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Research Article

Extraction of some heavy metal ions from aquatic solution by banana peel-based biosorbents

Doğu RAMAZANOĞLU*[1], Zaman Adnan MOHAMMED[1], Khalid Ali MAHER[2]

[1]*Zakho University, Scientific Research Center, Zakho, Iraq*
[2]*Department of Chemistry, Zakho University, Zakho, Iraq*

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ABSTRACT

In this work, economic, natural, and eco-friendly biosorbent want to be advised instead of traditional methods. For that reason, banana peel-based biosorbents were been done to remove Cu^{2+}, Ni^{2+}, and Co^{2+} ions from the solution by batch method. Moreover, how their natural assets like density, water intake, solubility, and heavy metal extraction performance were affected by their starch and oil contents had been determined. Flame atomic absorption spectroscopy (FAAS) having been using for the analysis of biosorbents uprooting performance. The density of the biosorbents had worked according to ASTM D 792 standards. As a result, the untreated banana peel-based biosorbents had transported 4.87 mg of Co^{2+} ions, 4.73 mg of Ni^{2+} ions, and 4.29 mg of Cu^{2+} ions from 25 ml 7 ppm of each heavy metal ions solution with 175 rpm agitation speed at 24°C during half-hour.

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INTRODUCTION

Processing of heavy metals had been beginning since antics time without awareness of their toxicity. The usage amount of heavy metal-containing coals that causes air pollution also develop industrialization. Water pollution is the thinnest point for damage to the food chain for that reason, the studies about extraction of organic and inorganic contaminants from wastewater are so valuable [1–8]. Numerous organic and inorganic studies have been done and suggested for wastewater treatment methods like as, electrochemical treatment, ion exchange, reverse osmosis, and chemical precipitate. These traditional methods have low performance, are expensive, and are unsuitable for large-scale processing [9–12]. Hence, an alternative method has been desiring.

Nowadays, the biosorbents have been shined like an alternative method instead of these traditional ones. Biosorption is a natural potential of biomaterials to the extraction of heavy metal ions from water metabolically or physiochemically [13]. Non-living biomass like shrimp, bark, crab shell, etc.; were used as traditional biosorbent [14]. In this study, banana peels have operated as an alternative biosorbent because of their abundance and low cost [15, 16]. As a biosorbent, they have the potential for reducing toxic metal ions like Cu^{2+}, Ni^{2+}, and Co^{2+} from urban environ-

***Corresponding author.**
*E-mail address: doguramazanoglu@hotmail.com

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mental problems as well as metal-contaminated industrial effluent treatment expenses.

Banana is one of the most enjoyed fruits around the world. Although, its peels do not have specific usage. For that reason, the banana peels were tested as adsorbents of metal ions. This biomass has polymeric groups such as proteins, pectin lignin, cellulose, and hemicellulose which take a role in the adsorption of metal ions [17].

Besides these, it has other chemical groups like carboxylic acid, phosphate, and hydroxyl group attach to metals ions [18]. Figure 1 shows the chemical groups of banana peels; (a) carboxyl, (b) hydroxyl, (c) phosphate, and metal ions. In this study, 6 different biosorbents were supplied from banana peels to extract Cu^{2+}, Ni^{2+}, and Co^{2+} ions from the aquatic. Lastly, how their content affects their extraction performance during 30 minutes of contact time at room temperature investigated.

MATERIALS AND METHODS

Materials

Corn and wheat starch, apple cider vinegar (4–5% acetic acid), sunflower oil, Banana has bought from a local grocery store in Zaho. Cobalt (II) Acetate $C_4H_6CoO_4$, Nickel (II) Nitrate Hexahydrate $Ni(NO_3)_2.6H_2O$, and Copper (II) chloride dihydrate $CuCI_2.2H_2O$ has provided from (Merck, Germany).

Methods

Am Scope brand microscope has trained for taking surface images at the biology lab at Zakho university. Atomic absorption spectroscopy (FAAS) that (PerkinElmer, Turkey) brand has applied for a measured left of the concentration of solution after treatment with biosorbents in the scientific research center. Banana (Musa) peels having dried for two days at 103±2°C. Dried peels had been granulated by a coffee pulverizing machine.

