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RESEARCH ARTICLE

The Removal of Heavy Metals from Contaminated Water Copper Sulfate and Lead Nitrate Using Household Waste as an Adsorbent

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ABSTRACT

The heavy metals copper sulfate and lead nitrate are used in this study which are degraded by household waste the egg shells, banana peels, and pumpkin peels. The egg shell powder, banana peel powder, and pumpkin powder are prepared as an adsorbent and treated with heavy metals copper sulfate solution and lead nitrate solution. After the treatment with the both, the heavy metal solution with all the three adsorbents showed the toxicity reduction by checking with pH 2–pH 5 using pH meter.

Keywords: Copper sulfate, Lead nitrate, Egg shells, Banana peels, Pumpkin peels

INTRODUCTION

Nowadays, various toxins are released into the water leading to a great deal of water pollution. Many heavy metals from various industries such as battery plants, tanneries, metal processing industries, pharmaceuticals, hospitals, and mining fields 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 (Aria and Fernandez, 2001). 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 physiochemical methods, various biological methods, and to large extent nano-based techniques. The methods that we have employed are purely based on the aim to achieve environmental sustainability using household 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. Moreover, there is no scope of any organic compounds dissolving in the solution such as pumpkin powder, banana peel powder, and pomegranate powder leaving the solution colorless (Charles, 2001). 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 (King *et al*., 2006). 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. Pumpkins also have good adsorbent properties due to the lignocellulose compounds in the organic matter that contains functional groups such as carboxyl, hydroxyl, and ester. A large number of lignocellulose biosorbents are utilized for metal cautions.

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The household wastes that we are dealing with are very common in our day-to-day lives. Not only are they easily and readily available but also they are cheap and economically valuable. The eggshell powder we prepared was a white chicken eggshell which comprises calcium carbonate. The banana peel used was small and yellow with the scientific name *Musa acuminate* which is majorly found in Asia.[1-5]

MATERIALS AND METHODS

Sample and raw material collections

The materials, chemicals, and glassware were collected before starting the project. The household waste was obtained from the nearby Vellore markets and the chemicals and glassware were provided by our laboratories.[6]

Chemicals

1. 15 g of copper (ii) sulfate
2. 15 g of lead nitrate
3. 1 M NaOH (to set the pH)
4. 1 M HCl (to set the pH).

Raw materials

1. Eggshells
2. Banana peels
3. Pumpkin.

Preparation of heavy metal contaminated water

1. Sterilize all glassware in an autoclave
2. For preparing 1000 ppm solution for the experiment add 3.93 g of copper (ii) sulfate in 1 L of deionized water (STOCK SOLUTION)
3. For preparing 1000 ppm solution for the experiment add 1.598 g of lead nitrate in 1 L of deionized water (STOCK SOLUTION)
4. Mix well to obtain homogenous solution
5. For preparation of 1 ppm solution, take 4 ml from 1000 ppm (both for Cu and Pb, respectively) solution in a beaker and add deionized water up to 250 ml
6. For preparation of 5 ppm solution, take 20 ml from 1000 ppm (both for Cu and Pb, respectively) solution in a beaker and add deionized water up to 250 ml

Preparation of eggshell powder (Adsorbent)

1. Collection of raw material (from GDN canteen) about 20 eggshells was collected
2. Washing of eggshells first with normal tap water then with distilled water (using latex gloves to avoid contamination)
3. Leaving the eggs on blotting paper to absorb excess water
4. Drying of eggshells in hot air oven at 50°C overnight (RDB27 HIS TC-102)
5. Pulverize and shred eggshells to fine particles using mortar and pestle
6. Subject crushes eggshells to a mixer to obtain fine powder
7. Sieve the powder to get a homogenous powder using a sieve (from the laboratory)
8. Store the powder in sterilized Petri plates.

Preparation of banana peel powder (Adsorbent)

1. Collection of raw material about 18 bananas was collected
2. Washing of banana peels with normal tap water then with distilled water (using latex gloves to avoid contamination)
3. Leaving the banana peels on blotting paper to absorb excess water
4. Drying of banana peels in sunlight for 2 days and then subject to hot air oven at 50°C overnight (RDB27 HIS TC-102)
5. Pulverize and shred banana peels to fine particles using mortar and pestle
6. Sieve the powder for a homogenous powder
7. Store the powder in sterilized Petri plates.

