

Removal of Heavy Metals from Water (Cu and Pb) Using Household Waste as an Adsorbent

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Abstract

Chicken eggshells, Banana peels and Pumpkins are used as good adsorbents for removing heavy metals from contaminated water, which have been observed and studied currently. The effects of various parameters such as pH, agitation speed and contact time was studied and good results were obtained at pH 7, 100 rpm and 90 mins of contact time. The results indicate that usage of household waste such as these can be used as a good biosorbent for removal of heavy metals on a large scale and create effective, cheap and efficient methods in treating wastewater.

Keywords: Eggshell; Banana peel; Pumpkin; Biosorbent

Introduction

Now a day's various toxins are released into water leading to a great deal of water pollution. Many heavy metals from various industries like battery plants, metal processing industries, pharmaceuticals, hospitals, mining fields etc. are being released into the water bodies leading to unsafe water for normal consumption. The most common heavy metals found are copper and lead, which when present in high concentrations may be very fatal to the health and the surrounding environment as well [1]. In order to obtain clean and safe water it is required that these toxic chemicals and metals should be removed.

Many methods have been undertaken in the process to remove these unwanted contaminants such as physio-chemical methods, various biological methods and to large extent nano-based techniques [2]. The methods that we have employed are purely based on the aim to achieve environmental sustainability by using house hold waste such as eggshells, banana peels and pumpkin which are cheap, easily available and a very effective adsorbent. Eggshells are a very reliable adsorbent due to its calcium carbonate content [2,3]. Moreover, there is no scope of any organic compounds dissolving in the solution like pumpkin powder, banana peel powder, pomegranate powder leaving the solution colourless [4,5]. Banana peels have good adsorbent properties and may be a successful method in purification of water due to the compounds in the banana peels that contain atoms 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 bind with metals in the water that usually have a positive charge [5,6]. Pumpkins also have good adsorbent properties due to the lignocellulosic compounds in the organic matter that contain functional groups like carboxyl, hydroxyl, ester, etc. A large number of lignocellulosic biosorbents are utilized for metal cation sorption.

The main objective of our project is see how efficient eggshell powder is in adsorbing heavy metals such as copper and lead at a concentration of 5 ppm at various different parameters such as pH, agitation (rpm) and contact time [2,3]. We have devised our own protocol and decided various parameters which we thought suited the best.

Material and Methods

Materials

We tested our protocol using the three adsorbents on two heavy metals namely Copper and Lead. Copper (ii) Sulphate and Lead Nitrate (both S.R.L) was used to prepare a stock solution of 1000 ppm in

deionised water respectively. A .1 M of HCl and NaOH solutions were used to adjust the pH. All the chemicals used were of laboratory grade used in the laboratories of our college. We measured the absorbance of heavy metals by Atomic Absorption Spectrometer (AAS) [1].

Preparation of solutions

The solutions were self-contaminated. To prepare a 1000 ppm of stock solution of Copper sulphate we added 3.93 g of copper(II) sulphate in 1 L of deionised water. Likewise, we added 1.598 g of Lead nitrate in 1 L of deionised water to prepare the 1000 ppm stock solution. From the stock solution we prepare a 5 ppm concentration of heavy metal contaminated water. For preparation of 5 ppm solution we took 20 ml from 1000 ppm (both for Cu and Pb respectively) solution in a beaker and add deionised water upto 250 ml (till required).

Preparation of adsorbent

Around 20 eggshells were collected from daily kitchen waster and washed with normal tap water followed by distilled water (using latex gloves to avoid contamination). The eggshells were left to dry on blotting paper to absorb excess water and were then subjected to the hot air oven at 50°C for 2 days (RDB27 HIS TC-102). Once completely dried we pulverised and shred eggshells to fine particles using mortar and pestle followed by a mixer, later we sieved the pulverised adsorbent to obtained a homogenous size. Likewise 20 small banana peels and 2 small size pumpkins were taken washed thoroughly, air dried then subjected to the hot air oven at 50°C for 2 days then they were sieved to obtain uniform particl size.

