Removal of Pb^{+2} heavy element by using Biochar and Magnetic Biochar prepared from rice husks

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Abstract

Heavy metal pollution has become a major problem surrounding our environment. Conventional heavy metal processing techniques were unsuccessful and expensive. As a result, in our current work, biochar and magnetic biochar have been used as an efficient, low-cost, safe, and environmentally friendly method for heavy metal removal for Pb^{+2}. Rice husks were used to absorb Pb^{+2}, and it was discovered that removability is affected significantly by the initial concentration of minerals, the adsorbent dosage, and the amount of adsorbent. Due to a direct increase in the amount of active adsorption sites available on the adsorbent surface, the produced biochar had a positive effect on improving the removal efficiency of heavy metals Pb^{+2}, resulting in a higher removal efficiency of the heavy metal ions present, with 92.94% , at doses of 1 gm., adding the magnetization property to biochar prepared by doping with Fe_3O_4 significantly improved the adsorption performance, with Pb^{+2}removal efficiency reaching 97.96%. The addition of the magnetization property increased the number of active sites, expanded the adsorption surface field, and provided an attractive material for mineral ions, explaining magnetic biochars high adsorption performance.

Keywords: Magnetite biochar, Biochar, Heavy metal, Removal efficiency, Rice Husks.

Introduction

Due to its excellent ability to absorb heavy metals in an aqueous solution, biochar has attracted many researchers to use it as a process material in various aqueous solutions. The treatment process requires the subsequent separation of the biochar (pulverized) from the aqueous medium, through centrifugation or filtration processes [1].

To improve the absorption efficiency of the biochar material and increase its usefulness in controlling the removal of water pollution, transition metals, such as iron, nickel etc., or their oxides are added to the biochar matrices to create magnetic biochar [1-2]. This is a successful problem-solving technique, which removes magnetic biochar from aqueous media quickly and easily. Magnetic species have an unavoidable effect on the physical and chemical properties of biochar[2]. Magnetic biochar, in particular, is ideal for extracting pollutants from aqueous solutions due to the compact properties of biochar and magnetic materials. Magnetic biochar was found to be an important absorbent for removing heavy metal contaminants from any contaminated aqueous solutions, in the majority of studies [1-3]. Biochar, a low-cost, environmentally friendly material made from organic wastes such as agricultural wastes, forestry residues, and municipal wastes, is gaining popularity, as demonstrated by its growing usage in a variety of environmental applications. Various methods, such as pyrolysis, hydrothermal carbonization (HTC), gasification, and adsorption, may be used to transform organic wastes into biochar. Pyrolysis is the most common method for producing biochar, while chars from gasification, Torre faction, and HTC do not necessarily meet the definition of biochar defined in the European Biochar Certificate guidelines (EBC)[4]. The improved properties of the material include a high carbon content, increased surface area, high cation-anion exchange power, and a stable structure [4-5]. The properties of biochar should be modulated to allow for better removal efficiency for some recalcitrant molecules that are present at low concentrations[6]. Therefore, the motivation in our current work

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is the manufacture of magnetic biochar to improve the properties of ordinary biochar and improve the physical and chemical properties of the adsorbent material.

Materials And Methods

Preparation Of Adsorbent (Biochar, Magnetic Biochar)

In order to prepare the rice husks for incineration, they were thoroughly washed with distilled water several times and then dried at room temperature. Biochar was made by slowly pyrolysing it at 500 ^{0}C in a convection oven with continuous N_2 gas flow. For four hours, the temperature stayed the same. After the biochar has cooled to room temperature, remove it from the oven. It was ground and sieved at 0.15 mm. The biochar was then pretreated with 0.1 M HNO_3 for four hours, washed with distilled water, and dried at room temperature[7].

Diluting the obtained Fe_3O_4 (approximately 0.5 gm) in 500 mL deionized water yielded Fe_3O_4-Biochar. After that, 2 gm biochar was applied to the Fe_3O_4suspension, which was stirred for 4 hours at room temperature. The Fe_3O_4-biochar composite was magnetically isolated and washed five times in distilled water before being dried for six hours at 80 ^{0}C in an oven. Figure 2-1 depicts biochar (B.C), magnetic materials (Fe_3O_4), and magnetic biochar (M.B.C) prepared experimentally[8].