Preparation of Biosorbents

The component of the banana peel-based biosorbents cornstarch, banana, sunflower oil having weighed and placed in a 500 ml beaker as given in Table 1. 25 ml of pure water summed to the beaker. Later, 3 ml of acetic acid was added and stirred to break the long-chain molecules of the starch. After, 1–2 ml of sunflower oil was combined as a plasticizer to re-crystallize to depolymerized polymer chains. It having mixed and fired at 75°C until gelation proceeds. Then, they left in the oven for 45 minutes at 103±2°C as shown in Figure 2.

Solubility Test (%)

The solubility test had found in 1992 by Gontard et al. [17]. Samples have taken in the oven for 24 hours at 103±2°C.

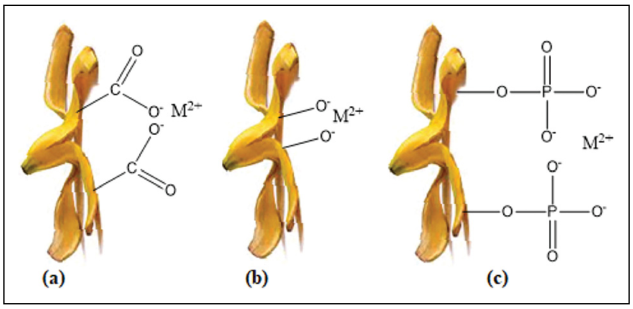

Figure 1. Interactions between the metal ions (M^{2+}) and the chemical groups present in the banana peel; **(a)** carboxyl, **(b)** hydroxyl, and **(c)** phosphate groups [10].

Table 1. Content of biosorbents

B1	B2	B3	B4	B5	B6
1g.B/ 2g.S	1.5g.B/ 1.5g.S	2g.B/ 1g.S	1g.B/ 2g.S	1.5g.B/ 1.5g.S	2g.B/ 1g.S
0.5 ml Oil	0.5 ml Oil	0.5 ml Oil	1 ml Oil	1 ml Oil	1 ml Oil

Then, they were weighed (Wi) and washing with 50 ml of purified water at 175 rpm for a day. After the rinsing step, they have balanced again. Finally, the solubility of the biosorbents had determined according to the equation given in (1).

$$S=(Wi-Wf)/Wix100 \quad (1)$$

Wi: Initial mass; Wf: Final mass.

Water Intake (%)

The water intake (%) values of biosorbents kept in pure water for 24 hours have determined according to the formula is given in (2).

$$SW=[(Mw-Md)/Md]x100 \quad (2)$$

Md=Sample initial weight (g); Mw=The weight of the sample after immersion in water (g); SW=water uptake rate (%).

Density Test (g/cm³)

The Air-dry weights of the samples were found and recorded. Then, they were immersed in water and weighed. The density of those samples had calculated concerning the equation in (3).

$$\text{Density } (g/cm^3)=[Ma/Mw] \quad (3)$$

Here, Ma=weight of the sample in the air (g). Mw=The weight of the sample in water (g) is given.

Batch Experiment

$CuCI_2.2H_2O$, $Ni(NO_3)_2.6H_2O$, and $C_4H_6CoO_4$ were used for preparing 25 ml 7 ppm of Cu^{2+}, Co^{2+}, and Ni^{+2} heavy metal ions solutions. Then, 25 mg of biosorbent was separated for the adsorption of each solution. Adsorption circumstances have adjusted to 175 rpm of stir speed, at 24°C for 30