Method used

After preparing 5 ppm solution (Cu and Pb) we added 100 ml of solution in 16 (250 ml each) conical flasks for Cu and Pb respectively, where each flask has 100 ml of 5 ppm solution we then adjusted the pH

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Received August 21, 2014; Accepted December 29, 2014; Published December 31, 2014

Citation: Kanyal M, Bhatt AA (2015) Removal of Heavy Metals from Water (Cu and Pb) Using Household Waste as an Adsorbent. J Bioremed Biodeg 6: 269. doi:10.4172/2155-6199.1000269

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using 0.1 M HCl and NaOH such that flasks had a pH of 4-7 respectively in order. We labelled the flasks with respect to their pH, agitation (rpm) of 100 rpm and 165 rpm then added 0.1 g of the adsorbent (different set of trials for different adsorbents) and subjected them to a shaker with a contact time of 60 minutes and 90 minutes at room temperature. Afterwards we filtered the solutions using Whatmann filter paper 1 and observed the absorbance of metal using the AAS. The experiment was taken out in two batches on the first day the batch for Cu and Pb at 5 ppm were tested at a pH of 4 and 6 (flasks 1-4 were at pH 4 and 5-8 were at pH 6) Likewise the next day they were tested at pH 5 and pH 7 (flasks 1-4 were at pH 5 and 5-8 were at pH 7). There were samples of each flask 1-pH 4 ,rpm 100,contact time-60 mins, 2-pH 4 ,rpm 100,contact time-90 mins, 3-Ph 4 ,rpm 165 ,contact time-60 mins , 4-pH 4 ,rpm 165,contact time-90 mins, 5-pH 6 ,rpm 100,contact time-60 mins, 6-pH 6 ,rpm 100,contact time-90 mins, 7-pH 4 ,rpm 165,contact time-60 mins, 8-pH 6 ,rpm 165,contact time-90 mins). The same process is employed for pH 5 and pH 7.

Effect of ph on Cu and Pb adsorption

The range of pH used was 4-7. The 100 ml solutions which are at a concentration of 5 ppm in the conical flasks were subjected to .1 g of adsorbent the adjustments were done using a .1 M solution of HCl and NaOH [1] later the flask were subjected agitation of 100 rpm and 165 rpm (marked accordingly) with a contact time of 60 mins and 90 mins. Once the contents were taken from the mixture they were filtered using Whatmann fileter paper no. 1 and given to the AAS to check the adsorption of heavy metals by the adsorbent.

Effect of agitation on Cu and Pb adsorption

The agitation on the shaker was decided to be 100 rpm and 165 rpm to make the process more efficient for a contact time of 60 mins and 90 mins after the pH adjustment and addition of .1 g of adsorbent was done. Afterwards filtration using Whatmann filter paper number 1 was done followed by giving the samples to AAS to check the adsorption.

Effect of contact time on Cu and Pb adsorption

The contact time used was 60 mins and 90 mins during the agitation period after which again filtration occurred and adsoprtion was checked by subjecting the samples to the AAS (Tables 1, 2 and Figures 1-6).

Results and Discussion

Effect of pH ON Cu and Pb adsorption

It was seen that at the lower pH values the absorbance was less as compared to that at the higher pH values, it could be because at the lower values the adsorption could have been compromised due to competitive interactions between the heavy metal ions and the hydrogen ions, which restricts the adsorption whereas at higher pH values like 7 the carbonate groups present in the eggshells may have resulted in attracting the heavy metals due to an increase in the negative charge on adsorbent surface area [1] In banana peel and pumpkin also the results were good at a higher pH , which may be due to the various compounds and acids present. The overall best results were obtained at pH 7 .

Effect of agitation on Cu and Pb adsorption

Agitation is very important to increase the efficiency of adsorbance and it helps speeding the process. It was observed that the best adsorbance was found at 100 rpm, although contradictory to the fact that at low rpm the matter might accumulate at the bottom of the flask, it did not hinder the adsorbance process and we got good results.

