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INVESTIGATION OF REMOVING Cd^{2+} AND Pb^{2+} FROM AQUEOUS SOLUTION WITH FAVA BEAN HUSK (*VICIA FABA)* AS A BIOSORBENT

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ABSTRACT

Fava bean is one of the oldest crops and common legumes in the world, which ranks sixth in production among the different legumes. Than many people, grow *V. faba* as a horticultural plant. Tokat people like it and consume widely that is named as "boduç". Therefore, that excess consumption brings a large amount of husk-waste.

Technological advancements and industrial revolution have broughtheavy metal pollution, which is threatening all living creatures. Many investigators are seeking for new low-cost and easy-to-apply ways to remove this pollutant.

This study aims to investigate sorbent properties of fava bean. The husk of the fava beans (*Vicia faba*) were used as biosorbent because of widely consumed in Tokat. The husk powder of fava beans (> 0.5 mm and ≤ 0.5 mm) were interacted with, Pb^{+2} and Cd^{+2} solutions in 25 mg / L and 75 mg / L concentration at 25 ^{o}C and 45 ^{o}C temperature. The capacity of cadmium and lead removal from aqueous solutions was investigated. As a result, sorbent value of 75 mg / g for both heavy metals were reached in a short time and at low temperatures. The results are considered as significant with literature and efficient for further studies.

Keywords: Biosorbent, heavy metal removing, *Vicia faba*

INTRODUCTION

Fava beans is an annual and herbaceous plant with a height of 50- 100 cm, with pilous leaves, white flowers (Baytop, 1984). Fava beans is one of the oldest crops and common legumes in the world, which ranks sixth in production among the different legumes. *V. faba* can grow in different soils and climates that has a large amount of proteins, carbohydrates, B-group vitamins and minerals. Besides, it contains antinutritional components such as phytic acid, tannins (Vidal-Valverde et al., 1998; Li et al., 2010).

Trace metals are very important for living organisms (Phipps, 1981) but some of them (especially Cd, Pb, Hg, Cr) are not biodegradable and tend to accumulate which causes the stimulating several diseases and disorders (Bailey et al., 1999). Some of heavy metals act as a strong poison for metal sensitive enzymes, resulting in growth inhibition and mortem of organisms (Sharma & Agrawal, 2005).

Presence of heavy metals in natural habitat is huge threat for organisms especially for human. Heavy metal pollutants could be diffused from one species to another and then it may result significant health problems or death. (Muslu, 1985; Eckenfelder, 1989; Gül, 1992; Li et al., 2009). Lead can be taken into human body from different contaminant including water sources;

causes various disorders related to gastrointestinal, neurological, hematological and bone tissue (Yeşilyurt & Akcan, 2001; Özmert, 2005). The presence of these metals in aquatic environment is a source of great environmental concern (Rangsayatorn et al., 2004).

Heavy metals such as Pb, Cd, Cu, Hg, Cr, Ni and Zn are serious hazards for human health in high concentration. These harmful metals are dispersed into the nature in many different ways (Karabulut et al., 2000) including metal plating facilities, mining operations, tanneries etc. These toxic metal are the main reason for water and soil contamination. Surface water and ground water are under threat because of these pollutant (Bailey et al., 1999) (Stanescu et al., 2015).

Stringent environmental regulations require the treatment of wastewater to remove trace metals. This requirement is very costly for industries (Johns et al., 1998). Petrochemically product resins have been used for a long time to clean industrial wastewater. All of them are costly, regenerative and nonbiodegradable (Wing, 1996).

