CaRBoKem: A Biofilter to Treat Heavy Metals by using the Household Waste Products

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Abstract

Environmental toxic waste from heavy metals along with minerals within the waste matter is one of the most significant issues in an Asian country. The activities like industrial operations particularly mining, agricultural processes, and disposal of industrial waste materials; their concentration has redoubled to hazardous levels. Major metals in industrial sewage represent Cu, $Cr^{3+}$and Pb, etc. So far, varieties of inexpensive strategies are reviewed for the removal of these metals. The various processes include chemical precipitation, reverse diffusion, electro qualitative analysis, nanofiltration, and floatation. But these strategies have many disadvantages like high chemical agent demand, unpredictable metal particle elimination, and production of unhealthful sludge. Surface absorption method being terribly straightforward, economical, effective, and versatile has become the most popular strategies for removal of unhealthful contaminants from waste matter. This paper gives a new idea for the utilization of natural materials as adsorbents for significant metal removal from industrial wastewater. The components used are mustard plant roots, human hair, and some common household waste products such as eggshells and coconut shells. Efficiently utilizing their adsorbent properties, it can be used to filter industrial heavy metals that cause pollution.

I. Introduction

These day's toxins are discharged into the water leading to water contamination. Numerous heavy metals from various industries like battery plants, metal processing industries, pharmaceuticals, hospitals, mining fields, etc. are being discharged into the water bodies leading to unstable water for everyday use [2]. Lead, Chromium, Copper, etc are the heavy metals that induce toxicity plus carcinogen when present in high concentration [3]. To obtain dirt-free and safe water, toxic chemicals, and metals should be eliminated. The standard of our environment is decreasing day by day, which means giant cities reaching saturation points and unfit to cope with the rising pressure on their infrastructure [4]. Major pollutants that contaminate the environment are sewage and industrial effluents. Most of the industries discharge wastewater. Environmental pollution especially from heavy metals and minerals in wastewater is the major concern in India [5].

Many methods have been undertaken in the process to remove these unwanted contaminants such as physio-chemical methods, a range of biological methods to a large extend nano-based techniques. One of the most important treatment processes used in water and wastewater treatment is filtration. In water management, the aim is to fabricate effluent of good criterion so that it can be reused for various purposes [6]. A biofilter is a filter with linked biomass on the filter-media. Biofilters can be trickling filters, horizontal rock filters or granular activated carbon (GAC), or sand filter in the water treatment plant. Biofilter applications are found in air, water, as well as wastewater treatment [7]. Biofiltration reduces odor and hydrogen sulfide (H_2S) emissions by 95% and ammonia by 65% approximately. Biofilters are operated in automatically ventilated buildings or on the pit fans of naturally ventilated buildings [8]. A biofilter is a layer of material that is organic, a mixture of compost that supports a population of

microbes. Biofilter performance is controlled by the amount of time the odorous air spends in the biofilter and also the moisture content of the filter material [9].

The biofilter we have prepared with the sole purpose to attain environmental sustainability by using household waste such as mustard plant roots, eggshell, human hair, and coconut shell. Mustard plant roots have high-quality adsorbent properties and maybe a thriving technique in the purification of water due to the compounds in roots that contains the amount of nitrogen, sulfur, and organic compounds such as carboxylic acids. These acids are charged such that their negatively charged electron pairs are exposed, meaning they can combine with metals in the water that typically contain a positive charge. Eggshells are a very dependable adsorbent due to their carbonate content. Keratin is the main constituent of wool, hair, feathers, horn, and nail. Keratinous materials, wool, feather, and hair have been used to absorb metal ions from solution in their native state, and with suitable chemical pre-treatment; the adsorption capacity for these ions can be drastically enhanced. The main idea of our project is to see how efficient mustard plant roots, eggshell, human hair, and activated carbon are in absorbing heavy metals. We have devised our own protocol and decided on various parameters that we thought suited them best.

I I. Materials And Methods

A. Materials Required

Mustard seeds, Eggshell, Human hair, Coconut shell, Bell Jar, Beaker, Soil, 0.5 M H_2O_2, 1.5 M $ZnCl_2$, 0.1 M HCl, and NaOH solutions were used to alter the pH. All the chemicals were of laboratory grade used in our college. Industrial Water Sample 1 was collected from a sheet metal industry; Industrial Water Sample 2 was collected from a paint industry. We measured the absorbance of heavy metals by Atomic Absorption Spectrometer (AAS).