Concentration	pH	Absorbance	RPM	Contact time
3.244	4	0.2493	100	60
3.495	4	0.2703	100	90
3.969	4	0.3114	165	60
3.333	4	0.2567	165	90
3.813	5	0.3283	100	60
3.703	5	0.3163	100	90
3.895	5	0.3375	165	60
4.085	5	0.3597	165	90
0.669	6	0.0647	100	60
0.854	6	0.0636	100	90
0.977	6	0.0728	165	60
0.456	6	0.034	165	90
0.783	7	0.0608	100	60
0.733	7	0.0569	100	90
1.242	7	0.0968	165	60
1.158	7	0.0901	165	90

(a): For copper with eggshell.

Concentration	pH	Absorbance	RPM	Contact time
3244	1	0.2493	100	60
3.495	4	0.2703	100	90
3969	4	0.3114	165	60
3.333	4	0.2567	165	90
869	5	0.0647	100	60
0.854	5	0.0636	100	90
0.977	5	0.0728	165	60
0.456	5	0.034	165	90
1991	6	0.3655	100	60
3.531	6	0.3233	100	90
3278	6	0.1002	165	60
3.341	6	0.306	165	90
3.479	7	0.3186	100	60
3245	7	0.2971	100	90
3394	7	0.3108	165	60
3.113	7	0.2851	165	90

(b): For copper with banana peel.

Concentration	pH	Absorbance	RPM	Contact time
3.38	4	0.2715	100	60
3.727	4	0.2993	100	90
3.595	4	0.2887	165	60
3.465	4	0.2783	165	90
3.103	5	0.2634	100	60
3.14	5	0.2665	100	90
3.137	5	0.2663	165	60
3.503	5	0.2973	165	90
3.495	6	0.2807	100	60
3.168	6	0.2544	100	90
3.551	6	0.2852	165	60
3.267	6	0.2623	165	90
3.257	7	0.2765	100	60
3.605	7	0.306	100	90
3.474	7	0.2948	165	60
3.422	7	0.2904	165	90

(c): For copper with pumpkin.

Table 1: Table for copper with parameters.

Concentration	pH	Absorbance	RPM	Contact time
2.03	4	0.2046	100	60
229	4	0.2253	100	90
1.79	4	0.184	165	60
2.23	4	0.2204	165	90
198	5	0.1796	100	60
0.91	5	0.0868	100	90
64	5	0.0614	165	60
0.06	5	0.006	165	90
119	6	0.1276	100	60
1.37	6	0.1452	100	90
167	6	0.1733	165	60
1.87	6	0.1908	165	90
0.05	7	0.0045	100	60
0	7	0.0003	100	90
0.11	7	0.0107	165	60
0.19	7	0.0184	165	90

(a): For lead with eggshell.

Concentration	pH	Absorbance	RPM	Contact time
2.92	4	0.2299	100	60
2.79	4	0.2197	100	90
3	4	0.2366	165	60
116	4	0.249	165	90
2.03	5	0.2046	100	60
229	5	0.2253	100	90
1.79	5	0.184	165	60
223	5	0.2204	165	90
113	6	0.2469	100	60
305	6	0.2402	100	90
115	6	0.2478	165	60
3.38	6	0.2665	165	90
1.19	7	0.1276	100	60
1.37	7	0.1452	100	90
1.67	7	0.1733	165	60
1.87	7	0.1908	165	90

(b): For lead with banana peel.

Concentration	pH	Absorbance	RPM	Contact time
3.35	4	0.2441	100	60
2.63	4	0.1912	100	90
3.24	4	0.2357	165	60
2.58	4	0.1881	165	90
1.96	5	0.1588	100	60
1.39	5	0.113	100	90
2.08	5	0.1686	165	60
112	5	0.0908	165	90
2.21	6	0.1607	100	60
2.23	6	0.1621	100	90
2.76	6	0.2006	165	60
1.97	6	0.1432	165	90
2.36	7	0.1909	100	60
1.74	7	0.141	100	90
248	7	0.2007	165	60
1.85	7	0.1501	165	90

(c): For lead with pumpkin.

Table 2: Table for lead with parameters.