Various researches have shown that hazard metal ions can be removed from aqueous solutions by the biosorption process (in batch or continuous mode operations) on a laboratory scale system (Garcia-Reyes & Rangel-Mendez, 2010; Stanescu et al., 2015). Features that make biosorption superior to other methods are high efficiency, low-cost and chance of recovery (Kratochil & Volesky, 1998). Biomass used as sorbent are high in content tannin etc. that have functional groups such as hydroxyl and amino groups which can hold metals (Bahadır, 2005). Arthropod shells as well as organisms such as bacteria are the commonly used biosorbents (Chubar et al., 2004). In many study, wide variety of cheap biosorbents including microorganisms, seaweeds, plant materials, industrial and agricultural wastes, natural residues, inorganic precursors, red mud, clays, blast furnace slags, zeolites, chitosan, and peat have examined for their ability to remove pollutant (Luda, 2011, Rahman & Sathasivam, 2015). Some of the researches and the removing capacity can be listed as follows;

- Srivastava, 31.00 mg Cd^{2+}/ g Aluminum oxide and 33.00 mg Pb^{2+}/ g Aluminum oxide (1988)
- Meunier et al., 6.20 mg Pb^{2+}/ g cocoa shell (2003),
- Saeed, 39.99 mg Cd^{2+}/ g Black gram husk and 49.97 mg Pb^{2+}/ g Black gram husk (2005)
- Abdel-Aty, 111.10 mg Cd^{2+}/ g alga and 121.95 mg Pb^{2+}/ g alga (2013),
- Abdollali et al., 38.25 mg Cd^{2+}/ g *MMBD** and 108.12 mg Pb^{2+}/ g *MMBD** (2017)

These findings and the others have led us to investigate sorbent capacity of *V. faba*waste which is widely consumed in Tokat region. Unlike other sorbents, low temperature metal extraction drops the cost of processing. The aim of this study was to evaluate the removal of Cd^{2+} and Pb^{2+} from aqueous solution using *Vicia faba* as a natural biosorbent under batch conditions.

MATERIALS AND METHODS

Biosorbent

*V. faba*was bought from a local market in Tokat. In this research, plants wastes used as a sorbent. Plants wastes were *V. fabas'*mesocarp. All plants pulps were removed and dried (Figure 1.) in an oven at 50 ^oC for two days. Then all dried wastes were pestled with a porcelain mortar and riddled with a sieve. Plants powder was collected two types as under sieve (≤0.5 mm) and refuse sieve (>0.5 mm).

Figure 1. **Preparing / drying of fava beans husks**

Reagent

Cadmium and lead solution were prepared from $Cd(NO_3)_2.4H_2O$ (>%99 purity) (*Sigma-Aldrich*) and $Pb(NO_3)_2$ (%99 purity) (*Alfa Aesar*) by dissolving cadmium and lead salts in distilled water. Both of metal solutions were prepared at the concentration of 25.0 mg.L^{-1} and 75.0 mg.L^{-1}.

Biosorption Experiments

A set of 250 mL erlenmeyer flasks containing 100 mL metal solution and 1 g plant granule (≤ 0.5 mm or > 0.5 mm) used and rotated at 170 rpm on an orbital shaker (Shaker SK 600 and ZHICHENG - ZHWY - 111C), at pH value 7.0, at temperature of 25±0.5 ^{o}C and 45±0.5 ^{o}C. Approximately 5.0 mL sample – eluate was taken for every flasks, after 1 hour, 8 hours and 24 hours and then filtered with quantitative blue spot filter paper (∅ 125 mm) and finally all samples were analyzed with atomic absorption spectrometer (Perkin Elmer AAnalyst 700).

RESULTS AND DISCUSSION

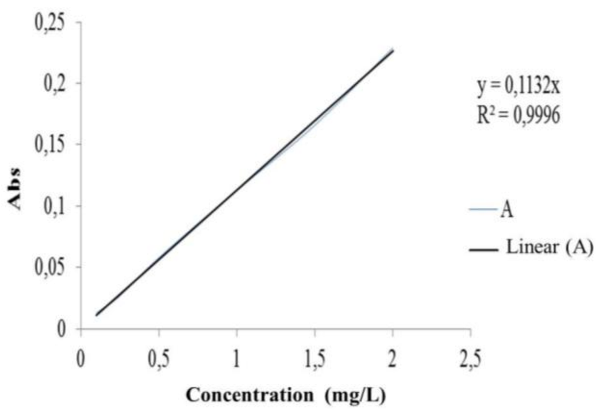

Figure 2. Absorbance-concentration changing graphic of standard

All capturing data were calculated by general formula;

$$q_e = \frac{(c_0 - c).V}{M}$$

q_e = metal uptake (mg metal / g dry sorbent weight)

c_o = initial concentration of metal in solution (mg /L)
c = final concentration of metal in solution (mg/L)
V = volume of metal bearing solution contacted (batch) with the biosorbent (L)
M = dry weight of biosorbent added (g *V. faba*)

The concentration was calculated using graphic (Fig.1) that has absorbance value.
All figures are shown biosorption results for fava bean. Experiment properties (granule size, temperature, concentration of metal solution) are shown below the figures from 3 to 10 (n=3 and pH value is 7, for all experiments).

