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STUDIES ON THE ADSORPTION CAPACITY OF ORGANO CLAY (POT POWDER) TO REMOVE COPPER IONS FROM AQUEOUS SOLUTIONS

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Abstract: The pollution of ecosystems and river waters is escalating. In this situation, adsorption can be used as an efficient method for removal of pollutants from water and thus decontaminating it. However, this process is restricted due to the high cost of the traditional adsorbents like activated carbon. Research is therefore being focused on the transformation and recycling of bio-waste as biodegradable, low-cost adsorbents. In particular, pot powder shows potential for the marketable use because of its being widely available and efficient. In this study abundant and low cost adsorbent (Pot powder) is tested for its ability to adsorb copper ions. Batch wise experiments have been carried out and the effect of key variables such as the Initial concentration of copper, pH of solution, Adsorbent dosage and Refractive index were studied. The experiments were carried out under the conditions of pH 6, agitation speed of 200 rpm, equilibrium time of 60 minutes and temperature of 25°C.
Keywords: Adsorption, Copper, pH, Pot powder, Refractive index

1. INTRODUCTION

The elimination of heavy metals from wastewater and water is essential for environment protection and public health. The pollutants are released into water bodies through different ways. They can be released from wastewater treatment facilities, industrial effluents, refineries etc [1-3]. Clay minerals are extensively used as adsorbents for the elimination of heavy metals from the aqueous solution. The pros of using the clay minerals as substitute adsorbents for the elimination of heavy metals are: low permeability, high ion exchange capacity, mechanical and chemical stability, swelling ability and huge specific surface area [4-6]. There are a variety of methods existing for the elimination toxic metals from the water such as Reverse osmosis, Ion-exchange, Membrane separation and Precipitation etc. Considering the easy operational conditions and simplicity, adsorption and the retention of copper ions from aqueous solutions by raw Pot powder is studied in this work [7-9]. The heavy metal ions such as Pb(II), Cu(II), Zn(II), Hg(II), Cr(VI) and As(V) primarily come from industrial effluents in the aqueous environment. These metal ions present in water causes numerous poisonous effects on the human health and environment. The extended half-life of heavy metal ions and their nonbiodegradability causes a buildup of metal ions in the living organisms, causing various diseases such as nervous system damage, poisoning, and cancer. Consequently, it is necessary to clean wastewater by eliminating its heavy metal content by using proficient methods [10-12].

Minerals and clays such as vermiculite, montmorillonite, kaolinite, illite and bentonite are known as substitute materials used for the adsorption of heavy metals because of numerous cost-effective pros and their intrinsic characteristics, such as excellent chemical and physical stability, large specific surface area, and surface and structural properties. Apart from these, other cheap adsorbents have been studied, mainly by using bio-adsorbents, such as chitosan and algae. Still the experiments performed in fixed-bed offered incomplete results. Bentonite clays are extensively used as barriers to evade underground and subsoil landfill water pollution by leaching of heavy metals [13].

2. MATERIALS AND METHODS:

— Preparation of Adsorbent and CuSO4.5H2O Stock solution

The pot powder was collected from the nearby villages. The sample was washed by distilled water, grounded and dried at 100°C for 24 hours. The experiments of copper adsorption were performed batch wise.

Solutions of copper ions of different concentrations (0.05, 0.1, 0.15, 0.2mg/lt) were prepared from a stock solution of CuSO4.5H2O.The pH was adjusted with 0.1 NaOH or H2SO4.

— Experimental procedure

The experimental set up mainly includes 5 conical flasks, burette with stand, funnel, pipette, measuring jar, Whatman filter paper (Grade 1 ~ Particle Retention of 120 μm).

The adsorbent Pot powder is prepared by washing with distilled water. It is then filtered and dried. Fresh synthetic solution is prepared. The Pot powder (1 g, 2 g) is added to the 100 ml of copper solution and the variation of % removal of Copper with adsorbent dosage, contact time and pH are studied.

— Calibration chart

Table 1 and Figure 1 shows the relation between Weight of copper and Refractive Index.

