Impact of Rice Husk, Banana Peel and Egg Shell as Biodegradable Adsorbent for Heavy Metal Treatment of Industrial Wastewater

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Abstract

Industrialization causes pollution of the environment around globe. This contamination is a problem because the water gets contaminated with harmful metals. Heavy metals are becoming source of contaminating the ocean, soil, factories, and even cleaned waste water. These metals are being released into the environment, both naturally and artificially. The release of industrial waste into water can harm plants and animals in the water and can also make people sick. This is a major problem around the globe because the waste is poisonous and can cause serious harm.

Non-biodegradable items cannot break down naturally, so if they end up in an ecosystem, they negatively affect the environment. That's why it's important to find new ways to remove heavy metals from pollution sources before they harm the environment by an environmentally biodegradable material. Now adays, there are various ways to filter waste water of industries containing heavy metals [6]. These methods include precipitation, reverse osmosis, activated sludge process, and adsorption [16, 18, 19, 21]. Some scientists used soil for treatment the industrial waste water as well [8, 16]. In recent years, the Adsorption method has been considered as a top choice for removing heavy metals from industrial waste. It works just as well as traditional methods. Therefore, authors used biodegradable solution to the problem using rice husk, banana peel and egg shell.

This study explores how rice husk, banana peels and egg shells can be used effectively as eco-friendly biodegradable adsorbents. Rice husk, banana peels and egg shells were used to create a natural and environmentally friendly biodegradable material that can remove impurities from water solutions. Rice husk, banana peels and egg shells are easily found waste products that were selected for this purpose. Rice husk, banana peels and egg shells were cleaned, dried, and crushed to very small sizes orderly in 100-150 µm and 200 µm. These small particles were then used to treat pharmaceutical waste water. All three selected substances were combined and used to clean dirty water with different amounts, different pH levels, and different amounts of time. The authors used the batch method to understand how adsorption works. The test was done in two different situations including one where things were steady and one where things were moving.

Keywords: Biodegradable, Bio-adsorbent, Banana Peel, Egg shell, Rice Husk, Wastewater Treatment.

Introduction

India is a country that is growing and having approximate 25% population of whole. Due to development of industries, agricultural practices and other biological or chemical factories without a sustainable plan, a lot of the land and water nearby are dirty because the factories are dumping garbage without thinking about it. This is a serious concern because the community relies on groundwater as their main source of water for survival. The high number of atoms packed closely together are well known as heavy metals. Certain harmful heavy metals, like lead, chromium, arsenic, cadmium, nickel, cobalt, iron, and zinc, can cause metal toxicity by using contaminated water [13]. These contaminants get passed on and increase in concentration as they move in the food web [23]. Multiple types of aforementioned harmful metals cannot be broken down naturally [2, 3, 7]. There are laws in place, the Ministry of Environment and other authorities but quantity of metal ions and synthetic pollutants in our ecosystem are increasing because industries are not treating their waste properly. As industries and energy stations grow quickly, they are causing metal waste to be released into the environment in different manners. Presence of too much contaminating metals causing a lot of mortalities and we are witnessing these types of cases regularly through proper channels.

Because factories release a lot of dirty water with metal pollution into the river, they cause the river to have high levels of toxic metals e.g., cadmium, chromium, lead, zinc, copper, and arsenic. which are very dangerous and can be taken in by all living things [13]. When heavy metals get into our food, they start to build up in our bodies. If you eat too much of it, it can make you very sick [5,23]. Therefore, it is important to effectively clean-metal polluted water by using various techniques. Various traditional methods are being used based on the types of heavy metals present and how well the methods can remove these heavy metals from wastewater [11]. However, every method has its own limitations. Therefore, nowadays, it is necessary to find ways to filter heavy metals from contaminated waste water of industries that are just as effective as

traditional methods. Adsorption is a new way to clean up dirty water from factories so that it meets the cleanliness requirements [10,12]. Because it has a lot of tiny holes, activated carbon is commonly used to clean water that has metal pollution. Adsorption is the most effective and financially viable method of them all [24]. When compared to other techniques, adsorption is incredibly affordable and efficient [4]. Large-scale natural materials or specific agricultural waste products may have the potential to be employed as inexpensive adsorbents as they are abundant, untapped resources, and ecologically benign [9]. Adsorption is a successful method for separation and purification.