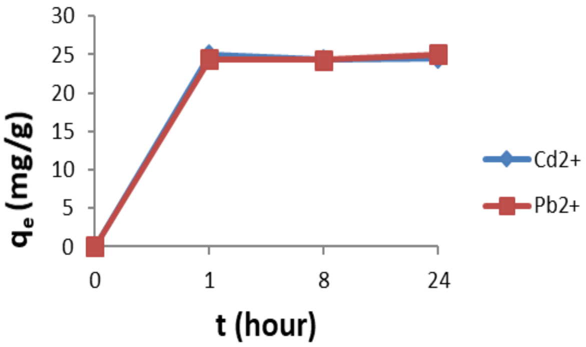

Figure 3. Cd^{2+} & Pb^{2+} biosorption of sorbent at 25°C, 25mg.L^{-1} concentration & ≤0.5mm particle size (N=3)

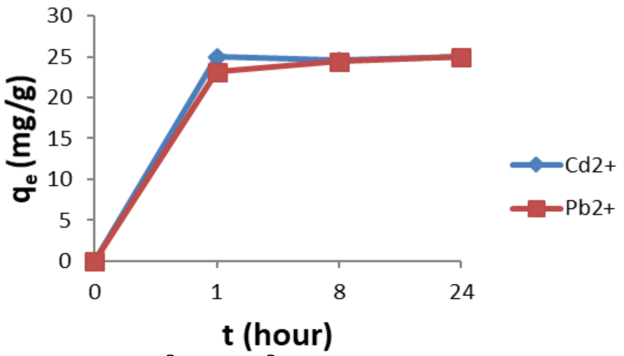

Figure 4. Cd^{2+} & Pb^{2+} biosorption of sorbent at 25°C, 25mg.L^{-1} concentration &>0.5mm particle size (N=3)

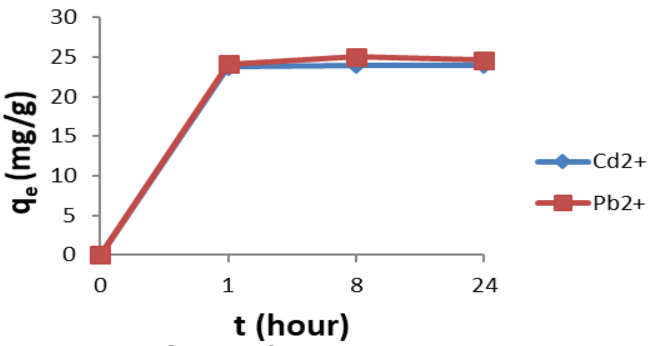

Figure 5. Cd^{2+} & Pb^{2+} biosorption of sorbent at 45°C, 25mg.L^{-1} concentration & ≤0.5mm particle size (N=3)

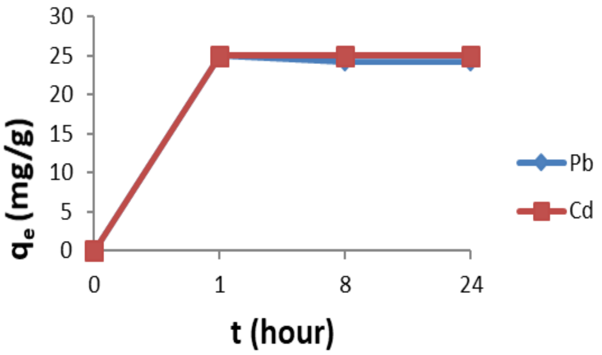

Figure 6. Cd^{2+} & Pb^{2+} biosorption of sorbent at 45°C, 25mg.L^{-1} concentration &>0.5mm particle size (N=3)