B. Preparation of solutions

To prepare 0.5 M H_2O_2 we added 10g of H_2O_2 into 500ml of deionized water. Likewise, we added 10g of $ZnCl_2$ into 100ml of deionized water to prepare 1.5 M $ZnCl_2$.We labeled the samples concerning their pH, contact time of 60mins, and 90mins at room temperature. Afterward filtered the solutions and absorbance was taken using ASS.

C. Preparation of Adsorbents

Cultivation of Mustard plant roots

Mustard seeds were taken and soaked in water for about 5 hours, later laid on cotton, and allowed to sprout. After sprouting in a tray they were grown for 3 weeks in the soil.

Preparation of Eggshell

Twenty eggshells were collected from daily kitchen waste and washed by normal tap water followed by distilled water. The eggshells were left to dry on blotting paper to absorb surplus water and then subjected to the hot air oven at 50°C for 2 days. Once totally dehydrated we pulverized and shred eggshells to fine particles with mortar and pestle followed by a mixer. Later we sieved the crushed adsorbent to obtain a homogenous dimension around 0.05cm.

Production of Activated Carbon

Some amount of coconut shell was cleaned to remove impurities such as coconut fiber and sand. Dried under the sun for 7 hours and followed by 3 hours in an oven to obtain charcoal. The charcoal was crushed to a 0.5 mm mesh size. About 200 g of this crushed charcoal was introduced into 1.5 M $ZnCl_2$ and stirred to form a paste/slurry. This was heated for about 5-6 hours and allowed to chill at room temperature, thus impregnated with $ZnCl_2$. This is called doping. The doped charcoal was heated in an electric furnace to 450 ^{o}n for an hour and allowed to cool in the air. Then it was carefully washed to eradicate traces of $ZnCl_2$.

Preparation of human hair

Hair samples were obtained from local barbershops. Human hair samples were washed with detergent and rinsed several times with deionized water and left to dry at room temperature. The hair was cut to an approximate length of less than 5mm by using scissors. 20g of washed dried biomaterial was weighed out and soaked in 0.5 M H_2O_2 and the solution was filtered. Finally, the treated and cleaned biomaterials were dried at room temperature.

I I I. Packaging Of A Biofilter

The roots of the mustard plant were grown in the soil and were cut and kept as the first layer, followed by the eggshell layer. The third layer and fourth layer were constituted by human hair and activated carbon respectively.

I V. Method

The industrial wastewater containing heavy metal is passed through each layer. This setup for filtration was arranged as layers in the bell jar and the contact time used was 60 mins and 90 mins respectively. pH and absorption of the sample were checked by subjecting to the AAS.

Effect of pH on Adsorption

The range of pH used was 4-7. The adjustments were done using a 0.1 M solution of HCl and NaOH. Later the flasks were subjected to contact times of 60mins and 90 mins respectively. Then the filtrate was

taken and AAS was used to verify the absorption of the heavy metals.

Effect of Contact Time on Absorption

After 60 mins and 90 mins of contact time filtration occurred and the adsorption was checked by using AAS.

V. Results And Disscusion

Effect on pH of Adsorption

At lesser pH values the absorbance was found to be smaller compared to higher pH values. It could be because at lesser values the adsorption could have been contrasting due to the competitive interactions between the heavy metal ions and the hydrogen ions which restrict the adsorption. The presence of carbonate groups in the adsorbents was identified at higher pH values. In general best results were obtained at pH 7.

Effect of Contact Time on Adsorption

The absorbance will be higher at a larger surface area and contact time. Better results were obtained when exposed for a contact time of 90mins. The results of both filtered and unfiltered sample testing were done in the College of Veterinary and Animal Sciences, Mannuthy.

Metal	pH	Absorbance	Contact time	Unfiltered	Filtered
Cu	4	0.2493	60 mins	37.92ppm	8.50ppm
	5	0.3283	60 mins		
	6	0.034	90 mins		
	7	0.0901	90 mins		
Pb	4	0.2204	60 mins	12.01ppm	3.86ppm
	5	0.006	60 mins		
	6	0.1908	90 mins		
	7	0.0184	90 mins		
Cr^{3+}	4	0.1881	60 mins	6.77ppm	1.82ppm
	5	0.0908	60 mins		
	6	0.1432	90 mins		
	7	0.2007	90 mins		

Table 1: Table of heavy metals with parameter

V I. Conclusion

The elimination of heavy metals Cu, Pb, and Cr^{3+} using mustard plant roots, eggshell, human hair, and activated carbon as adsorbents was carried out by various parameters such as contact time and pH values. The best results were observed at the conditions, having pH value 7 and contact time of 90 mins. As the size of the adsorbent was small the competence of adsorption was increased; also these household wastes are economical and the manufacturing process is very sustainable. Moreover, this will not cause any damage to the future of the environment and it is very safe to use. At the primary stage itself, the filtration was achieved and it was found that all these adsorbents were finest for adsorption of heavy metals from wastewater. Upgrading the size of particles to nanoscale was found to be futuristic. Also, element modifications may be done on the household waste to amplify the absorbance capability.

