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Research Article / Araştırma Makalesi

USE OF AQIS FOR ADSORPTION OF Pb^{+2} FROM AQUEOUS SOLUTION

Hakan ÇELEBİ*, Oğuzhan GÖK

Aksaray University, Environmental Engineering, AKSARAY

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ABSTRACT

The aim of this work was to investigation the applicability of removing Pb^{+2} from aqueous solutions using acorn (*Quercus ithaburensis*) shell (AQIS), using batch adsorption process.Various experimental parameters such as adsorbent dose, pH and contact time were studied to observe their effects on the Pb^{+2} adsorption process. At optimum values of the above mentioned parameters, more than 90% removal efficiency was obtained within 2 minutes at AQIS amount of 1 g/100 mL, pH range of 2-6 for Pb^{+2} concentration of 100 mg/L. This study demonstrated the ability of AQIS as an effective, readily available, and low-cost adsorbent for removal of the Pb^{+2} removal from its aqueous solutions.
Keywords: Adsorption, acorn (*Quercus ithaburensis*) shell (AQIS), Lead ions (Pb^{+2}).

SULU ÇÖZELTİDE KURŞUNUN ADSORPSİYONU İÇİN AQIS KULLANIMI

ÖZ

Bu çalışmanın amacı adsorpsiyon yöntemi kullanılarak AQIS ile sulu çözeltilerden Pb^{+2}'nin gideriminin araştırılmasıdır. Çeşitli deneysel parametrelerin (AQIS dozu, pH ve temas süresi) Pb^{+2} adsorpsiyon prosesi üzerindeki etkileri çalışılmıştır. Yukarıda belirtilen parametrelerin optimum değerlerinde, Pb^{+2} konsantrasyonu 100 mg/L için % 90'dan fazla bir giderme verimi elde edilmiştir. Bu çalışma, AQIS'nin sulu çözeltilerden Pb^{+2}'nin giderilmesinde etkili, kolaylıkla elde edilebilen ve düşük maliyetli bir adsorbent olduğunu göstermiştir.
Anahtar Sözcükler: Adsorsiyon, palamut kabuğu (AQIS), kurşun iyonları (Pb^{+2}).

1. INTRODUCTION

Lead is one of the most toxic heavy metals. There are three most common oxidation cases of Pb as mineral deposits Pb, Pb^{+2} and Pb^{+4} [1]. Lead is classified as a priority hazardous substance by various agencies including the Agency for Toxic Substances and Disease Registry [2]. Since lead pollution in drinking water leads to important health problems for people, it is seen as significant environmental issue. Lead is related to industrial activities. Activated carbon is usually used as the versatile material due to high surface area, micro porous structure, high adsorption capacity [3]. However, activated carbon is expensive and there is a need for its

[*] Corresponding Author/Sorumlu Yazar: e-mail/e-ileti: hakancelebi@aksaray.edu.tr, tel: (382) 288 35 98

regeneration after each adsorption experiment. In order to decrease the cost of adsorption, low cost forest wastes are presently considered promising adsorbents for adsorption [4, 5]. Acorn shell has benefits such as powerful mechanic density, surface area, simple regeneration, strength to decomposing, high chemical stability and strong hydrophobicity [6]. A comparatively small number of studies were performed on the production of low cost activated carbon from acorn shell [7-10]. The most significant differences of this study compared to other studies, is to use the experiment system without modifying the adsorbent. There are several studies in the literature modified acorn shell which is used for removal of heavy metals by adsorption. In our study, high adsorption capacities were obtained in natural form rather than modified acorn shell. The aim of this study is to investigate the adsorption properties of AQIS.

2. MATERIALS & METHODS

2.1. Analytical Methods

The AQIS samples used for the investigations in this study were collected from the Aksaray locality in the Middle Anatolia region of Turkey. Before the start of the experiments, AQIS were dried and placed in ball mill and obtained crumbs were sifted to acquire the size of smaller than 100 μm. The surface morphology of AQIS was investigated using a field emission scanning electron microscope (SEM). AQIS samples, dried completely, was put into the conductive carbon tape attached to a metal stub and coated with a thin layer of gold for charge dissipation during SEM imaging. All chemicals were analytical grade, as they were purchased from Merck. The stock solution of Pb^{+2} was made by dissolving 1.598 g $Pb(NO_3)_2$ in 1 L double distilled water. From the stock solution, working solution of 100 mg/L of Pb^{+2} was prepared by serial dilution. The pH measurements were performed with LABQUEST2 digital ion analyzer. Adsorption experiments were performed in batch systems, using AQIS amount, pH and contact time as variables.The Pb^{+2} concentrations in the initial and effluent samples were analyzed using the Perkin Elmer Optima 2100 DV model inductively coupled plasma optical emission spectrometry (ICP-OES). Ash, volatile material, fixed carbon and moisture experiments were carried out by Mopoung et al. [25] according to ASTM D 2866-94, ASTM D 5832-95, ASTM D 3172-89 and ASTM D 2867-95 methods, respectively. All experiments were performed in triplicate, mean values were considered in data analysis.