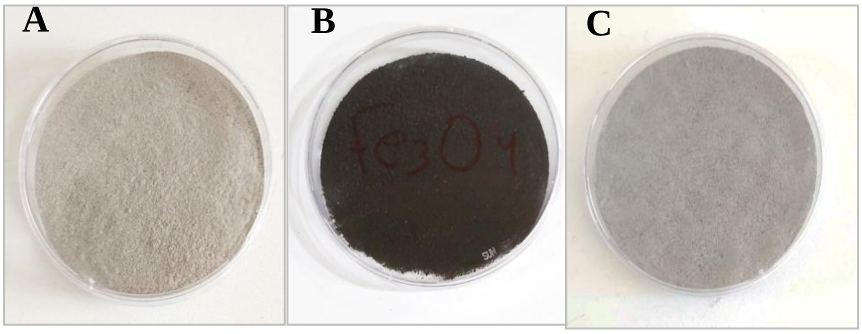

Figure :1 Prepared materials, **A**: Biochar (BC), **B**: Magnetic materials (Fe_3O_4), **C**: Magnetic Biochar (M.B.C)

Preparation Of Stock Solution

Dissolving 1.59 g of $Pb(NO_3)_2$ in 1000 ml of deionized water yielded an industrial stock solution of water containing Pb^{+2} (1000 mg/L). The concentrations of all other metal ions were obtained by serial dilution of stock solutions at concentrations of 10, 20, and 30 ppm.

Adsorption Efficiency Test

Adsorption experiments were performed with Pb at an ambient temperature of (25±0.5)°C . The removal efficiency (RE) of each of the prepared materials (biochar, magnetic biochar) was measured using different weights (0.1, 0.5, and 1) gm from the prepared material (Biochar, magnetic biochar). A 100 mL glass container was filled with 100 mL of Pb stock solution at concentrations of 10, 20, and 30 ppm. The three weights (0.1, 0.5, and 1) gm were used in the experiment. The three weights (0.1, 0.5, and 1) gm were separately applied to each concentration of lead-cadmium, implying that the three weights of the solution were added at concentrations of (10, 20, and 30) ppm.

Stir the mixture for half an hour at a steady pace in a reciprocating shaker. The solid and liquid phases were separated after equilibrium was achieved. Each sample's precipitate was dried on filter paper before being stored in a plain tube with the sample weight attached. Pb^{+2} concentration in the filtrate and precipitate were determined using atomic absorption spectroscopy (AAS). The adsorption ratio was calculated using the equation below [9]:

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$$\text{RE}(\%) = \frac{C_i - C_f}{C_i} \times 100\% \quad \dots\dots..(1)$$

Where:
RE: Removal efficiency.
C_i: The concentration before adsorption. C_f : The concentration at equilibrium.

The amount of metal ions sorbed per unit mass of the adsorbent was calculated using equation 2: [10]:

$$q_e = \frac{(C_i - C_f)\,V}{W} \times 100\% \quad \dots\dots..(2)$$

Where:.
q_e: The amount of solute adsorbed from the solution
V: Volume of the adsorbate. W: the weight in gram of the adsorbent.

Result and discussion

Biochar (B.C) Rice Husk (RH).

In the prepared Biochar, Table:1 displays the initial and final concentrations (C_i:, C_f), the adsorbed dose (W), the absorbed amount (qe), and the removal ratio (%) respectively for Pb^{+2}

Table 1: Removal efficiency (RE %) for Pb^{+2} from the solution in different adsorbent doses using Biochar

	Weight(gm.)	Ci (mg/L)	Cf (mg/L)	qe(mg/gm)	RE%
Biochar (B.C), Pb^{+2}	0.1	10	2.4975	7.50	75.03
		20	6.1510	13.85	69.25
		30	15.8068	14.19	47.31
	0.5	10	0.5758	1.88	94.24
		20	1.5248	3.70	92.38
		30	4.5852	5.08	84.72
	1	10	2.2365	0.78	77.64
		20	3.4108	1.66	82.95
		30	2.1179	2.79	92.94