From Figure 1, it is clear that if concentration of copper solution increases Refractive index also increases.
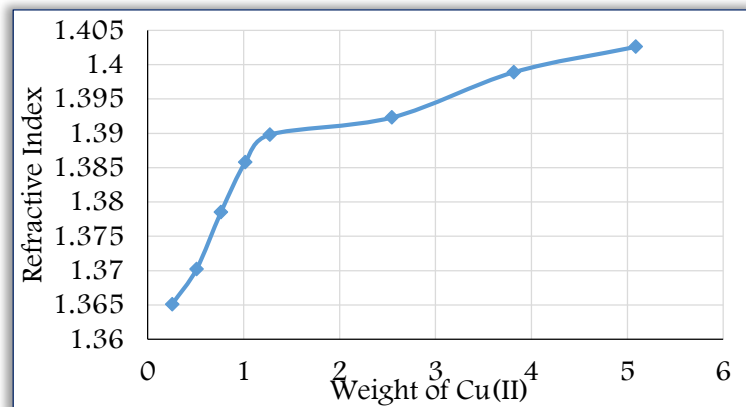

Figure 1: Calibration chart

Table 1. Calibration chart

S.No	Volume of water(ml)	Wt. of Copper sulphate, g	Wt.of Cu, g	Refractive index
1	100	1	0.254505	1.3651
2	100	2	0.509011	1.3702
3	100	3	0.763516	1.3785
4	100	4	1.018022	1.3858
5	100	5	1.272527	1.3898
6	100	10	2.5448	1.3923
7	100	15	3.8173	1.3989
8	100	20	5.0897	1.4026

3. RESULTS AND DISCUSSIONS

Effect of Contact time and Adsorbent Dosage with Refractive index on Cu (II) Adsorption:

Table 2. For $t_{contact}$=20min

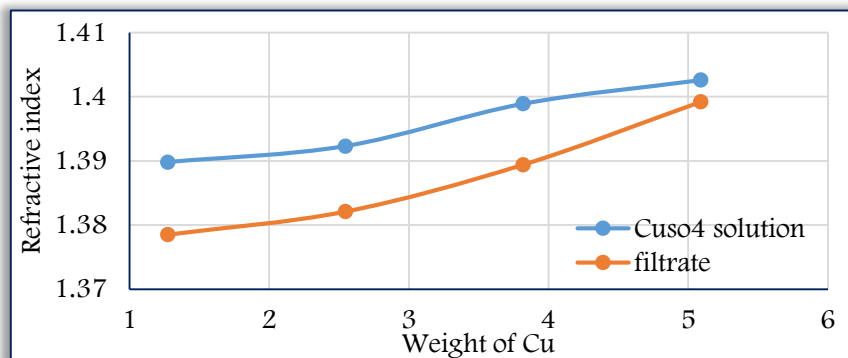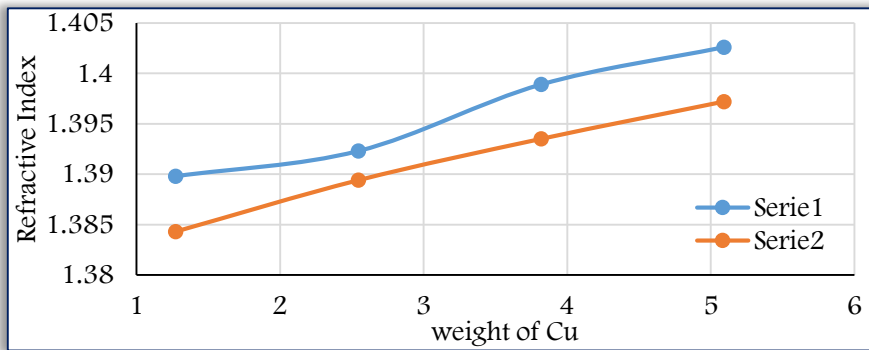| S.No	Volume of water(ml)	Wt.of adsorbent (Pot Powder), g	Wt.of Cu, g	Refractive index (Copper sulphate solution)	Refractive index (filtrate)
1	100	1	1.2724	1.3898	1.3785
2	100	1	2.5448	1.3923	1.3821
3	100	1	3.8173	1.3989	1.3894
4	100	1	5.0897	1.4026	1.3992

Figure 2: Refractive Index vs. wt. of Copper (20 min & 1gm PP)

Figure 2 shows the increase in Refractive Index with increasing weight of copper for contact time of 20minutes and adsorbent dosage of 1gm.