Preparation of pumpkin powder (Adsorbent)

1. Collection of raw material about two pumpkins (small) was collected
2. Washing of pumpkin with normal tap water

then with distilled water (using latex gloves to avoid contamination)
3. Leaving the banana peels on blotting paper to absorb excess water
4. Drying of pumpkins in sunlight for 2 days and then subject to hot air oven at 50°C overnight (RDB27 HIS TC-102)
5. Pulverize and shred pumpkin to fine particles using mortar and pestle
6. Sieve the powder for a homogenous powder
7. Store the powder in sterilized Petri plates.

Experiment conduction

Procedure for experiment (eggshell, banana peel, and pumpkin)

For copper (ii) sulfate

1. After preparing 5 ppm solution add 100 ml of solution in the (250 ml) conical flasks
2. Each flask has 100 ml of 5 ppm solution
3. Now adjust the pH such that flasks 1–4 have a pH of 2, flasks 5–8 have a pH of 3, flasks 9–12 have a pH of 4, flasks 13–16 have a pH of 5, flasks 17–20 have a pH of 6, flasks 21–24 have a pH of 7, flasks 25–28 have a pH of 8, and flasks 28–31 have a pH of 9
4. Add 0.1 g of adsorbent and subject to the shaker at room temperature (37°C) for the respective times
5. Filtration of solutions by Whatman filter paper no. 1 was done using a funnel and solutions were kept in 1.5 ml centrifuge tubes and subjected to AAS
6. Obtain, tabulate, and interpret the results.

For lead nitrate

1. After preparing 5 ppm solution add 100ml of solution in the (250 ml) conical flasks
2. Each flask has 100 ml of 5 ppm solution
3. Now adjust the pH such that flasks 1–4 have a pH of 2, flasks 5–8 have a pH of 3, flasks 9–12
4. have a pH of 4, flasks 13–16 have a pH of 5, flasks 17–20 have a pH of 6, flasks 21–24 have a pH of 7, flasks 25–28 have a pH of 8, and flasks 28–31 have a pH of 9
5. Add 0.1 g of adsorbent and subject to the shaker at room temperature (37°C) for the respective times
6. Filtration of solutions by Whatman filter paper no. 1 was done using a funnel and solutions were kept in 1.5 ml centrifuge tubes and subjected to AAS
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RESULTS

The present experiment was carried out along with a given range of parameters revealed excellent and satisfactory results, which could further be used for primary filtration of heavy metal contaminated water in bulk. The adsorption process is shown in Tables 1-6.

DISCUSSION

Effect of pH on Cu and Pb adsorption, the variation in pH values of the solutions in the flasks may alter the absorption efficiency of the adsorbent under study. These variations may be positive in some case while negative in others, based on the value of the pH. The presence of H+ ions affects the capacity of the adsorbent to take up the heavy metal ions. 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 (Aria and Fernandez, 2001). 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 (King, 2011). The overall best results were obtained at pH 9. Consequently, the final absorbance noted varies with the change in pH which is brought about by the varying degrees of the presence of hydrogen ions.

Effect of agitation on Cu and pH adsorption agitation, like pH, is a variable that needs to be taken into consideration while setting the parameters of the adsorption system with a specific adsorbent. The degree of agitation needed for maximum efficiency

Table 1: It shows the absorption parameters of Cu using eggshell powder

Concentration	pH	Absorbance (nm)	RPM	Contact time (minutes)
3.11	2	0.967	100	60
4.288	2	1.332	100	90
4.382	2	1.361	165	60
4.057	2	1.260	165	90
3.440	3	1.069	100	60
4.147	3	1.288	100	90
3.501	3	1.088	165	60
4.231	3	1.314	165	90
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