Adsorbent dose was used as a parameter to assess the removal efficiency of Pb^{+2} concentration. To begin, for the Pb^{+2} cation, the percentage removal increased as the adsorbent dose increased, as shown in Figure 2:. Furthermore, raising the absorbed dose from 0.1 to 1 gm raised the percentage of Pb^{+2} elimination from 75.3 to 94.24% for a 10 mg/L concentration and from 69.25% to 92.38% for a 20 mg/L concentration, in both doses only (0.1 and 0.5)gm, respectively. Although there was a decrease in adsorption efficiency from previously values at the 1 gm adsorption level, it was 77.64% and 82.95 % for concentrations of 10 mg/L and 20 mg/L, respectively, due to a decrease in the surface area of absorption at this dose.

The removal of Pb^{+2} was increased from 47.31% to 84.72% to 92.94 % at a concentration of 30 mg/L in three absorbent doses (0.1, 0.5, and 1) mg/L, respectively, as well as the saturation state occurred in a variety of Interchangeable binding sites for lead adsorption in the absorbent per unit mass.

On the other hand, doubling the adsorbent dosage did not result in a significant improvement in the removal benefit, since large quantities of adsorbents cause the micro-components of the adsorbents to clump and thus reduce the gap between the micro components that make up the adsorbent mass, preventing the efficiency increase. It's also, because of the electrostatic interactions between the binding sites, the supply of the metal ion may be restricted at a higher concentration, reducing mixing at the adsorption dose.

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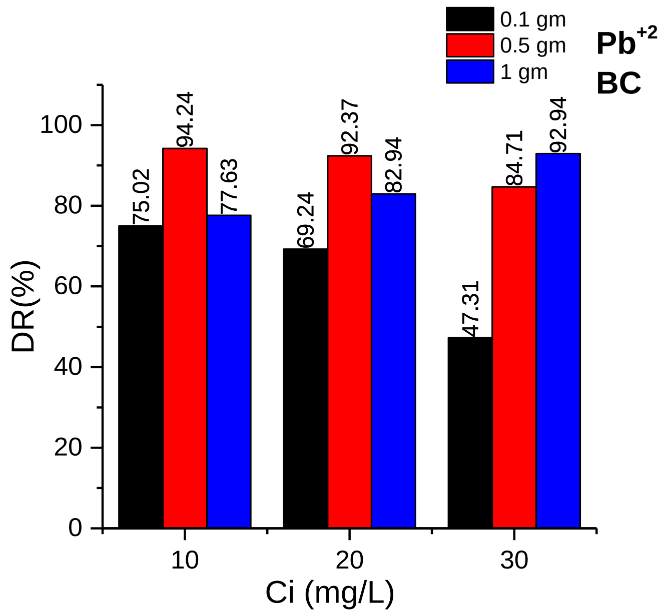

Figure 2: shows the effect of dosage on the Removal efficiency by Biochar (B.C) Rice husk for Pb^{+2} heavy element

At initial concentrations of (10, 20, and 30 mg/L), the effect of mineral element concentration on lead absorption was investigated. At a concentration of 30 mg/L and the maximum value of the adsorption dose of 1 gm, there was a significant improvement in adsorption efficiency with an increase in lead ion concentration, shows in Figure :3: Since an increase in the primary metal ion concentration raises the number of collisions between the metal ion and the substance adsorbent and therefore increases metal adsorption, the removal percentages reached 92.94% (the number of adsorbed ions in the solution increases, and thus the amount of adsorption increases). It can be assumed that under ideal conditions, the highest mineral absorption occurs at the highest mineral concentration, which is 30 mg/L. This finding was similar to that of , who found that as metal ion concentrations rise, so does the bio-absorption capacity of each bio-absorber.