Table 3. For $t_{contact}$=20min

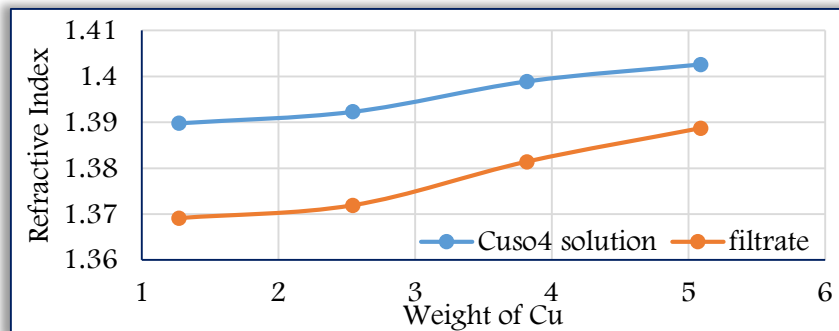| S.No	Volume of water(ml)	Wt.of adsorbent (Pot Powder), g	Wt.of Cu, g	Refractive index (Copper sulphate solution)	Refractive index (filtrate)
1	100	2	1.2724	1.3898	1.3843
2	100	2	2.5448	1.3923	1.3894
3	100	2	3.8173	1.3989	1.3935
4	100	2	5.0897	1.4026	1.3972

Figure 3: Refractive Index vs. wt. of Copper (20 min & 2 gm PP)

Figure 3 shows the increase in Refractive Index with increasing weight of copper for contact time of 20minutes and adsorbent dosage of 2gm.

Table 4. For $t_{contact}$=60min

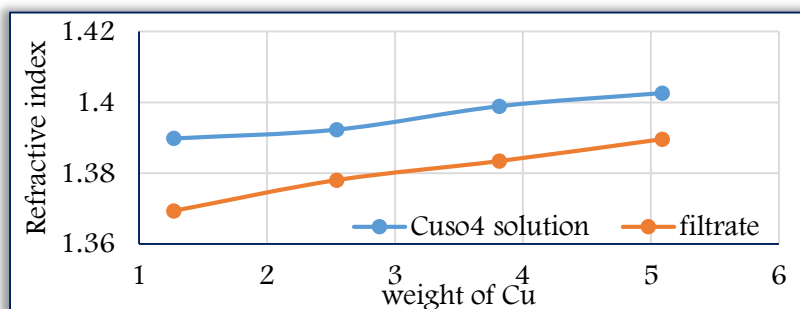| S.No	Volume of water(ml)	Wt.of adsorbent (Pot Powder ~ PP), g	Wt.of Cu, g	Refractive index (copper sulphate solution)	Refractive index (filtrate)
1	100	1	1.2724	1.3898	1.3691
2	100	1	2.5448	1.3923	1.3719
3	100	1	3.8173	1.3989	1.3814
4	100	1	5.0897	1.4026	1.3887

Figure 4: Refractive Index vs. wt. of Copper (60 min & 1gm PP)

Figure 4 shows the increase in Refractive Index with increasing weight of copper for contact time of 60minutes and adsorbent dosage of 1gm.

Table 5. For $t_{contact}$=60min

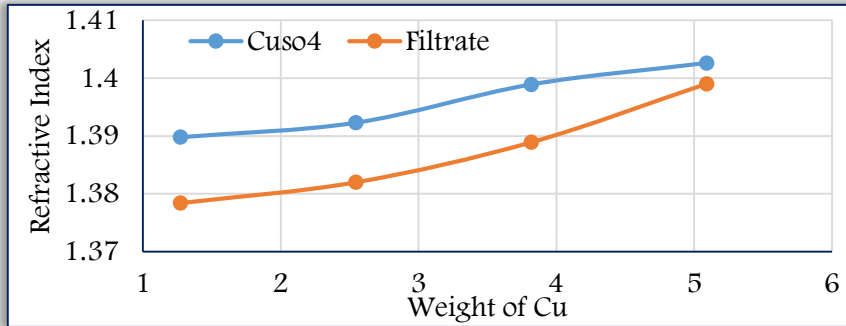| S.No	Volume of water(ml)	Wt.of adsorbent (Pot Powder), g	Wt.of Cu, g	Refractive index (Copper sulphate solution)	Refractive index (filtrate)
1	100	2	1.2724	1.3898	1.3693
2	100	2	2.5448	1.3923	1.3780
3	100	2	3.8173	1.3989	1.3834
4	100	2	5.0897	1.4026	1.3896

Figure 5: Refractive Index vs. wt. of Copper (60 min & 2 gm PP)

Figure 5 shows the increase in Refractive Index with increasing weight of copper for contact time of 60 minutes and adsorbent dosage of 2 gm.