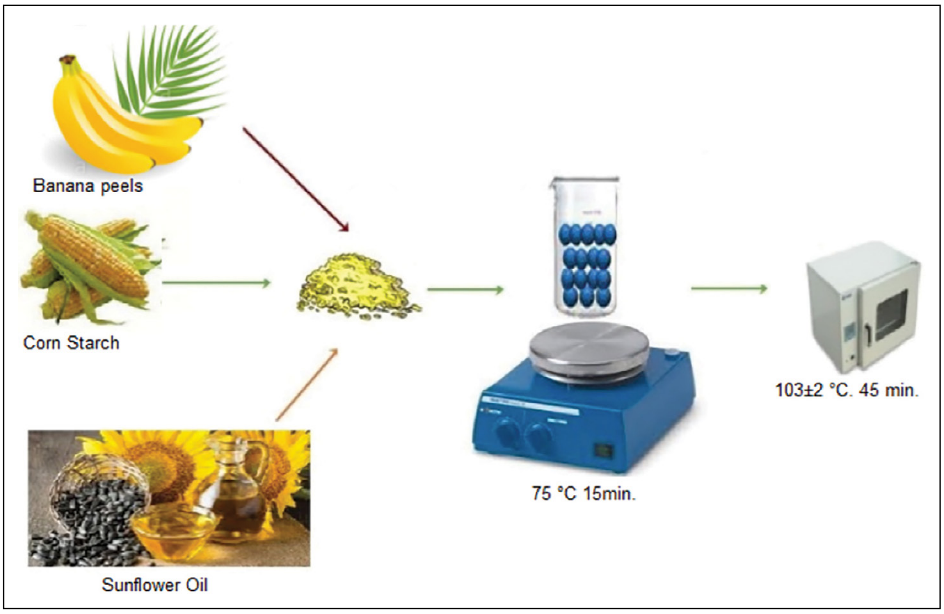

Figure 2. Preparation of biosorbents.

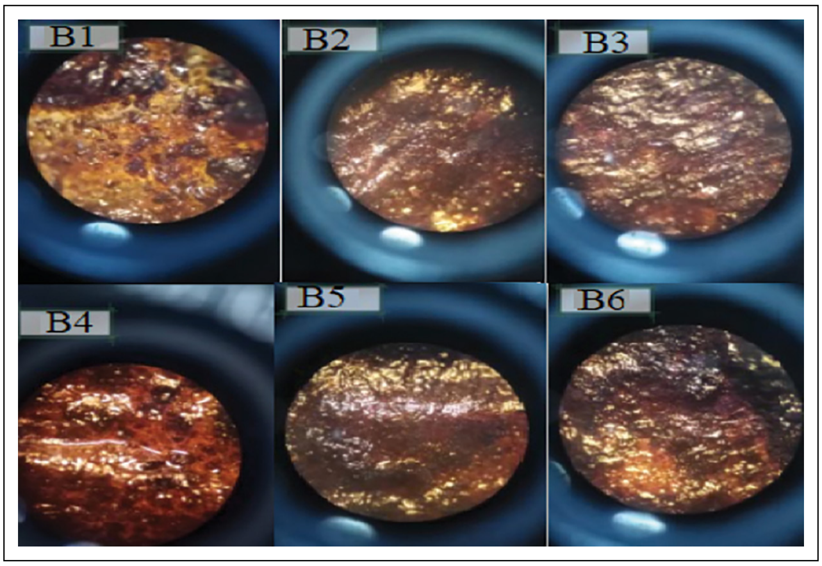

Figure 3. Banana peels-based biosorbents. Banana peels, starch, and oil content ratio of biosorbent (1/2/0.5) for B1, (1.5/1.5/0.5) for B2, (2/1/0.5) for B3, (1/2/1) for B4, (1.5/1.5/1) for B5, (2/1/1) for B6 respectively.

minutes. The performances have been obtained from the equation in (4).

$$Q=[(Co-Ce).V]/ m \tag{4}$$

Where; Co (mg/L) is an initial concentration, and Ce (mg/L) is the final concentration. V is the volume in a liter (L) unit, and m is biosorption in gram (g) units.

Morphology of Biosorbents

The surface photographs of biosorbents having taken by microscope in Figure 3. The biosorbents have different ingredients that make appearing not the same.

RESULTS AND DISCUSSION

Water Intake Analysis of Biosorbents

Banana peels-based biosorbents solubilities are calculated according to the equation in (1). Also, water intake values are shown in Figure 4.