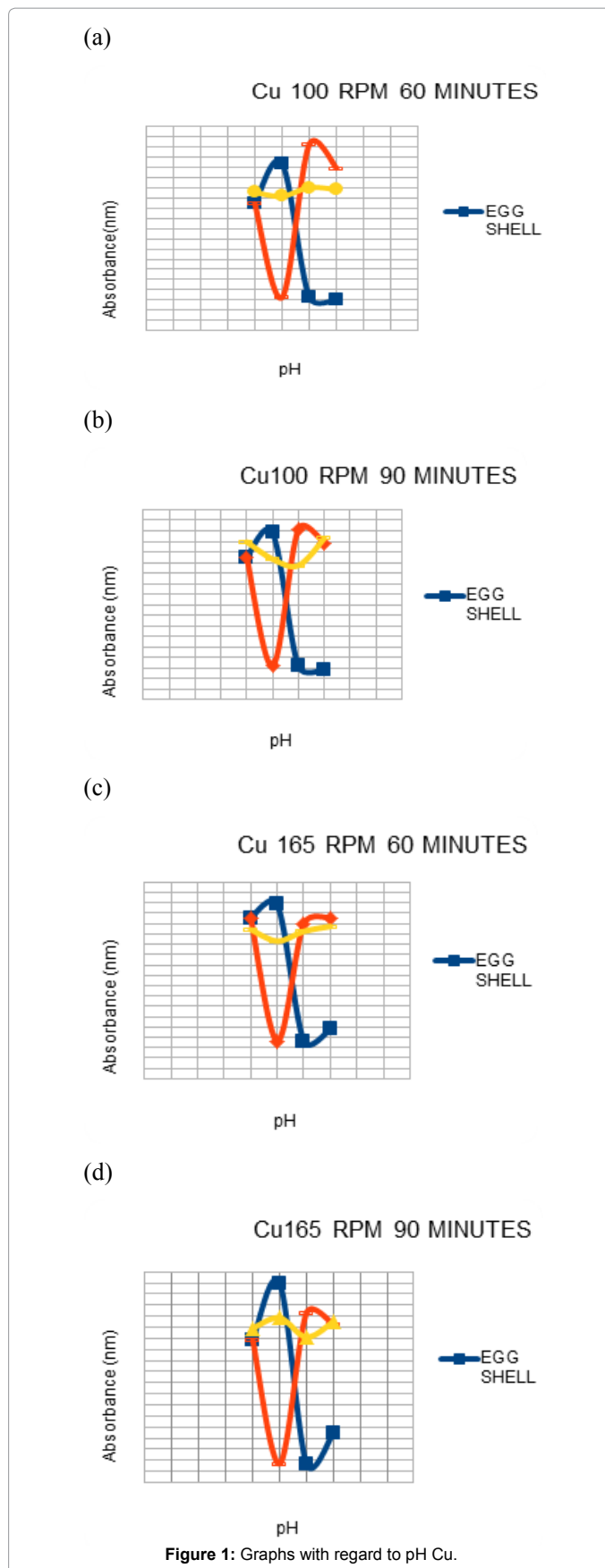
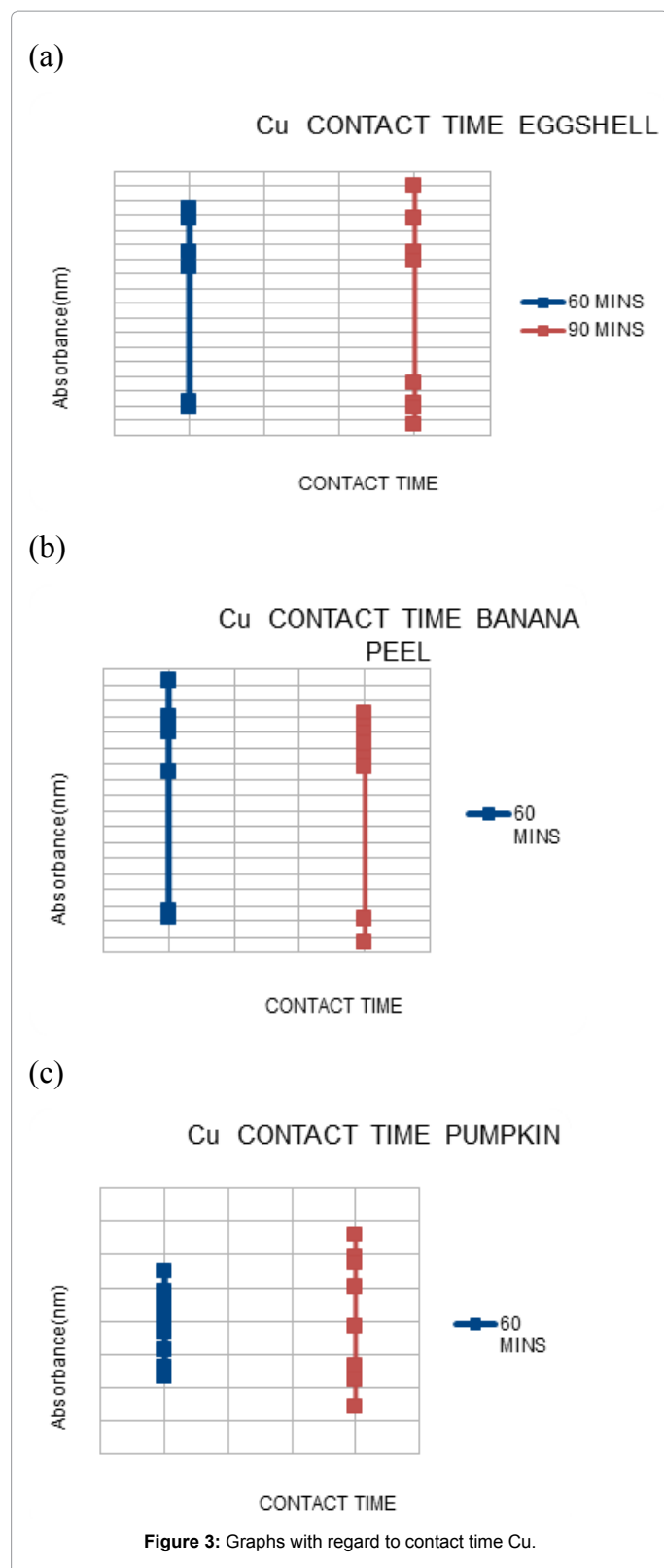