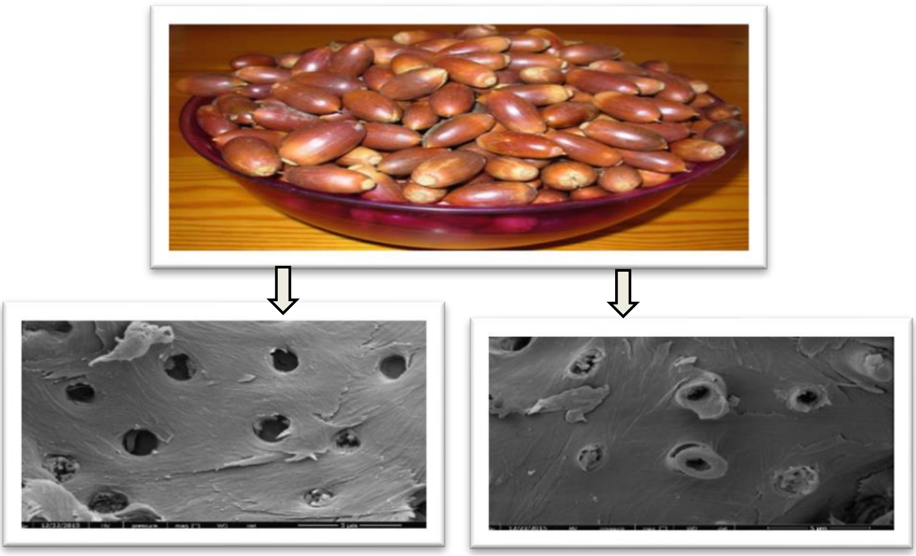
3. RESULTS & DISCUSSION

3.1. Characterization of AQIS and SEM Analysis

The characteristics results were given in ratios of volatile material, ash, fixed carbon, moisture (Table 1) [8, 11]. Pores of different size and different shape was observed. The micrographs points out that the external surface of the AQIS is full of gaps (Figure 1). The AQIS has closed pores, which have geometry of slit-shaped pores or slit. The open pore geometry is a slit-shaped pore or slit, as cylindrical pores represents the closed pore geometry.

Table 1. Characteristics of AQIS sample [8, 11].

Properties and Element Composition	**Values (%)**
Volatile material	70.6
Ash	2.5
Fixed Carbon	19.4
Moisture	7.5
Carbon	48.7
Hydrogen	6.2
Nitrogen	1.0
Oxygen	44.1
Iron	6.0
Calsium	4.0
Aluminium	0.5



Before Adsorption **After Adsorption**

Figure 1. SEM micrograph of AQIS for Pb^{+2} adsorption experiments

3.2. Effect of pH

The effect of pH on the Pb^{+2} by AQIS was investigated for different pH. Solution pH would affect both aqueous chemistry and surface binding sites of the adsorbents. Moreover, a change in pH also results in a change in the charge profile of the adsorbate species which consequently influences the interactions between the adsorbate species and adsorbent. Values of pH>6 have not been studied due to precipitation of Pb^{+2} as $Pb(OH)_2$, being the process of entrapment actually a combination of adsorption and micro precipitation. The the maximum Pb^{+2} yields which were found 96% at pH 6 (Figure 2).

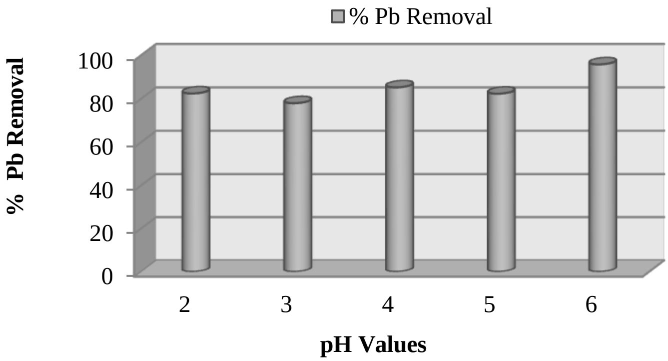


Figure 2. Effect of pH on the removal of Pb^{+2} ($Pb^{+2}_{initial}$=100 mg/L, AQIS amount = 1 g/100 mL, stirring speed= 250 rpm, contact time=2 minutes, T= 25 °C)

Örnek et al. [9] provided evidence for an apparent increase in the Pb^{+2} removals by acorn from 20% to 96% when the pH value increased from 2 to 5. Similarly, Ghaedi et al. [11] indicated that using of acorn waste was positively correlated with adsorption level for Pb^{+2} when pH was increased from 2 to 6. The findings of our paper were parallel to those of the previous studies [11-14].

