size. The powdered form of Papaya seeds was stored in a container in a cool dry place for further use. No other physical or chemical treatments were employed prior to sorption experiments.

3.2 Egg Shell Powder

The eggshell used in the experiment collected from different hotels located in Pune city, India. The samples were then washed with distilled water several times to remove impurities and dirt. The eggshells were then dried in oven at 40^{o} C. The dried eggshells were ground into small particles and then finally sieved to fine powder of less than 0.425mm particle size and stored into small particles and stored in air tight container for future use.

4. Effect of pH on Cu(II) and Zn(II) adsorption

The effect of solution pH on adsorption of Cu(II) and Zn(II) was studied by mixing 2.5 g of individual adsorbent with 250 ml of mixed metal solution having concentration of 3.6mg/L, 4.2 mg/L, of Copper and 3.3 mg/L and 3.7 mg/L of Zinc concentration at different pH value (5 – 8) at room temperature. The pH was adjusted with 1 N NaOH or 1 N HCl solutions and pH meter was used to pH. Agitation rate was kept at a constant stirring speed of 170 rpm for 180 minutes. The remaining concentration of Cu(II) and Zn(II) after adsorption was measured using AAS.
The percentage uptake of Cu(II) and Zn(II) was calculated according to the following equation:

$$\text{Percentage uptake (\%)} = \frac{C_{ini} - C_{fin}}{C_{ini}} \times 100$$

Where C_{ini} is the initial concentration and C_{fin} is the concentration at time *t*.

5. Effect of Contact time on Cu(II) and Zn(II) adsorption

The effect of solution Contact Time on adsorption of Cu(II) and Zn(II) was studied by mixing 1.25 g of both adsorbents with 250 ml of mixed metal solution having concentration of 4.2 mg/L, of Copper and 5mg/L of Zinc concentration at pH value of 6 at room temperature. Agitation was made at a constant stirring rate of 170 rpm. The concentration remaining of Cu(II) and Zn(II) after adsorption was measured at different time intervals of 30, 60 120 and 180 minutes using AAS.
The percentage uptake of Cu(II) and Zn(II) was calculated according to the following equation:

$$\text{Percentage removal (\%)} = \frac{C_{ini} - C_{fin}}{C_{ini}} \times 100$$

Where C_{ini} is the initial concentration and C_{fin} is the concentration at time *t*.

6. Effect of Adsorption dose on Cu(II) and Zn(II) Adsorption

The effect of adsorption dose on Cu(II) and Zn(II) adsorption was investigated by different amount of adsorbents 1.5 gm, 2 gm and 2.5 gm in 250 ml of mixed metal solution having initial concentration of 4.4 mg/l, 7.9 mg/l of Copper and 5 mg/l, 9.2 mg/l of Zinc. Agitation was made at a constant stirring speed of 170 rpm for 120 minutes. The remaining concentration of Cu(II) and Zn(II) after adsorption was measured using atomic adsorption spectrometer (AAS).

7. Results and Discussion

7.1 Effect of pH on Cu(II) and Zn(II) adsorption

The pH value of aqueous solution is an important parameter in adsorption process because it affects the surface charge of the adsorbent, the ionization degree and adsorbate specification. The batch experiment studied of mixed metal solution having concentration of 3.6mg/L, 4.2 mg/L, of Copper and 3.3 mg/L and 3.7 mg/L of Zinc concentration at different pH value ranging from 5to 8 were carried at room temperature. Fig. 1 and Fig. 2 shows that maximum percentage of Cu(II) and Zn(II) adsorption on egg shell and papaya seed were observed at pH 6.

Table 1: Effect of pH on the adsorption of Cu(II) and Zn(II) by chicken eggshells

Sr. no	Quantity of Eggshell powder(gm)	pH	Initial concentration of Cu (mg/L)	Initial concentration of Zn (mg/L)
			3.6	3.3
			Adsorption Efficiency (%)	
1	2.5	5	97	99
2	2.5	6	99.7	99
3	2.5	7	95.8	96.6
4	2.5	8	97	99