The bar diagram trades with the water intake capacity of banana peel-based biosorbents. When, water intake was being decreased from B1 to B3 with an increasing quantity of banana peels contents [18, 19]. While the starch amount was raising biosorbents, the water adsorption capacity was diminishing. The chart has separated into

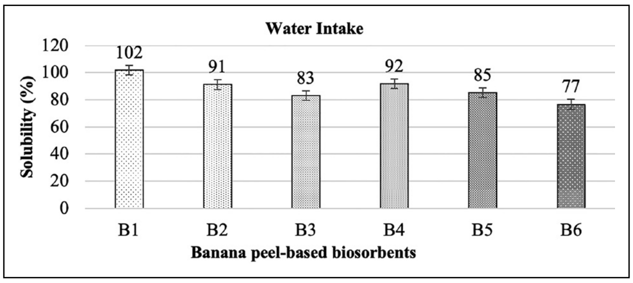

Figure 4. Water-intake of banana peels-based biosorbents. Banana peels, starch, and oil content ratio of biosorbent (1/2/0.5) for B1, (1.5/1.5/0.5) for B2, (2/1/0.5) for B3, (1/2/1) for B4, (1.5/1.5/1) for B5, (2/1/1) for B6 respectively.

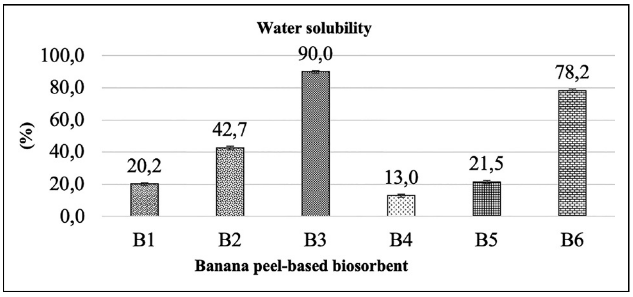

Figure 5. Solubility of banana peel-based biosorbents. Banana peels, starch, and oil content ratio of biosorbent (1/2/0.5) for B1, (1.5/1.5/0.5) for B2, (2/1/0.5) for B3, (1/2/1) for B4, (1.5/1.5/1) for B5, (2/1/1) for B6 respectively.

two groups referring to their oil contents. The first group of biosorbents had B1, B2, and B3. The second group had B4, B5, and B6.

Water Solubility Analysis of Biosorbents

The solubility of banana peel-based biosorbent was measured and given in Figure 5. The increasing amount of starch in biosorbent causes more solubility. However, the increased oil contents for B4, B5, and B6 show us how to decrease the solubility percentage. Hence, the B4 was the least water-soluble banana peel-based biosorbent with a 13.0% value and the B3 had the highest solubility value with 90.0%. There is just one difference between B1, B2, and B4, B5 that double oil content which decreased to solubility nearly 50%. On the other hand, B3 and B6 nearly lose the solubility ratio 10 percent. It showed how starch content negatively affects the solubility of biosorbents.

Density of Biosorbents

The bar chart has given in Figure 6 deals with the density of banana peel-based biosorbents. While the density of biosorbents was diminishing, starch content was rising. The elevated sunflower oil causes a slight uptick in mass [18–21]. The frequency of biosorbent had been directly equivalent to banana barks content.

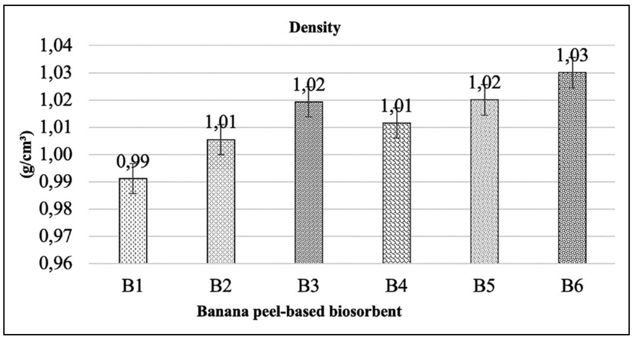

Figure 6. Density of banana peel-based biosorbents. Banana peels, starch, and oil content ratio of biosorbent (1/2/0.5) for B1, (1.5/1.5/0.5) for B2, (2/1/0.5) for B3, (1/2/1) for B4, (1.5/1.5/1) for B5, (2/1/1) for B6 respectively.