Table 6. For $t_{contact}$=40min

| S.No	Volume of water(ml)	Wt.of adsorbent (Pot Powder), g	Wt.of Cu, g	Refractive index (Copper sulphate solution)	Refractive index (filtrate)
1	100	1	1.2724	1.3898	1.3784
2	100	1	2.5448	1.3923	1.3820
3	100	1	3.8173	1.3989	1.3889
4	100	1	5.0897	1.4026	1.3990

Figure 6: Refractive Index vs. wt. of Copper (40 min & 1gm PP)

Figure 6 shows the increase in Refractive Index with increasing weight of copper for contact time of 40minutes and adsorbent dosage of1 gm.

Table 7. For $t_{contact}$=40min

S.No	Volume of water(ml)	Wt.of adsorbent (Pot Powder), g	Wt.of Cu, g	Refractive index (Copper sulphate solution)	Refractive index (filtrate)
1	100	2	1.2724	1.3898	1.3715
2	100	2	2.5448	1.3923	1.3792
3	100	2	3.8173	1.3989	1.3839
4	100	2	5.0897	1.4026	1.3960
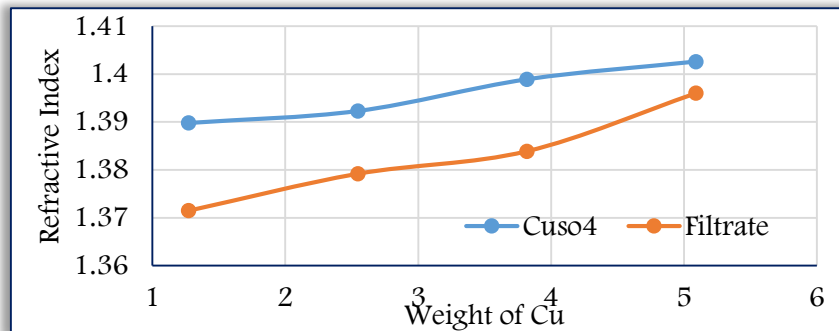
Figure 7: Refractive Index vs. wt. of Copper (40 min & 2 gm PP)

Figure 7 shows the increase in Refractive Index with increasing weight of copper for contact time of 40minutes and adsorbent dosage of 2 gm.

─ Effect of % Removal at different concentrations and contact times:

» At 1 gm of Adsorbent dosage:

Figure 8 shows that variation of % removal with concentration for an adsorbent dosage of 1 gram.
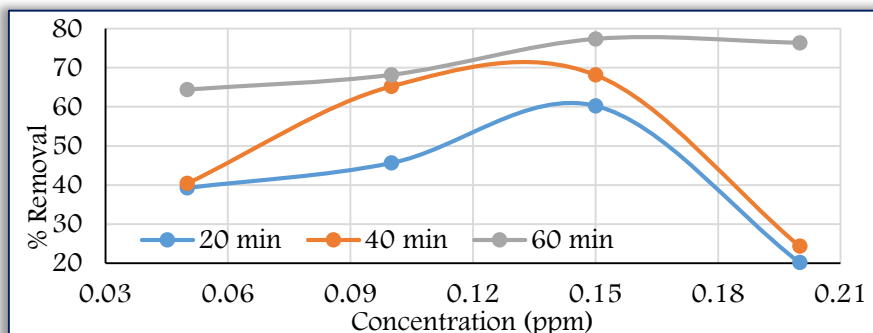

Figure 8: Concentration vs % Removal (1 gm adsorbent dosage)

The graph shows that for 0.2 ppm, the % removal is less for both at 20 and 40 minutes of adsorbent dosage of 1 gram, whereas for the same adsorbent dosage maximum % removal is at 60 minutes. Therefore for an adsorbent dosage of 1 gm, maximum removal of copper can be obtained at 60 minutes, which shows that more the contact time more will be the adsorption capacity. Initially at 20 and 40 minutes, the adsorption of copper increases upto 0.15 ppm, whereas there is a sudden decrease at 0.2 ppm, which means more the concentration, less the adsorption capacity.