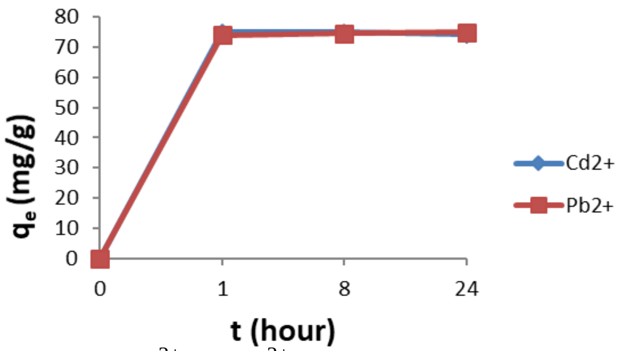

Figure 7. Cd^{2+} & Pb^{2+} biosorption of sorbent at 25°C, 75mg.L^{-1} concentration & ≤0.5mm particle size (N=3)

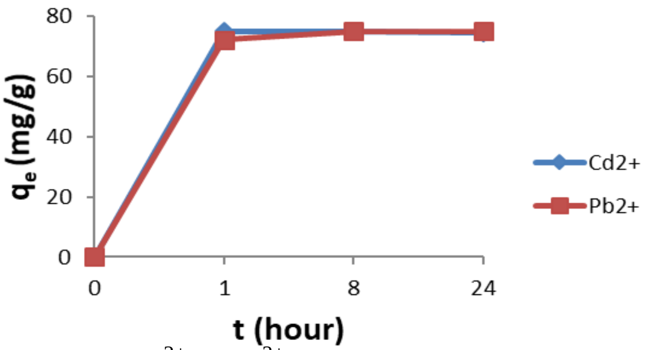

Figure 8. Cd^{2+}& Pb^{2+} biosorption of sorbent at 25°C, 75mg.L^{-1} concentration &>0.5mm particle size (N=3)

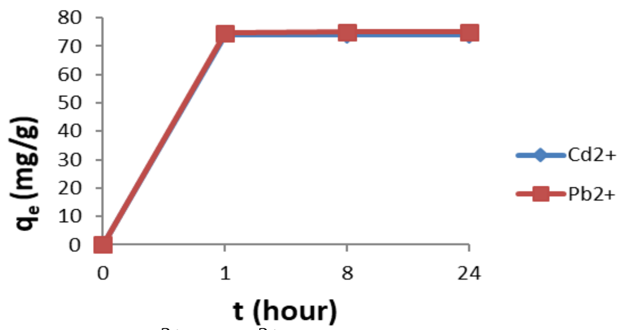

Figure 9. Cd^{2+}& Pb^{2+} biosorption of sorbent at 45°C, 75mg.L^{-1} concentration & ≤0.5mm particle size (N=3)

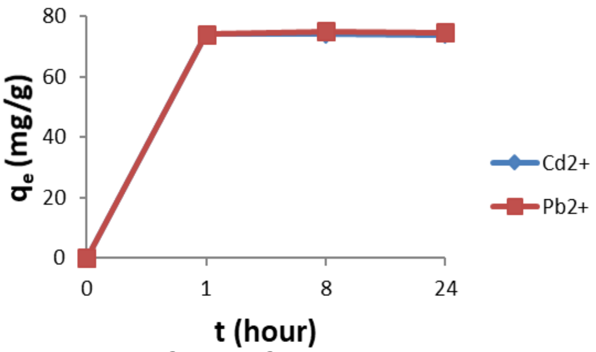

Figure 10. Cd^{2+}& Pb^{2+} biosorption of sorbent at 45°C, 75mg.L^{-1} concentration &>0.5mm particle size (N=3)

It has been determined that the absorbance values of *V. faba* pod changes different parameters as time, concentration, temperature, and particle size. According to data of;

- Cd^{+2} absorption reaches maximum at 1. hour for all parameters.
- Pb^{+2} absorption reaches maximum at;

- 25 °C; both particle sizes and both concentration at 24. hour,
- 45 °C; > 0.5 mm particle size and 25 mg/L concentration at 1. hour all the others at 8. hour.