3.3. Effect of AQIS Amount

In this stage of study, the relationship between 0.1-5.0 g/100 mL AQIS amount and Pb^{+2} removal efficiency was investigated (Figure 3). At a dose of 1.0 g / 100 mL of adsorbent, Pb^{+2} yield of 98.5% was obtained with no increase in Pb^{+2} efficiency after this amount. This results show that an increase in the number of active sites of the AQIS with increasing amount of the adsorbent. Further increase in the amount of the adsorbent does not bring any considerable change in the adsorption; thus 1.0 g/100 mL was chosen as the optimum AQIS. Other studies in previous literature report similar results for Pb^{+2} using different adsorbents [9, 11, 12, 14, 16]. In our previous studies, the different isotherm and kinetic studies were investigated for the Pb^{+2}. The adsorption mechanism was realized as a mono-layer adsorption on the AQIS surface (data not shown).

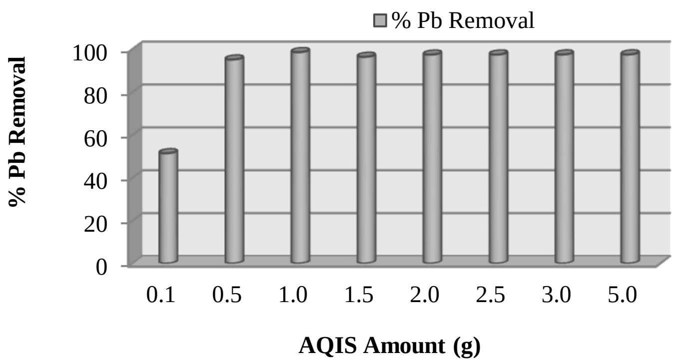


Figure 3. Effect of AQIS amount on the removal of Pb^{+2} ($Pb^{+2}_{initial}$= 100 mg/L, contact time=2 minutes, pH= 6, stirring speed= 250 rpm, T= 25 °C)

3.4. Effect of Contact Time

The adsorption of Pb^{+2} has been investigated on AQIS as a function of time in the range of 1-30 minutes. The efficiency initially increased rapidly and the equilibrium was attained in 30 minutes at efficiency of 99%. The maximum Pb^{+2} removal which were found 99.5% at contact time of 2 minutes for AQIS (Figure 4). The findings of several studies in the previous literatures in line with the results for Pb^{+2} of the study [11, 14, 15].

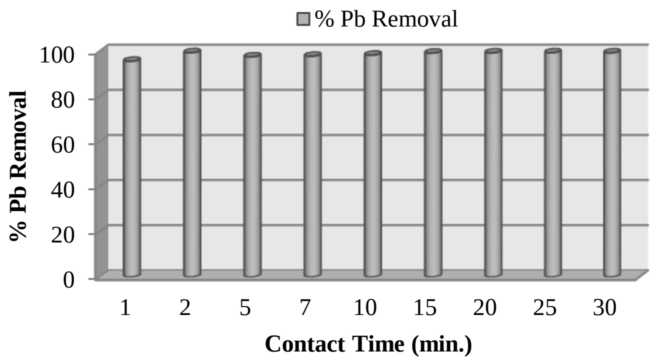


Figure 4. Effect of contact time on the removal of Pb^{+2} (AQIS amount = 1 g/100 mL, $Pb^{+2}_{initial}$= 100 mg/L, pH= 6, stirring speed= 250 rpm, T= 25 °C)

3.5. Comparison of Pb^{+2} Removal with Different Adsorbents Reported in Literature

A list showing the adsorption removal of different adsorbents for the adsorption of lead from aqueous solutions is given in Table 2. As it can be seen, the observed removal efficiencies of acorn shell for Pb^{+2} are comparable with other low-cost adsorbents.

Table 2. Comparison of adsorption removal of various adsorbents for Pb^{+2}

Adsorbent	Removal (%)	pH	Adsorbent Amount (g/100 mL)	Pb^{+2} conc. (mg/L)	References
Almond Shell	68	6-7	0.5	200	[17]
Antep pistachio	90	5.5	1.0	30	[18]
Groundnut shell	82.81	4.9	1.0	-	[19]
Hazelnut shell	90	6-7	0.5	200	[17]
Palm shell	-	3-5	-	10-700	[20]
Pecan shell	-	5.5	4	100	[21]
Pistachio shell	83	6-9	0.1	30	[22]
Walnut Shell	95	4	10	100	[23]
Groundnut shell	98	5.1	2.2	152.5	[24]
AQIS	**98**	**6.0**	**1**	**100**	**This Study**

4. CONCLUSION

The maximum adsorption efficiencies by the AQIS is obtained about 98% for Pb^{+2} ions under the optimum conditions ($Pb^{+2}_{initial}$= 100 mg/L, AQIS amount = 1 g/100 mL, contact time= 2 minutes, pH= 6, stirring speed= 250 rpm, T= 25 °C). It may be concluded that AQIS could be used, as a practical, effective and low-cost, high adsorption capacity, and abundant source to remove Pb^{+2} ions.

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