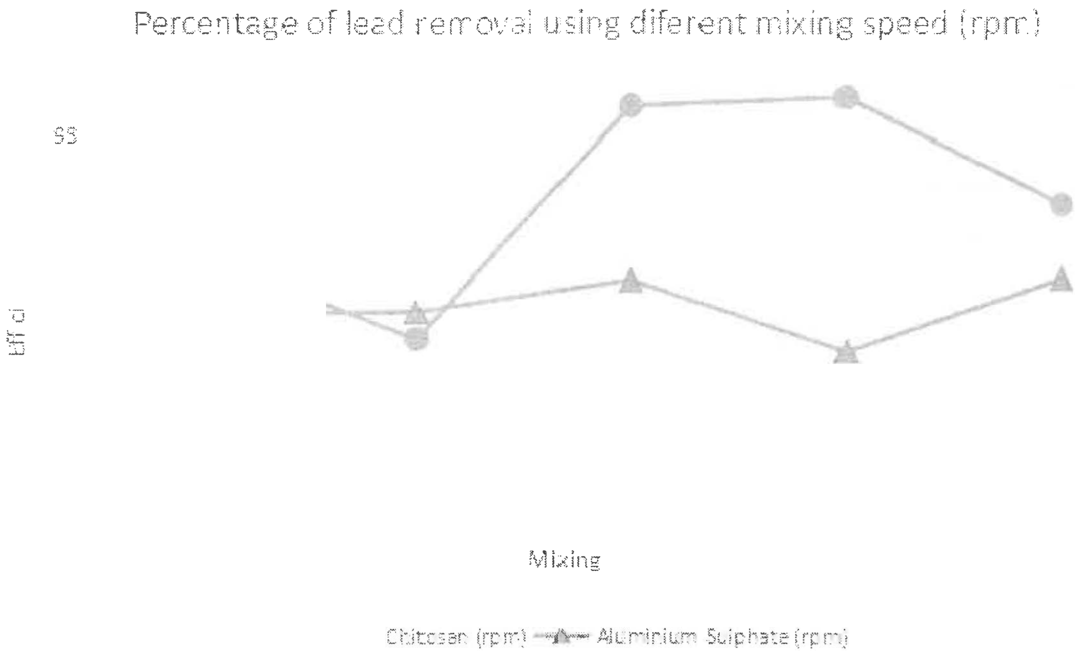

Figure 3: Percentage removal of lead by using different mixing speed

Figure 3 shows the graph of percentage removal of lead by using different mixing speed. The amount of absorbent used in this experiment was kept constant which was at 2g for both absorbents since from the previous experiment, the amount of Chitosan that gave the maximum percentage removal of lead was at 2g. Therefore, Chitosan was still the most efficient absorbent compared to aluminium sulphate because from the graph it can be seen that in the beginning, the percentage removal of lead between these two absorbent were almost the same, but starting from mixing speed of 150rpm, the percentage removal of lead was starting to arise from 89.97% to 99.10% at 200rpm which it almost reached to 100% of removal. The concentration at the highest percentage removal of lead when using Chitosan was 0.245 ppm which it successfully removed 49.755ppm of lead in lead (II) Nitrate and for the aluminium sulphate, the concentration of lead is 3.901 ppm. This was happening because in order to remove lead in waste water, moderate mixing speed must be used. This means that the mixing speed should not be too fast or too slow because if the mixing speed is too fast, it will damage the chains of the absorbent which will reduce the efficiency of the absorbent to absorb the heavy metal in the waste water. Even though, the result of the graph between chitosan and aluminium sulphate in term of mixing speed did not really show a lot of difference, the Chitosan was still being proven to be the most efficient absorbent since it only required moderate mixing speed to remove almost all of the lead in the waste water.