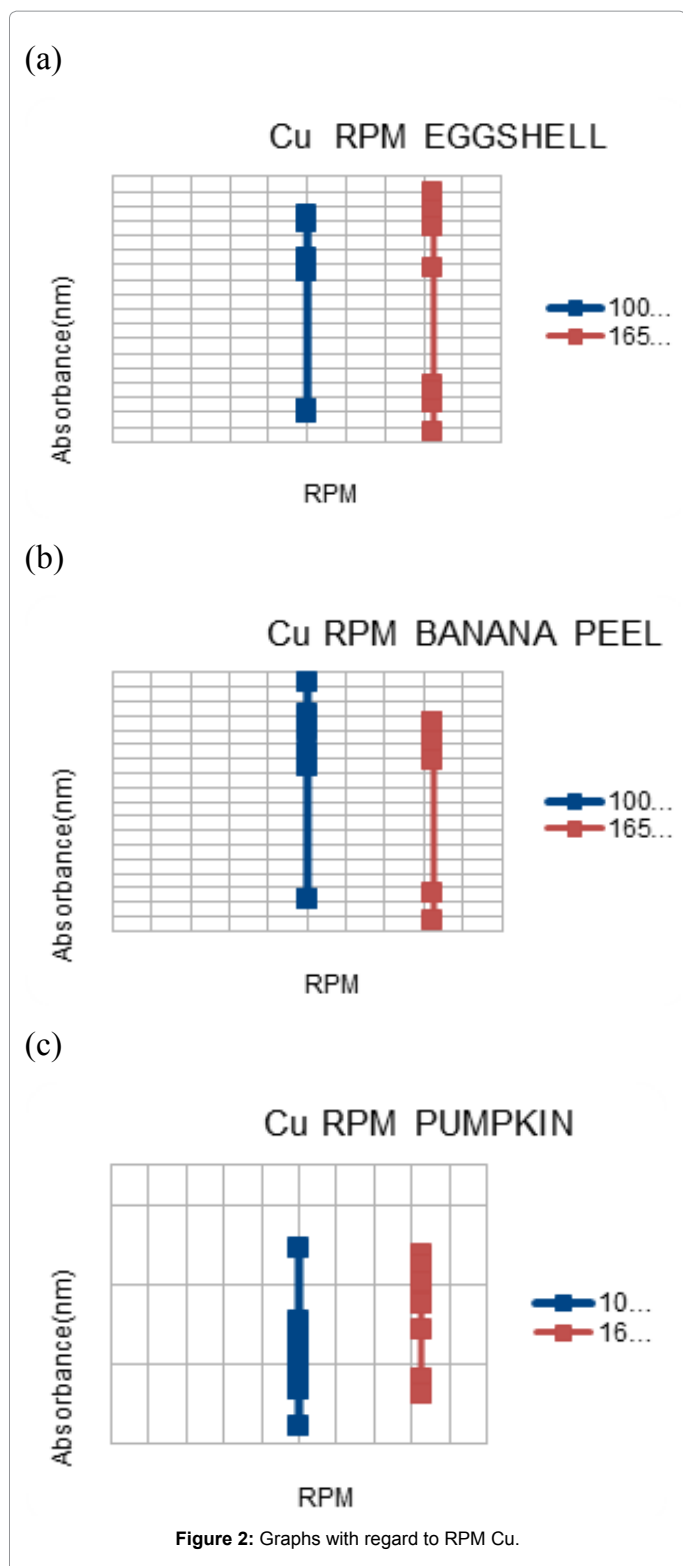