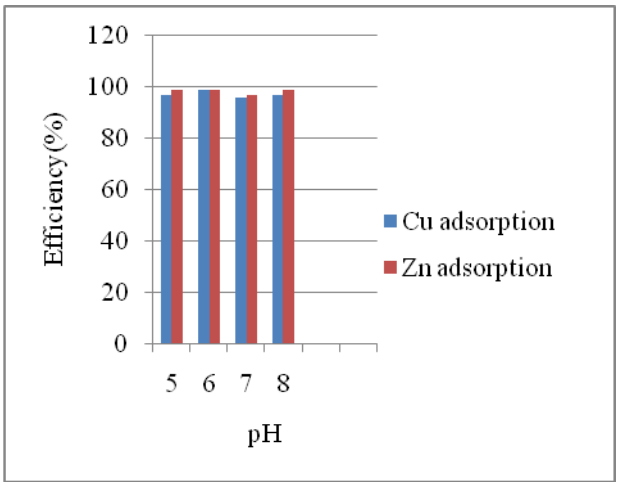

Figure 1: Effect of pH on the adsorption of Cu(II) and Zn(II) by chicken eggshells

Table 2 : Effect of pH on the adsorption of Cu(II) and Zn(II) by papaya seeds

Sr. no	Quantity of Papaya seeds powder (gm)	pH	Initial concentration of Cu (mg/L)	Initial concentration of Zn (mg/L)
			4.2	3.7
			Adsorption Efficiency (%)	
1	2.5	5	90	85
2	2.5	6	95.9	91
3	2.5	7	95.9	89
4	2.5	8	93	88

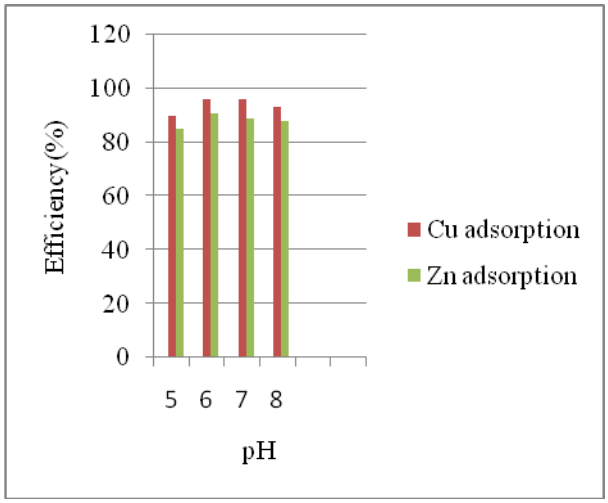

Figure 2: Effect of pH on the adsorption of Cu(II) and Zn(II) by papaya seeds

7.2 Effect of Contact Time on Cu(II) and Zn(II) Adsorption

Contact time plays an important role in adsorption process and the effect of contact time on adsorption capacity has been studied by varying the contact time from 30 to 180 minutes. The Copper and Zinc adsorption percentage at different contact time by chicken eggshell and papaya seeds is shown in Fig 3.Results indicated that the Cu(II) adsorption by chicken eggshell and papaya seeds reached almost 95% and Zn(II) adsorption by chicken eggshell and papaya seeds reached almost 86% at 2 hours contact time.

Table 3: Effect of contact time on the adsorption of Cu(II) and Zn(II) by chicken egg shells and papaya seeds

Sr. no	Quantity of Papaya seeds powder (gm)	Quantity of Eggshell powder (gm)	Contact Time (minutes)	Initial concentration of Cu (mg/L)	Initial concentration of Zn(mg/L)
				4.2	5
				Adsorption Efficiency (%)	
1	1.25	1.25	30	88.9	82
2	1.25	1.25	60	92.8	80
3	1.25	1.25	120	95.2	86
4	1.25	1.25	180	95.2	84

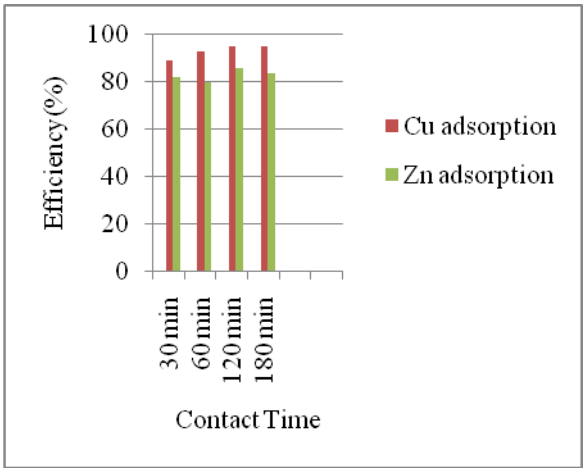

Figure 3: Effect of contact time on the adsorption of Cu(II) and Zn(II) by chicken egg shells and papaya seeds