V I I. Abbreviations

AAS: Atomic Absorption Spectrometer.

V I I I. Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable. No tests, measurements, or experiments were performed on humans as part of this work.

CONSENT FOR PUBLICATION

The authors have agreed to submit it is in current form for consideration for publication in the journal.

AVAILABILITY OF DATA AND MATERIALS

The authors approved the availability of data and materials for publishing the manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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CONTRIBUTIONS

All authors read and approved the final manuscript.

CORRESPONDING AUTHOR

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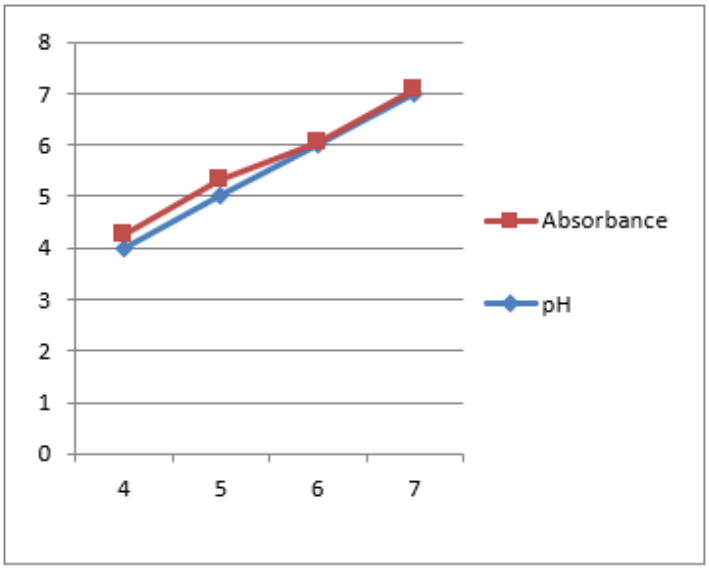
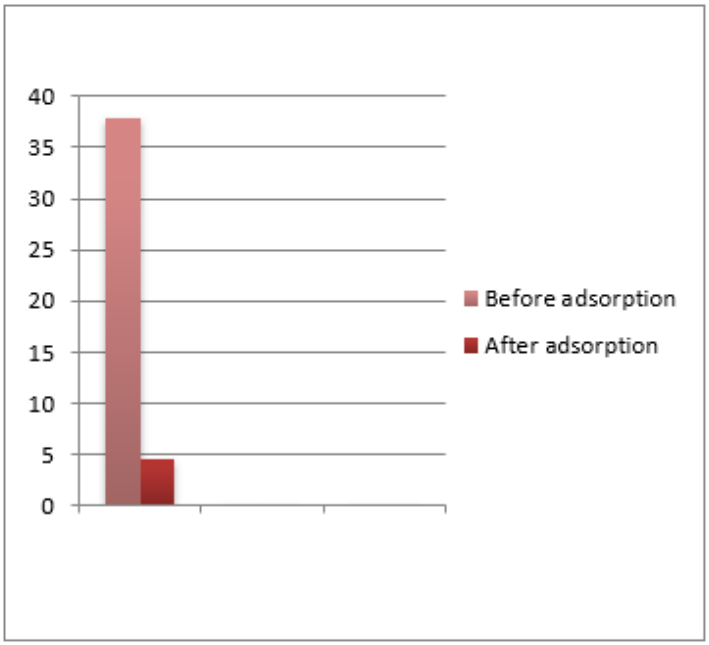
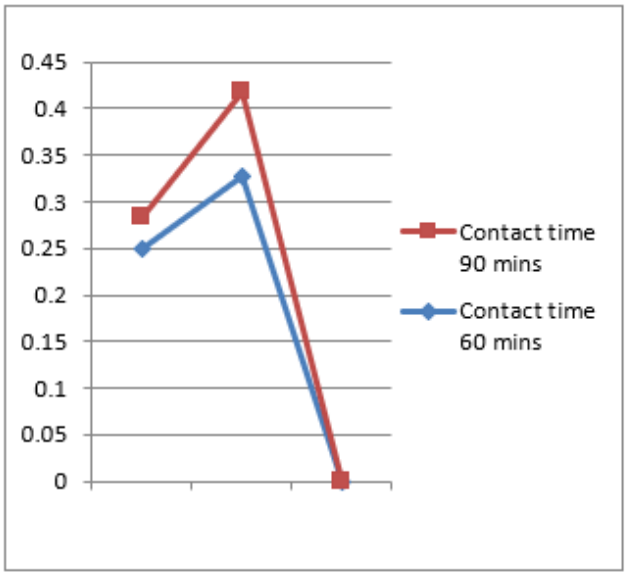
Figures