Figure 1: Graphs with regard to pH Cu.



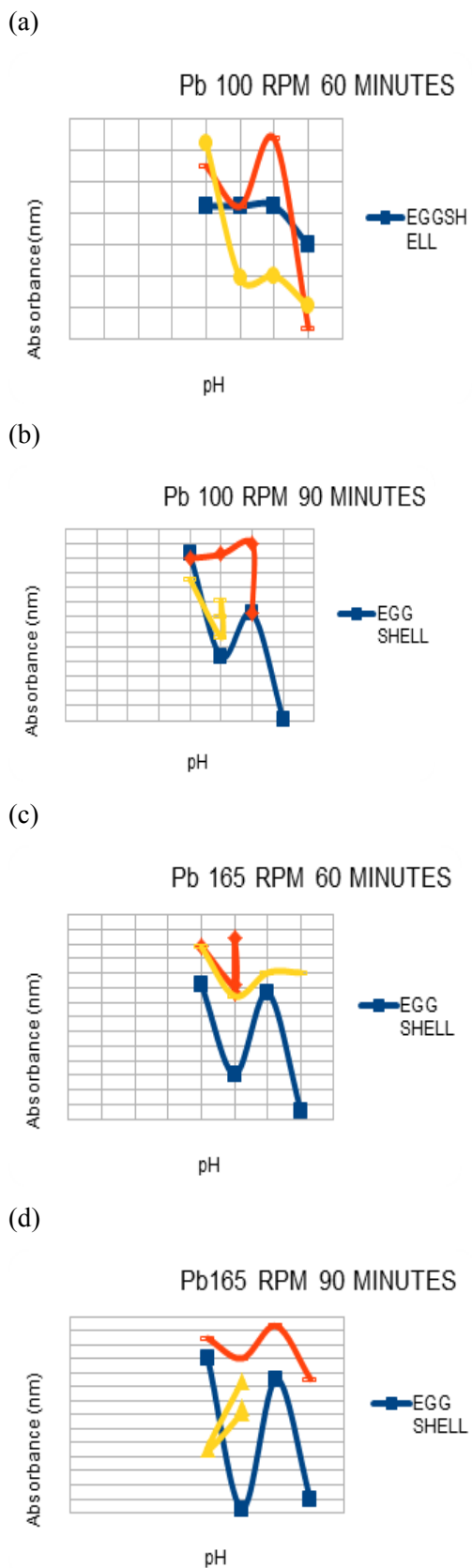


Figure 4: Graphs with regard to pH Pb.