Table 2: It shows the absorption parameters of Cu using banana peels

Concentration	pH	Absorbance (nm)	RPM	Contact time (minutes)
4.8040	2	1.4013	100	60
4.8980	2	1.4386	100	90
4.8640	2	1.4189	165	60
4.8810	2	1.4238	165	90
4.9850	3	1.4540	100	60
4.7760	3	1.3930	100	90
4.8330	3	1.4099	165	60
Over	3	1.4942	165	90
3.582	4	0.281	100	60
3.137	4	0.225	100	90
4.162	4	0.352	165	60
3.500	4	0.273	165	90

varies with each type of adsorbent. Although unlike pH, it is not the presence of hydrogen ions that affect the adsorption capacity of an adsorbent. The surface area available for adsorption on the surface of the adsorbent is a function of the agitation. In our project, we have utilized laboratory scale shakers to provide continuous agitation to the adsorption system in the flask. Agitation is very important to increase the efficiency of absorbance and it helps speeding up the process. It was observed that the best absorbance 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 absorbance process and we got good results in the form of low absorbance values as exhibited by the absorption spectra.

Effect of contact time on Cu and Pb adsorption time, being the third and final variable that we have considered in our project was a crucial regulation point of the project. Although pH, agitation, and contact time are not the only variables that affect the efficiency of an adsorption system, they are the most crucial factors. The time factor helps us determine to what degree the heavy metals are exposed to the adsorbents. As the time increases, the exposure is greater. Again, time is not an independent factor, the agitation and pH of the system will affect the extends of exposure of

Table 3: It shows the absorption parameters of Cu using pumpkins peels

Concentration	pH	Absorbance (nm)	RPM	Contact time (minutes)
4.9480	2	1.4359	100	60
Over	2	1.4615	100	90
4.9640	2	1.4406	165	60
4.9610	2	1.4396	165	90
Over	3	1.4741	100	60
4.8800	3	1.4162	100	90
4.9740	3	1.4433	165	60
4.9920	3	1.4486	165	90
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

Table 4: It shows the absorption parameters of Pb using eggshells

Concentration	pH	Absorbance	RPM	Contact time (minutes)
4.2400	2	0.2333	100	60
4.5100	2	0.2478	100	90
4.2000	2	0.2309	165	60
5.0000	2	0.2747	165	90
4.4300	3	0.2436	100	60
Over	3	0.2976	100	90
3.8100	3	0.2093	165	60
4.8000	3	0.2637	165	90
2.03	4	0.2046	100	60
2.29	4	0.2253	100	90
1.79	4	0.184	165	60
2.23	4	0.2204	165	90
1.98	5	0.1796	100	60
0.91	5	0.0868	100	90
0.64	5	0.0614	165	60
0.06	5	0.006	165	90
1.19	6	0.1276	100	60
1.37	6	0.1452	100	90
1.67	6	0.1733	165	60

the heavy metals to the adsorbents (AshtOukhy *et al*., 2007). The contact time required may vary based on the adsorbent used in the system but it is not mandatory for this to hold true, that is, the contact time required for all the three systems can be similar. The more the surface area of adsorbent the more absorbance occurs and if the contact time is more hence evens more absorbance. Good and

Table 5: It shows the absorption parameters of Pb using banana peels

Concentration	pH	Absorbance (nm)	RPM	Contact time (minutes)
Over	2	0.3373	100	60
Over	2	0.3255	100	90
Over	2	0.3147	165	60
Over	2	0.3125	165	90
Over	3	0.3059	100	60
Over	3	0.2999	100	90
Over	3	0.3115	165	60
Over	3	0.2965	165	90
2.920	4	0.230	100	60
2.790	4	0.220	100	90
3.000	4	0.237	165	60
3.160	4	0.249	165	90
2.250	5	0.226	100	60
2.393	5	0.285	100	90
1.992	5	0.023	165	60
2.461	5	0.238	165	90
3.130	6	0.247	100	60
3.050	6	0.240	100	90

Table 6: It shows the absorption parameters of Pb using pumpkins

Concentration	pH	Absorbance (nm)	RPM	Contact time (minutes)
Over	2	0.2903	100	60
Over	2	0.2768	100	90
Over	2	0.2789	165	60
Over	2	0.2823	165	90
Over	3	0.2601	100	60
1.86	3	0.0822	100	90
Over	3	0.2802	165	60
Over	3	0.2676	165	90
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
1.12	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

efficient results were obtained when samples were exposed for a contact time of 90 min.

CONCLUSION

The removal of the heavy metals Copper sulphate and lead nitrate using egg shells, banana peels, and pumpkin peels as adsorbents was carried out using pH values. 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.

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