(a) pH of Copper



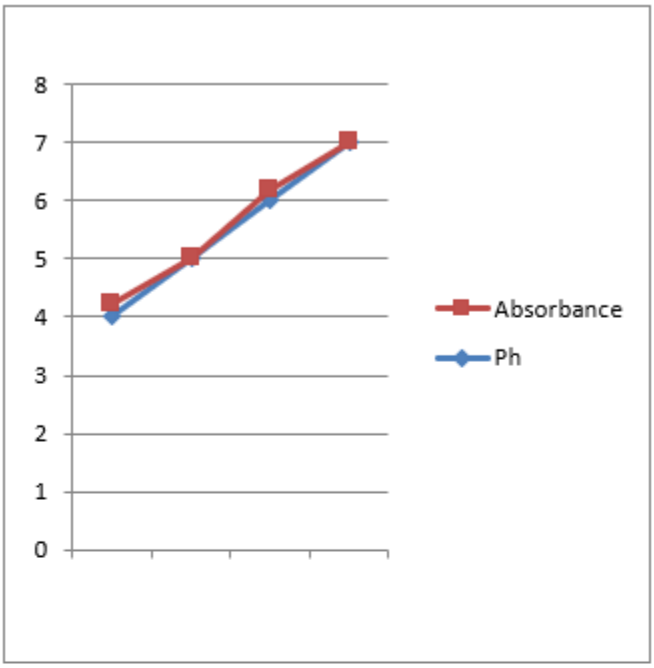
(b) The quantity of copper removed after adsorption



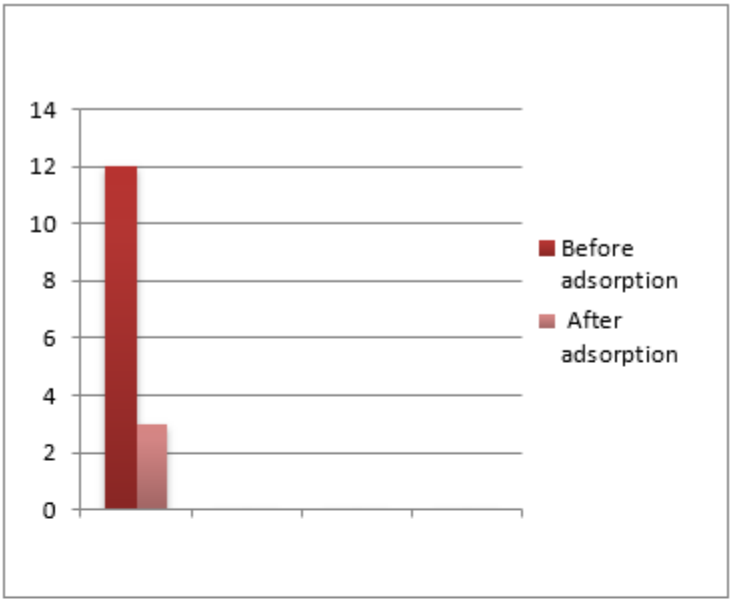
(c) About contact time

Figure 1

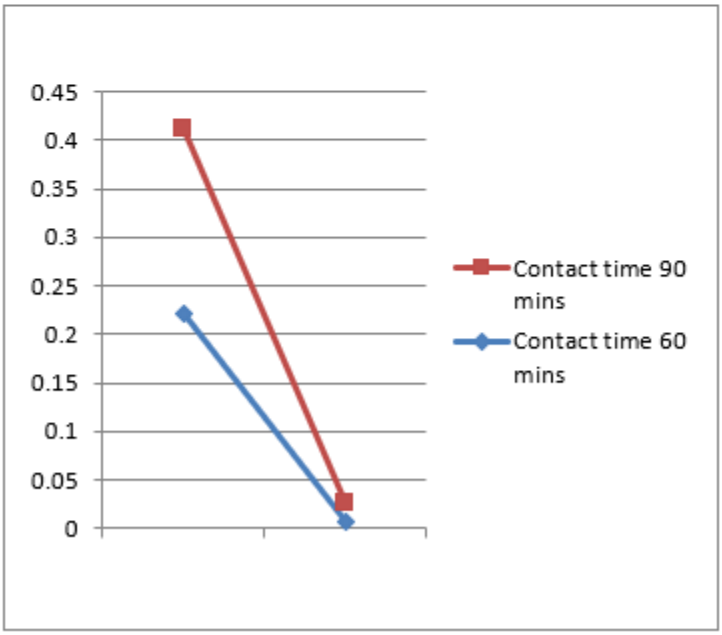
Graphs for copper with parameters.