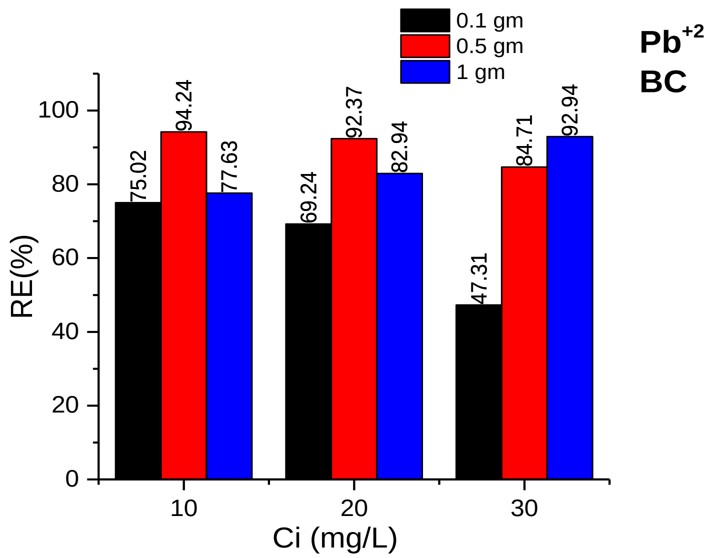

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Figure 3: shows the effect Ci mg/L as a functional of Removal efficiency onto Biochar (B.C) Rice husk for Pb^{+2} heavy element

When the amount of adsorption (qe) of the Pb^{+2} ion on the surface of adsorbents was studied, it was discovered that the relationship was a linear decreasing relationship, with the best weight being (0.1) gm. because the largest number of active centers in the adsorbent material are exposed to the adsorption from the lead ion, the amount of adsorption increases as the weight decreases, as shown in Figure 4:. The highest level of ion absorption in the solution was 14.19 mg/gm, according to the findings. With a 0.1 gm weight. Since the surface of the absorbent material has reached saturated with metal ions, the concentration is 30 mg/L.

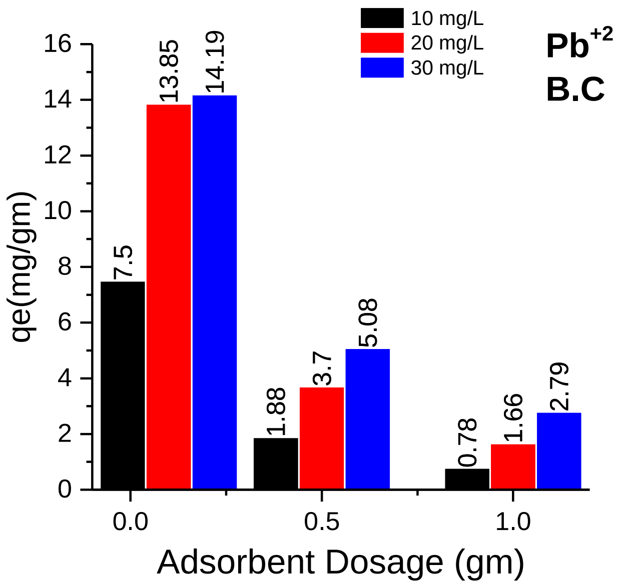

Figure 4: shows effect of adsorption weight on the amount of adsorption for Biochar (B.C) Rice husk for Pb^{+2} heavy element

Magnetic Biochar (M.B.C) Rice Husk (RH).

Adding in vitro prepared Fe3O4 to biochar to extract heavy metals with Pb^{+2} from standard aqueous solution and to increase adsorption efficiency and notice differences in adsorption capability. At a dose of 0.1 gm, the adsorption rate of magnetic biochar for positive pollutants of the heavy metal Pb^{+2} was found to be between 88.31%, 86.74%, and 68.98%. At a dosage of 0.5 gm, they were 96.97%, 97.54%, and 97.13%, respectively, and at concentrations of (10, 20, 30) mg/L straight, they were 94.72%, 96.23%, and 97.96%. It was also discovered that the rate of lead absorption increased as the absorption dose of the magnetic biochar increased, relative to its predecessor from the first biochar, since rapid absorption is linked to the availability of active sites on the treated material's surfaces. This is done by using magnetic biochar, in addition to the key mechanism of removal by magnetic biochar, which is primarily accomplished by electrostatic absorption, difficulty with functional groups, and ion exchange between heavy metals and adsorbents, thus increasing the absorption efficiency.