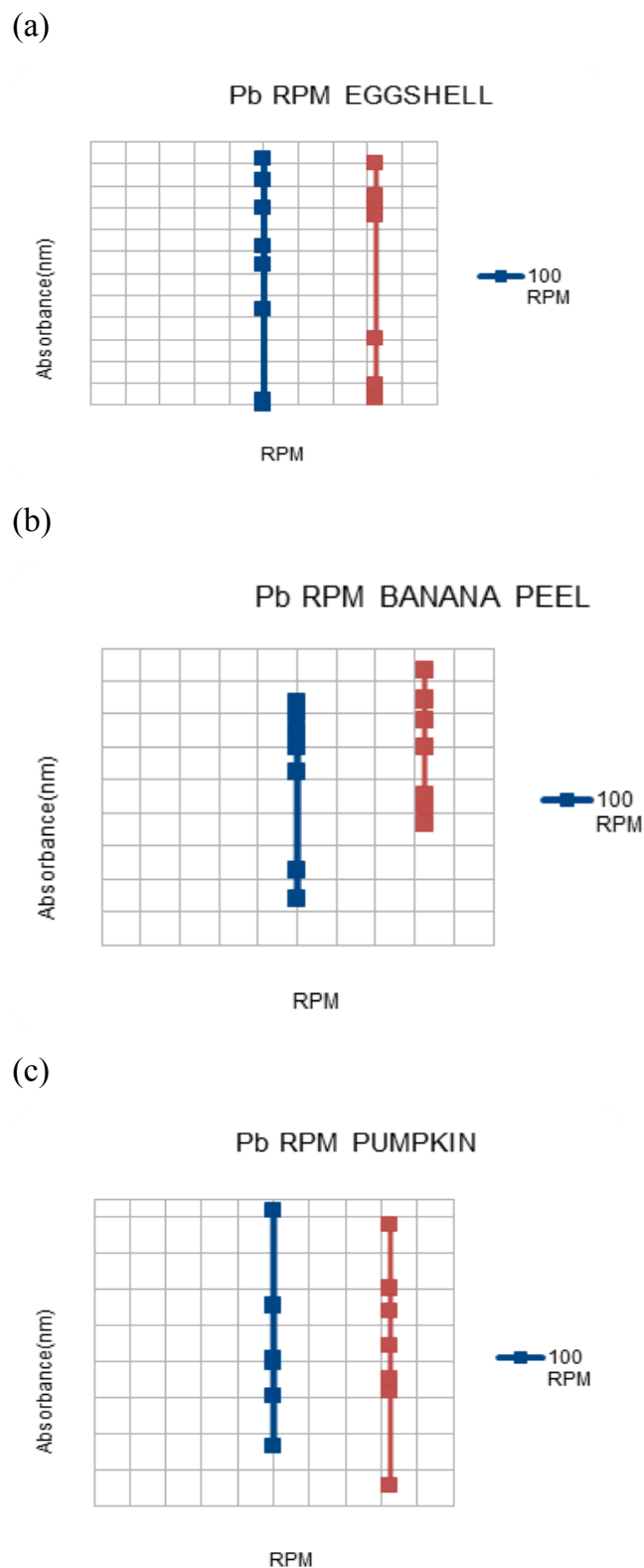
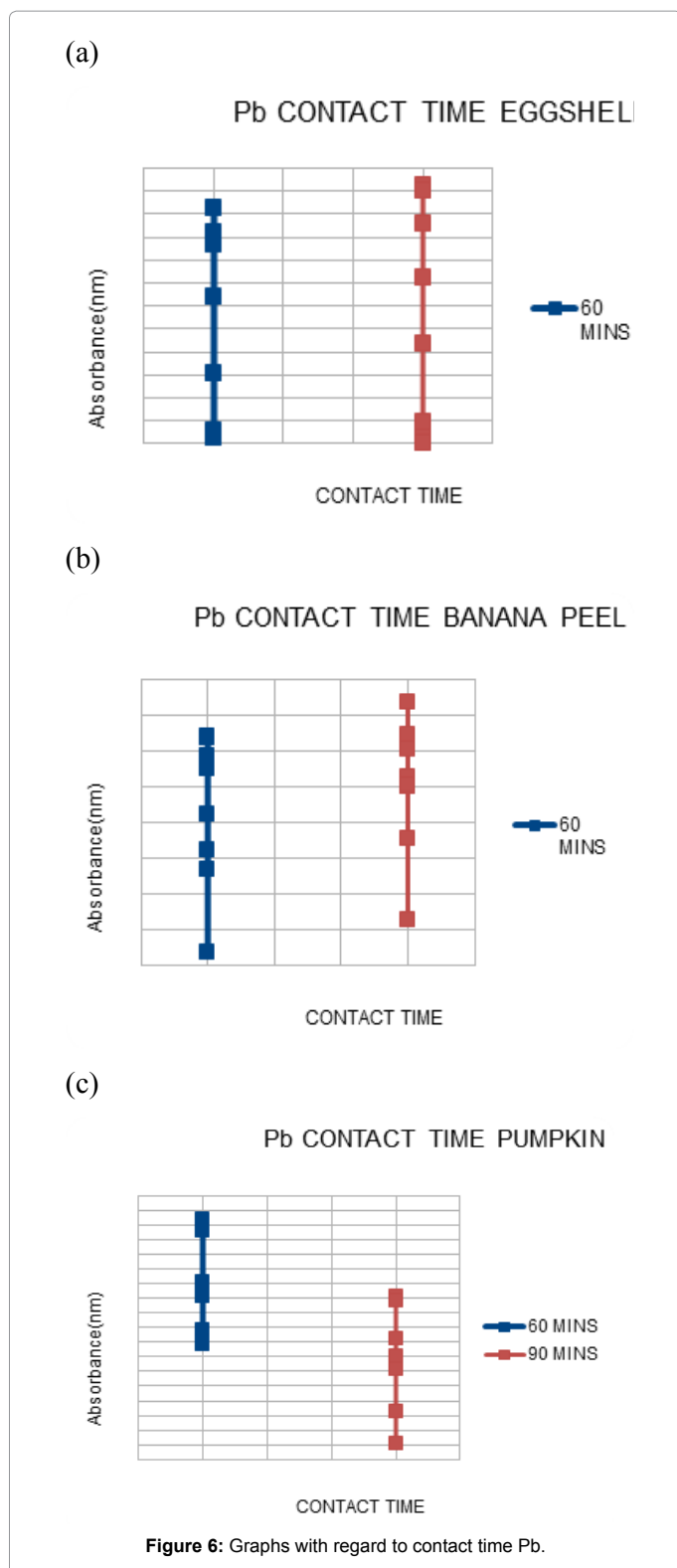