CONCLUSION

Fava bean (*V. faba*) is one of the most commonly consumed foods in Tokat region. Thanks to advanced processing techniques pod-free*V. faba* can be found on market shelves. In this way, pod waste can be obtained in large quantities and ceases to be domestic waste. Eventually this study establish waste of *V. faba* is cheaper and useful sorbent.

Fava bean (*V. faba*) pod contain a large quantities of tannins which are act as metals traps*(*Marquardt et al., 1974; Guillaume &Belec, 1977; Martin-Tanguy et al., 1977*)*. Pb^{2+} and Cd^{2+} ions were captured by common functional groups of tannins like (Stanescu et al., 2015) hydroxyl, etc. (Fig. 11).

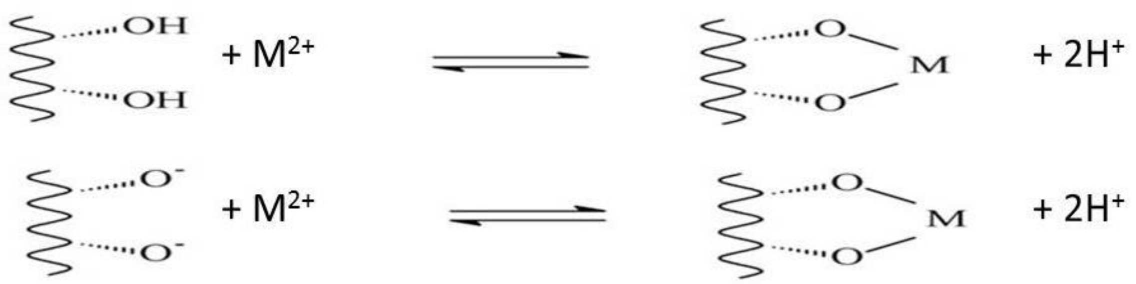

Figure 11. Mechanism of metal ions attachment to sorbent surface (Demirbaş et al., 2008)

In this study, the use of *V. faba* as a biosorbent was tested for Cd (II) and Pb (II) from aqueous solution with the Batch System. Chancing parameters were metal concentration, temperature, granule size and contact time. At the end *V. faba* reached min 64.43%, max 100% absorption capacity for Cd^{2+} and min 93.64%, max 100% absorption capacity for Pb^{2+}. That is mean capacity for absorption was 75 mg Cd^{2+}/ g faba and 75 mg Pb^{2+}/ g faba. These results are compared with literature (Table 1)

Table 1. Cd^{2+} and Pb^{2+} adsorption capacity (mg metal / g sorbent) for some sorbent in literature

Sorbent	**Cd^{2+}**	**Pb^{2+}**	**Reference**
Aluminum oxide	31.00	33.00	Srivastava, 1988
Iron oxide	71.68	230.00	Srivastava, 1988
Chitosan	250.00	-	McKay, 1989
Bentonite	-	20.00	Naseem, 2001
Cocoa shell	-	6.20	Meunier et al., 2003
Black gram husk	39.99	49.97	Saeed, 2005
Groundnut hull	-	31.54	Qaiser, 2009
Date pit	39.50	-	Al-Ghouti et al., 2010
Anabaena sphaerica	111,10	121,95	Abdel-Aty, 2013
S. cerevisiae cells	6,41	-	Stanescu, 2015
specifically multi-metal binding biosorbent (MMBB)	38.25	108.12	Abdolali et al., 2017

The results this study suggested that *V. faba* bean pod is a good biosorbent for Pb (II) and Cd (II). If comparing them with the results of previous studies the *V. faba* pod is so successful sorbent for removing Pb (II) and Cd (II) at low temperature. Unlike other sorbents, low temperature metal extraction drops the cost of processing. All these point at that bean pod is hard sorbent. Sorption capacity can be increased with further studies and converted common biosorbent for firms at least locally. Finally, all of the finding support the purpose of this study, which is a low-cost, available and biodegradable sorbent fabrication.

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