» **At 2 gm of Adsorbent dosage:**

Figure 9 shows the variation of % removal with concentration for an adsorbent dosage of 2 grams. At 20 minutes the adsorption decreases for 0.1 ppm and then it increases gradually but the % removal is less, whereas at 40 minutes the % removal increases upto 0.15 ppm and then a sudden decrease for 0.2 ppm, whereas at 60 minutes the % removal decreases at 0.2 ppm but it is comparatively more than that for 20 and 40 minutes.
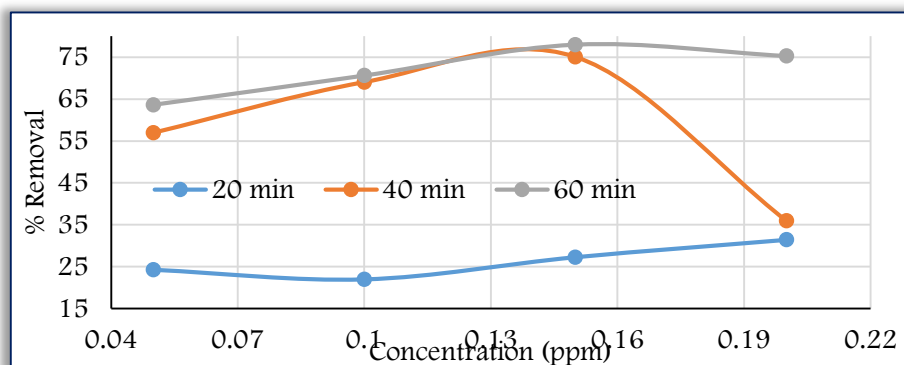

Figure 9: Concentration vs % Removal (2 gm adsorbent dosage)

— **Effect of Contact time and Adsorbent dosage on Cu (II) removal:**

Figure 9 shows the increase in refractive index with increasing weight of copper for the contact time of 40minutes and adsorbent dosage of 2 gm. The adsorption is carriedout for different time intervals (20-60 min). It is apparent from Figure 7 that, the % adsorption increases with increasing contact time and dosage of the adsorbent. The maximum adsorption takes place at 60 mins, after which there is not much significant change. Therefore, the adsorption for 60 minutes has been considered for further experiments.

— **Effect of pH on Cu(II) Removal**

In this experiment, the effect of pH was studied in the range of 3-8. The major driving force for copper adsorption is the electrostatic interaction i.e, the attraction between adsorbate and adsorbent. Figure 10 shows that the pH of 6 is suitable for better adsorption of copper.
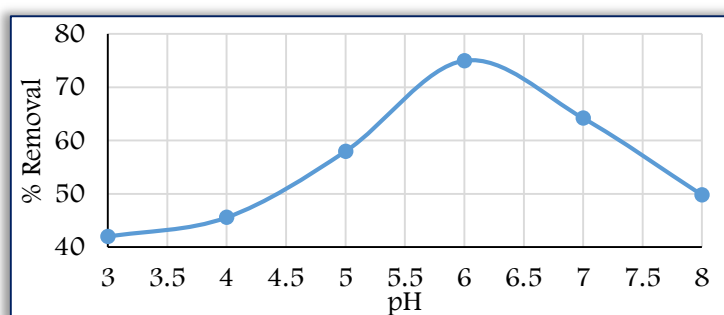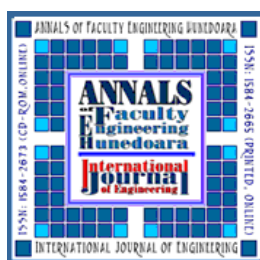

Figure 10: Effect of pH on Cu(II) Removal

4. CONCLUSION

The study shows that adsorption can be used as an efficient method for removal of pollutants from water and thus decontaminating it. However, this process is restricted due to the high cost of the traditional adsorbents like activated carbon. This study explored the potential of low cost adsorbent, pot powder for its ability to adsorb the copper ions for the marketable use because of its being widely available and efficient. Batch wise experiments have been carried out and the effect of key variables such as the Initial concentration of copper, pH of solution, Adsorbent dosage and Refractive index were studied. The maximum adsorption of copper was observed at the initial concentration of 0.1 ppm, contact time of 60 minutes, adsorbent dosage of 1 gm and refractive Index of 1.3719. The maximum adsorption of Cu(II) is observed at pH of 6.

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