Figure 5: Graphs with regard to RPM Pb.



Effect of contact time on Cu and Pb adsorption

The more the surface area of adsorbent the more adsorbance occurs and if the contact time is more hence evens more adsorbance. Good and efficient results were obtained when samples were exposed for a contact time of 90 mins.

Conclusion

The removal of the heavy metals Cu and Pb using chicken eggshell powder, banana peel powder and pumpkin powder as adsorbents was carried out using various parameters such as different contact time, agitation speed and pH values. The overall best conditions concluded from the experiment was at a pH 7, rpm 100 and contact time of 90 minutes. The size of the adsorbent was at a very small scale hence which helped in the efficiency of adsorption; also these household wastes are economical, easy to find and inexpensive making this process very sustainable. Moreover they will not harm the environment and is very safe to use. When added to the samples the eggshell left a colourless solution which made the filtration process easier.

By this experiment primary level of filtration was achieved and it was found that eggshells were the best adsorbents of heavy metals from water. This experiment can be used in the future probably by modifying the particle size to the nano scale to achieve better efficiency. Also chemical modifications may be done on the the domestic waste to increase the adsorbance capacity.

Acknowledgement

We would like to thank our guide Dr. C. Ramalingam Dean (Biotechnology), School of Biosciences and Technology, VIT University Vellore for his full support and guidance and Dr. Jayanthi Mahalingam, our co-guide for her efforts and support. Also we are grateful to the University for providing us with the funds and opportunity to pursue our research work.

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