7.3 Effect of Adsorption Dose

The effect of adsorbent dosage was studied by varying the amount of adsorbent from 1.5 gm to 2.5 gm in 250 ml of mixed metal solution of copper and zinc. After equilibrium the solutions were analyzed for the amount of Cu(II) and Zn(II). The results indicate that adsorption increased with increase in adsorption dosage.

Table 4: Effect of adsorption dose on the adsorption of Cu(II) and Zn(II) by chicken egg shells and papaya seeds.

Sr. no	Quantity of Papaya seeds powder(gm)	Quantity of Eggshell powder(gm)	Initial concentration of Cu (mg/L)	Initial concentration of Zn(mg/L)
			4.4	5.0
			Adsorption Efficiency (%)	
1	1.5	1.5	95	88
2	2.0	2.0	97	90

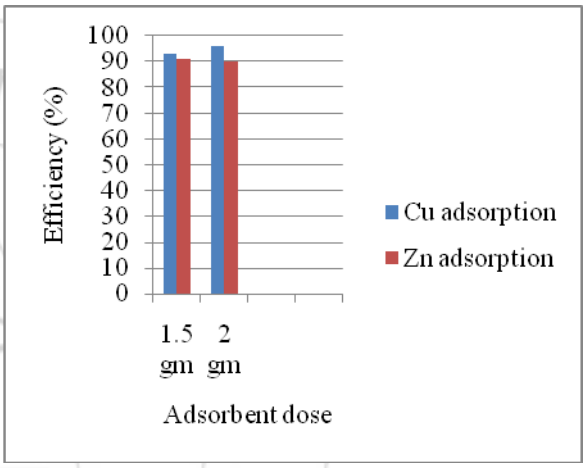

Figure 4: Effect of adsorption dose on the adsorption of Cu(II) and Zn(II) by chicken egg shells and papaya seeds

Table 5: Effect of adsorption dose on the adsorption of Cu(II) and Zn(II) by chicken egg shells and papaya seeds

Sr. no	Quantity of Papaya seeds powder(gm)	Quantity of Eggshell powder(gm)	Initial concentration of Cu (mg/L)	Initial concentration of Zn(mg/L)
			7.9	9.2
			Adsorption Efficiency (%)	
1	1.5	1.5	93	91
2	2.0	2.0	97	93

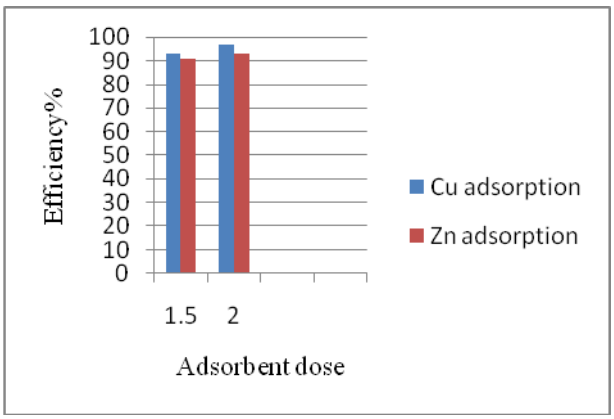

Figure 5: Effect of adsorption dose on the adsorption of Cu(II) and Zn(II) by chicken egg shells and papaya seeds

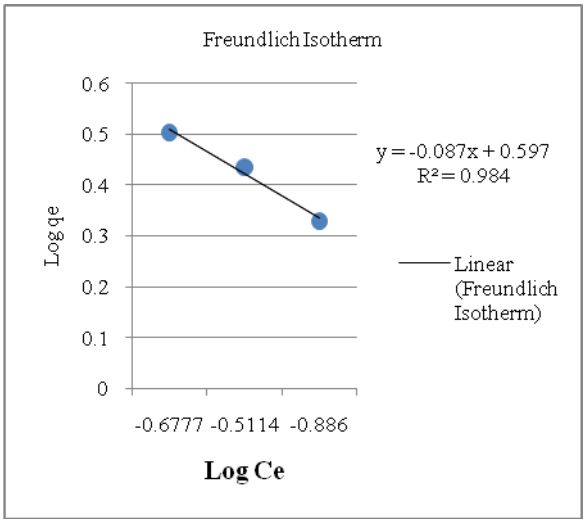

Figure 6: Freundlich Isotherm shown amount of copper adsorbed and equilibrium concentration