Materials and Methods

Collection and procedure of adsorbent Biomass preparation

Husk of Rice

The husk is a layer protecting rice grain from outside and made of cellulose [16]. The nearest rice mill provided rice husk and the authors preliminarily washed it with distilled water to clean the impurities. After wash, rice husk dried in a hot oven at 100°C for 24 h [18]. Partially prepared adsorbent biomass was stored in the safe boxes for further use. The rice husk is used to remove laterite as an adsorbent by Sarkale in a recent study, so we selected it as a known adsorbent [20].

Chicken eggshells

The eggshells of chicken were collected from local market (boiled egg seller street vendor) and cleaned as similar procedure followed to clean husk of rice and dried for four hours in an electric oven at 120 ºC and then kept in room temperature. Subsequently, these were crushed and sieved into particle size of 250-500µm. The chicken eggshell powder comprises of 94% $CaCO_3$ with small amount of organic matter including protein and $MgCO_3$ calcium phosphate. The prepared biomass adsorbent was stored in safe boxes [21].

Fresh banana peels

Fresh banana peels were collected from banana seller stall, without any cost and also due to easily available in the local fruit market. Banana peel contains carbohydrates (59%), crude fibre (31%), lipids (1.7%) and proteins (0.9%). The peels were washed several times by distilled water. The cleaned banana peels later chopped into pieces and dried in a hot air oven at 90˚C for 20 hours. After losing the moisture content the colour changed from yellow to brownish black. The dried material was finely ground and sieved of cut size of 250-500µm. The prepared biomass adsorbent of banana peel was stored in safe boxes [21].

Adsorbate

In this study well known heavy metals for their eco-toxicological hazardous substances were selected. The heavy metals tested in the present study are Hg, Pb, Cd and Cr. The heavy metal aqueous solution of 100 ppm of each metal was used.

Observations of Time Slot

The impact of contact time on metal ions adsorption of was examined through different slot of time (6, 12 hr) and dosages of 1gm and 2 gm rice husk, banana peel and egg shells and with the combination of two of them as set (rice husk [17] & banana peel [2, 15], rice husk & egg shells, banana peel & egg shells) adsorbents in 100 ml water sample.

Acronyms used for the combinations are as follows:

1. Rice husk & banana peel: RHBP
2. Rice husk & egg shells: RHES
3. Banana peel & egg shells: BPES

Result and Discussion

Effects of the adsorbents on different time slot and quantity

The experiment was designed to analyse the impact of different adsorbent combination (RHES, BPES, RHBP) dosage on two different time slots (6 Hrs, 12 Hrs). 1gm and 2 gm amount of adsorbent were taken in aqueous solution of 100 ml. These samples were analysed after filtration. According to the recorded analysis, it is recorded that the removal of heavy metals increases in respect to selected dose.

In the case of Cr, 1gm BPES on 6 hrs and 2 gm of RHES on 12 hrs filters 93.75% and 99.5% respectively, in case of Cd, 1gm of RHES on 6 hrs and 2 gm of RHES on 12 hrs filters 77.5% and 98.1% respectively, in case of Pb, 1 gm of RHES for 6 hours and 2 gm of BPES for 12 hrs filters 61.1% and 77.1% respectively. In the case of Hg, 1 gm of RHES for 6 hrs and 2 gm of BPES for 12 hrs filters 84.5% and 99.5% respectively. In the three combinations of adsorbents (Rice husk & banana peel: RHBP, Rice husk & egg shells: RHES, Banana peel & egg shells: BPES), BPES performed high filtration adsorbent followed by RHBP and RHES.