Table 2 shows the adsorbent efficiency(RE%) of Pb^{+2} in the prepared Magnetic Biochar (M.B.C):

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Table 2: Removal efficiency (RE %) for Pb^{+2} from the solution in different adsorbent doses using Magnetic Biochar

	Weight (gm.)	Ci (mg/L)	Cf (mg/L)	qe (mg/g)	RE%
Magnetic Biochar (M.B.C), Pb^{+2}	0.1	10	1.1689	8.83	88.31
		20	2.6517	17.35	86.74
		30	9.3063	20.69	68.98
	0.5	10	0.303	1.94	96.97
		20	0.4928	3.90	97.54
		30	0.8605	5.83	97.13
	1	10	0.5283	0.95	94.72
		20	0.7537	1.92	96.23
		30	0.6114	2.94	97.96

Generally, it was also found that the highest absorption occurred at a dose of 0.5 gm, so that the active sites were almost completely saturated with the element lead (competitive adsorption occurs). Figure 5: shows the effect of dose on adsorption efficiency (RE) of Pb^{+2} on the magnetic biochar (M.B.C) ,rice husk.

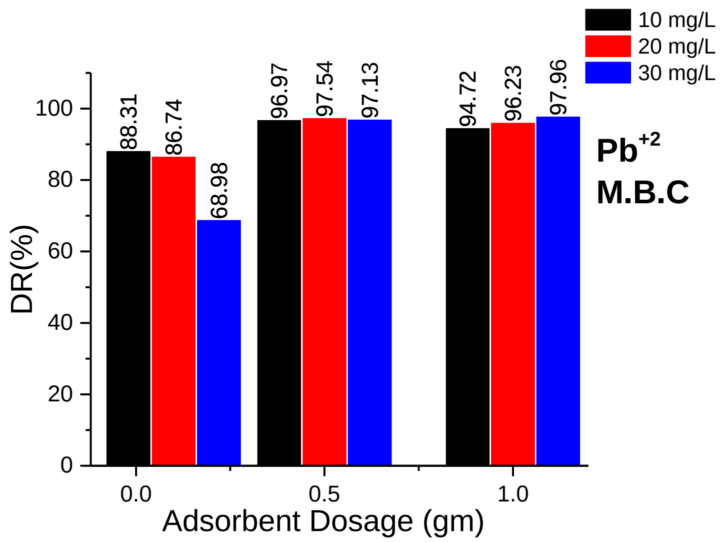

Figure 5: shows the effect of dosage on the

Removal efficiency by Magnetic Biochar (M.B.C) Rice husk for Pb^{+2} heavy element

When we apply the magnetization function to the prepared biochar, as shown in figure 6:, we see an increase in the removal ratios and a marked improvement, as the highest rate of Pb^{+2} removal was reported at 97.96 percent at a concentration of 30 mg/L and a dose of 1 gm to increase the surface area of the absorbent, boost the absorbing surface of the material, and a large number of free sites for polarizing lead cations At doses of 0.5 gm and 1 gm, concentrations of 20 mg/L achieved exceptional absorption, exceeding the saturation limit of the adsorbed Pb material. At a dosage of 0.1 gm, the adsorbing capacity decreased progressively at all three concentrations. This is due to the same cause as when biochar was used to remove Pb^{+2}ion .