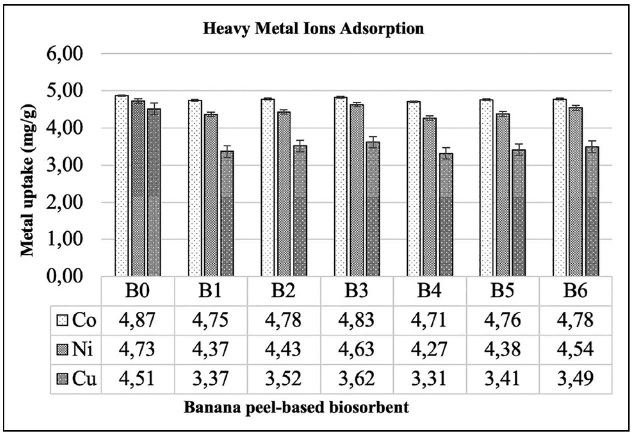

Figure 7. Heavy metal ions adsorption capacity of banana peels-based biosorbents; Banana peels, starch, and oil content ratio of biosorbent (1/2/0.5) for B1, (1.5/1.5/0.5) for B2, (2/1/0.5) for B3, (1/2/1) for B4, (1.5/1.5/1) for B5, (2/1/1) for B6 respectively.

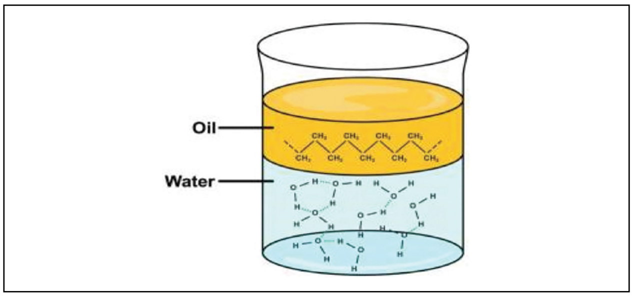

Figure 8. Interaction between water and oil molecules [22].

Adsorption Studies of Biosorbents

The adsorption studies of banana peel-based biosorbents having evaluated at the same condition for all heavy metal ions. The adsorption amount of Co^{2+}, Ni^{2+}, and Cu^{2+} heavy metal ions have given in Figure 7.

It has been obtained from the chart that untreated biosorbent has more adsorption capacity. Also, an expanded volume of biomass content boosted the sorption capacity. Generally, biosorbents had double the amount of sunflower oil ingredients that have less adsorption capacity than others. That might be explained better by the interaction between water and oil molecules in Figure 8.

Oil has non-polar molecules. As we know, the electronegativity of non-polar molecules atoms is equal. But water has polar molecules that mean their electronegativity is not stable. Because of these polarity distinctions, might be cause for the adsorption capacity diminished. The other reason why untreated biosorbent performed better adsorption than other bio-composites is because of the chemical group's abundancy like carboxyl, hydroxyl, and phosphate groups present on banana peels which includes less from others.

The untreated biosorbent; B0 was the highest biosorption among them with the values of 4.87 mg/g, 4.73 mg/g and 4.51 mg/g for Co^{2+}, Ni^{2+}, and Cu^{2+} heavy metals ions respectively during half hour, at 24°C and 175 rpm agitation speed.

CONCLUSION

1. In the water intake analysis, the water intake amount decreases with increasing oil content. When the amount of banana peels content has increased, intake of water has diminished. Moreover, the surged starch content was inversely proportional to the water intake of banana peel-based biosorbent.
2. In the water solubility study, the raised sunflower oil content having decreased the solubility of all biosorbents. The B3 was observed as the highest soluble one with value of 90% among its groups. The B4 was recognized as the least soluble with value of 13.0%. The increasing amount of biomass enhances the solubility of biosorbents. Moreover, expanded biomass inversely proportions with a starch content have not been saved in a bioform. That is why the diminished starch amount grows the solubility.
3. In the density analysis, the booming oil content improves density for all biosorbents. Biosorbent that has the highest densities in its group was B6 determined as 1.03 g/cm^3. The biosorbent B1 was found as lowest one with the value of 0.99 g/cm^3.
4. In the adsorption step, untreated Banana peels has the highest Co^{2+}, Ni^{2+} and Cu^{2+} ions adsorption among others. Moreover, the increased sunflower oil reduced the heavy metal ion adsorption. Additionally, decreasing the amount of starch content also lessened adsorption capacity. Oppositely, the raised amount of biomass improves the adsorption performance. The density of all biosorbents was directly proportional to adsorption capacities.

According to results, banana peels can be used as biosorbent directly instead of other expensive water treatment methods. Further studies can be about to determination of the optimum condition of biosorbents and their carbonized form.

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DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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