(a) pH of Lead



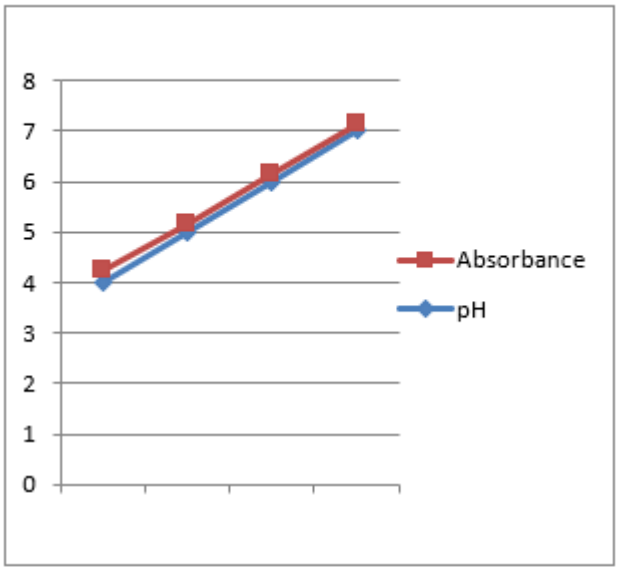
(b) The quantity of Lead removed after adsorption



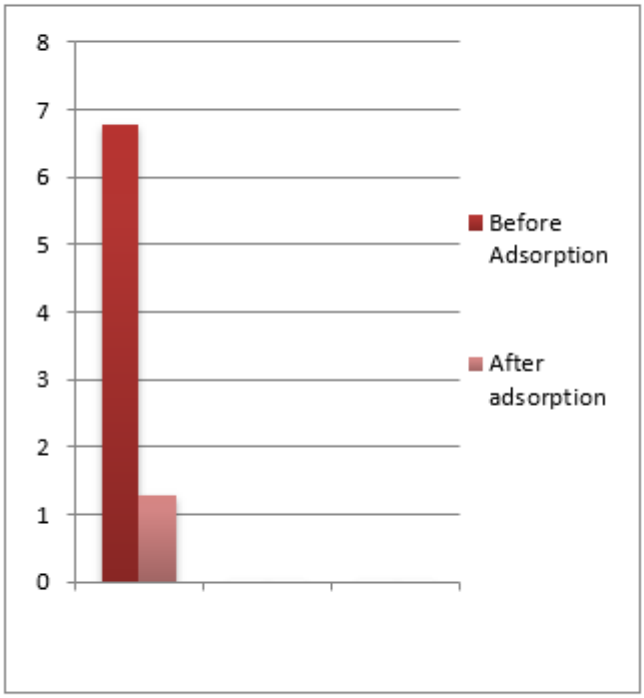
(c) About contact time

Figure 2

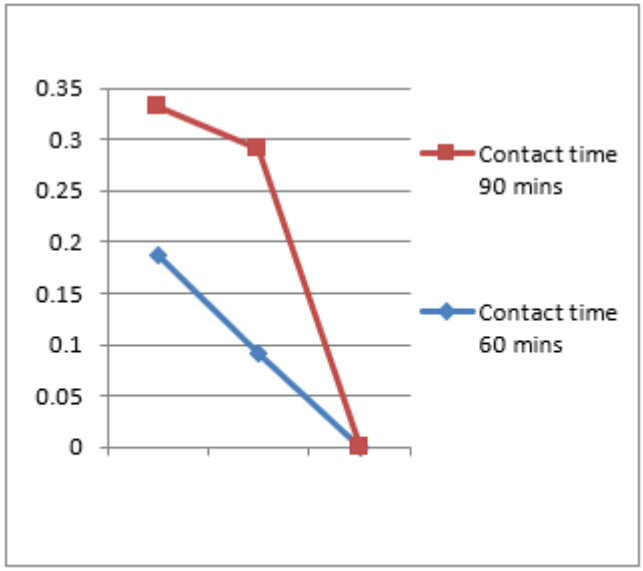
Graphs for Lead with parameters.



(a) For pH of chromium



(b) The quantity of chromium removed after adsorption



(c) About contact time

Figure 3

Graphs for Chromium with parameters

Supplementary Files

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- CarbokemGraphicalAbstract.docx