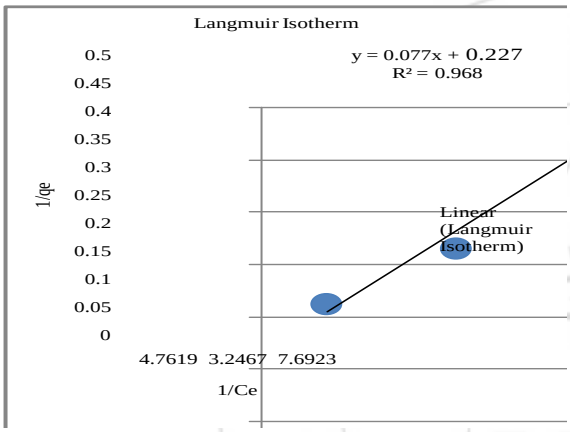

Figure 7: Langmuir Isotherm shown amount of copper adsorbed and equilibrium concentration

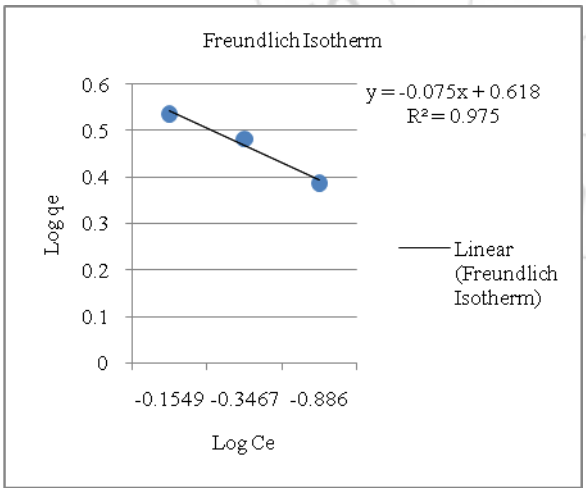

Figure 8: Langmuir Isotherm shown amount of zinc adsorbed and equilibrium concentration

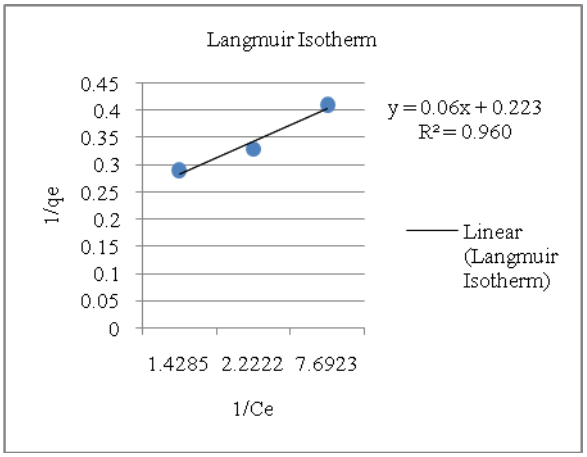

Figure 9: Langmuir Isotherm shown amount of zinc adsorbed and equilibrium concentration

8. Conclusion

The removal of Cu(II) and Zn(II) from water by using chicken eggshells and papaya seeds has been experimented under several conditions such as at different pH, contact time and adsorption dose. The optimum pH for copper and zinc adsorption was found at pH 6. The optimum contact time was found to be 120 minutes at an agitation speed of 170 rpm. Increase in adsorption dose increased the adsorption of metals. This study shows that chicken eggshells and papaya seeds have high potential to be used as low-cost adsorbent for the removal of copper and zinc from water.

Since the metals uptake by chicken eggshells is highly dependent on the number of active binding sites or functional groups on the adsorbents, further study can be attempted to enhance the existing results by modifying the chicken eggshell and papaya seeds adsorbents using bases or acids. Due to chemical modification, it is expected that the number of active binding sites or functional groups on the adsorbents might be increased which may result into increased adsorption capacity of the adsorbents.

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