Conclusion

This study examines a novel technique for water purification that requires less energy, labour, and financial resources. It also shows promise as a biodegradable and efficient alternative to chemicals and synthetic adsorbents. The tendency is for adsorption to rise with contact time. Since there are many available sites for adsorption to occur on, the rate of adsorption initially increases quite quickly. Therefore, it can be said that heavy metals may be extracted from waste water by using rice husk, banana peels, and egg shells. All of which are discarded waste products that are widely available in the local market. Banana peels and rice husk combination is less effective in removing high metal concentrations than rice husk and egg shells combination followed by banana peels and egg shells combination. Combining the two adsorbents results

in increased efficiency. After being utilised, the bio-adsorbents may be recovered by desorption techniques for a limited amount of time, and this may eventually be utilised in a commercial setting.

In the current investigation, adsorption was used to filter the contamination of heavy metals from collected aqueous solutions, including cadmium, lead & chromium. Lead, cadmium, and chromium were shown to be extremely effective at a particle size of 250µm. Because a smaller particle increases the number of available active sites, a smaller particle also increases adsorption. As a result, these adsorbents seem to be highly effective, economically viable, environmentally benign, and technically practicable. This study shown that a variety of adsorbents may be effectively employed to remove Therefore, before releasing waste water into the environment, industrial effluents must be cleaned of heavy metals. lead, cadmium, and chromium from wastewater. The current adsorbents may be used on an industrial scale to remove lead, cadmium, and chromium, in that order.

The experimental findings from this study unequivocally demonstrate that banana peel and egg shells powder are just as effective at removing lead from industrial waste water as activated carbon. Banan peels and egg shells should be used in industry as a more effective substitute for activated carbon in the filtration of lead from contaminated wastewater due to their inexpensive cost and easy availability in nature.

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Tables

Table: 1- Graphical representation of removing heavy metals by using Rice husk, Banan peel and Egg shell combinations as natural adsorbents