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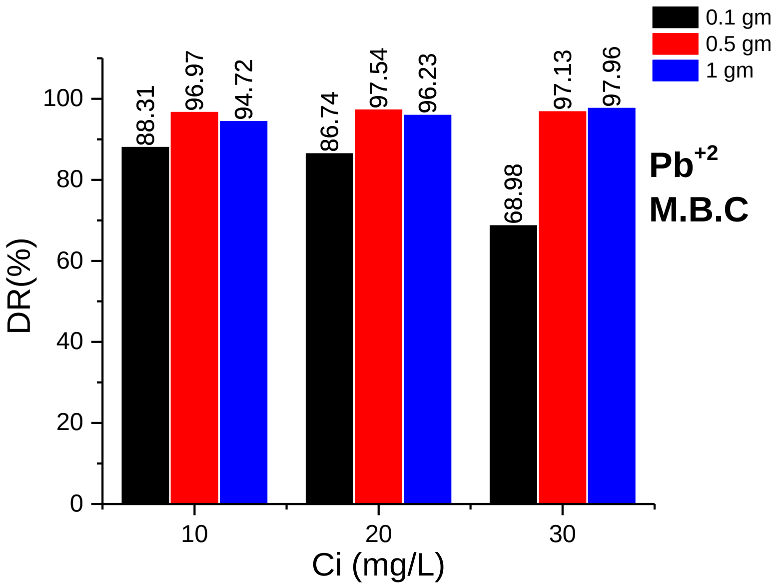

Figure 6: shows the effect Ci mg/L as a functional of Removal efficiency onto Magnetic Biochar (M.B.C) Rice husk for Pb^{+2} heavy element

The adsorption capabilities of magnetic biochar with different doses of adsorbent increased with a decrease in the concentration of Pb^{+2} in the lower dosage, since the absorbent material produced a large number of adsorption sites for metal cations at low concentrations. Figure 7. shows effect of adsorption weight on the amount of adsorption for Magnetic Biochar (M.B.C) Rice husk. for Pb^{+2} heavy element.

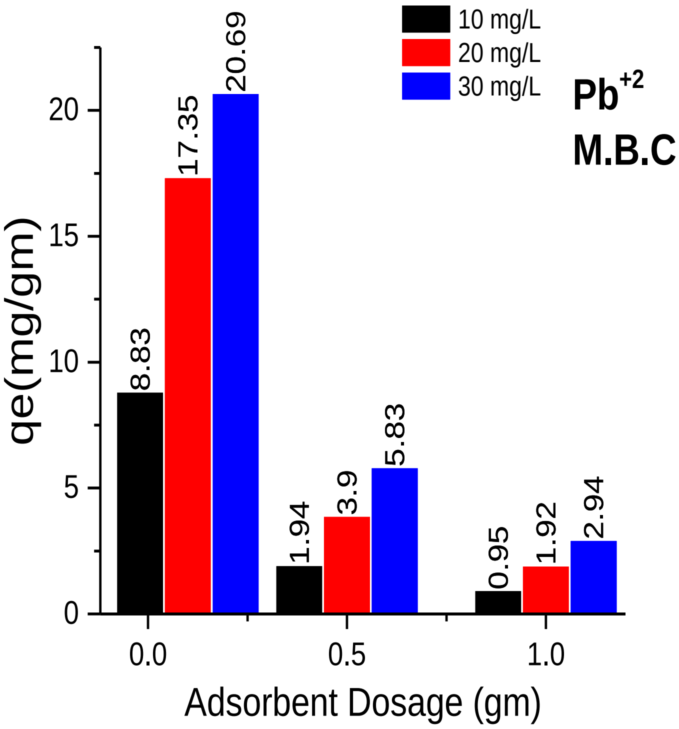

Figure 7: shows effect of adsorption weight on the amount of adsorption for Magnetic Biochar (M.B.C) Rice husk for Pb^{+2} heavy element

Conclusion

Biochar and magnetic biochar made from rice husks were used to absorb Pb^{+2}, and it was discovered that the removability is greatly influenced by the initial concentration of minerals, the adsorbent dosage, the amount of adsorbent .The produced biochar had a positive impact on improving the removal efficiency of heavy metals Pb^{+2}due to a direct increase in the amount of active adsorption sites available on the adsorbent surface, resulting in a higher removal efficiency of the heavy metal ions present, with 92.94% for Pb^{+2} and 46.88% for Cd^{+2} , respectively, at doses of 1 gm.

The addition of the magnetization property to biochar prepared by doping with Fe_3O_4 improved the adsorption rate significantly, with Pb^{+2} removal efficiency reaching 97.96% at a dose of 1gm. The addition of the magnetization characteristic increased the number of active sites, increased the adsorption surface region, and created an attractive material for mineral ions, which explains the high adsorption efficiency of magnetic biochar.

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