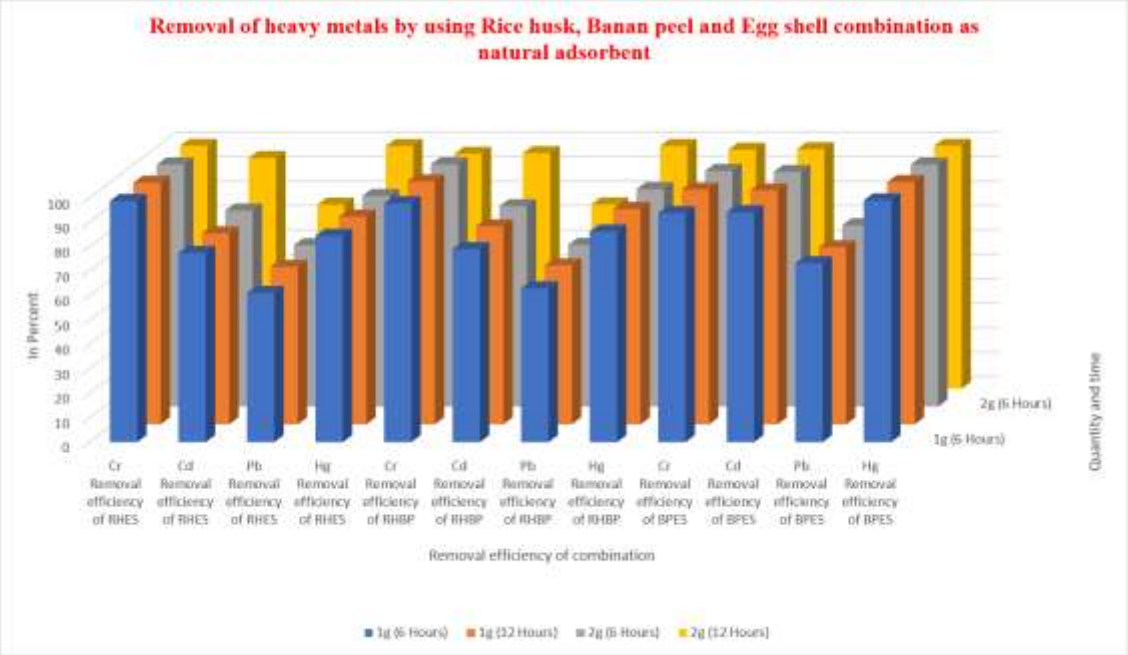

Table: 2- Detailed data of removing efficiency of heavy metals on different time slot and quantity of absorbents.

Removing efficiency of heavy metal	Quantity & Time 1g (6 Hours)	Quantity & Time 1g (12 Hours)	Quantity & Time 2g (6 Hours)	Quantity & Time 2g (12 Hours)
Cr Removal efficiency of RHES	98.75	98.96	99.10	99.5
Cd Removal efficiency of RHES	77.5	78.25	80.3	94.5
Pb Removal efficiency of RHES	61.1	64.5	66.05	75.4
Hg Removal efficiency of RHES	84.5	85.1	86.25	99.4
Cr Removal efficiency of RHBP	97.85	99.5	99.2	96.2
Cd Removal efficiency of RHBP	79.05	81.1	82.05	96.5
Pb Removal efficiency of RHBP	63.05	65.1	66.2	75.5
Hg Removal efficiency of RHBP	86.25	88.25	89.05	99.4
Cr Removal efficiency of BPES	93.75	96.1	96.5	97.9
Cd Removal efficiency of BPES	94.2	95.8	96.1	98.1
Pb Removal efficiency of BPES	73.25	72.5	74.25	77.1
Hg Removal efficiency of BPES	99.05	99.25	99.1	99.5

Table: 3- Detailed data of removing efficiency of heavy metals on different time slot and quantity of absorbents with values represented as mean ± SD (n = 4).

Heavy Metal	Quantity of adsorbent (g)	Removal efficiency of RHES	Removal efficiency of RHBP	Removal efficiency of BPES
Cr	1g (6 Hours)	98.75 ± 0.50	97.85 ± 1.50	93.75 ± 0.50
Cr	1g (12 Hours)	98.96 ± 0.65	99.50 ± 0.50	96.10 ± 0.50
Cr	2g (6 Hours)	99.10 ± 0.35	99.20 ± 0.20	96.50 ± 0.45

Cr	2g (12 Hours)	99.50 ± 0.40	96.20 ± 0.45	97.9 ± 0.30
Cd	1g (6 Hours)	77.50 ± 0.45	79.05 ± 0.50	94.20 ± 0.50
Cd	1g (12 Hours)	78.25 ± 0.35	81.10 ± 0.75	95.80 ± 0.40
Cd	2g (6 Hours)	80.30 ± 0.30	82.05 ± 0.20	96.10 ± 0.50
Cd	2g (12 Hours)	94.50 ± 0.20	96.20 ± 0.30	98.10 ± 0.40
Pb	1g (6 Hours)	61.10 ± 0.20	63.05 ± 0.20	73.25 ± 1.50
Pb	1g (12 Hours)	64.50 ± 0.30	65.10 ± 0.45	72.50 ± 0.50
Pb	2g (6 Hours)	66.05 ± 0.20	66.20 ± 0.10	74.25 ± 0.50
Pb	2g (12 Hours)	75.40 ± 0.426	75.50 ± 0.10	77.10 ± 0.10
Hg	1g (6 Hours)	84.50 ± 0.20	86.25 ± 0.40	99.05 ± 0.30
Hg	1g (12 Hours)	85.10 ± 0.25	88.25 ± 0.35	99.25 ± 0.30
Hg	2g (6 Hours)	86.25 ± 0.20	89.05 ± 0.20	99.10 ± 0.40
Hg	2g (12 Hours)	99.40 ± 0.25	99.40 ± 0.20	99.50 ± 0.20