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Elimination of Cu^+ and Zn^+ using Animal Bone Char: A Comparative Study

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Abstract:- Industrial effluent always containing toxic heavy metal. Heavy metal like Zn & Cu are highly harmful for both environment & human being. In this study, bone char of chicken, goat & cow are used for the purification of stimulated wastewater. Stimulated /Synthetic wastewater was prepared in laboratory in required condition. Investigation conducted in different conditions to study the effect of pH, Contact time & adsorbent dosage. Results shown that the Chicken & Cow bone char has the greater removal capacity at pH5. Removal capacity with Chicken bone char for Cu^+ & Zn^+ is 91.80% & 94.28% respectively. Goat Bone Char shown the removal efficiency for Cu^+ & Zn^+ was about 91.74% & 91.40%. And Cow Bone Char shown the removal efficiency for both Cu^+ & Zn^+ was about 91.94% & 91.59%.

Keywords:- *Bone Char, Heavy Metal, Stimulated Wastewater, Copper, Zinc, Adsorption.*

I. INTRODUCTION

Wastewater treatment is a critical process aimed at mitigating the adverse environmental impacts of industrial and domestic activities. One particular concern is the presence of heavy metals in wastewater, such as zinc (Zn) and copper (Cu), which can pose significant risks to aquatic ecosystems and human health if not properly managed. Zinc and copper are commonly found in wastewater due to their widespread use in various industries, including mining, electroplating, metal finishing, and the production of consumer goods. Can streams through industrial discharges, stormwater runoff, and domestic sources like household cleaning products and plumbing systems. The presence of Zn and Cu in wastewater is of concern due to their toxicity and potential for bioaccumulation in aquatic organisms. These metals can disrupt the biological processes of aquatic life, impairing growth, reproduction, and overall ecosystem health. Additionally, if untreated wastewater is discharged into surface waters or used for irrigation, it can contaminate water resources and enter the food chain, posing risks to human health. Hence, treating of such wastewater needs to be done.

II. MATERIALS AND METHODOLOGY

➢ *Preparation of Adsorbents-Bone Char*

In this part, collection of chicken, goat & cow leftover bones were collected in Gadag mutton market. Boiled them for to remove the remaining flush. And dried them for 15-20days in sun light. Then the Bones are subjected into the muffle furnace at the highest temperature of about 500°C-650°C in the absence of Oxygen for 60mins-150mins. In the end the left-over ash content is taken out and kept for cooling. After 30mins-45mins the bones were grinded thoroughly and sieved to get geometrically uniform sized bone char for to get better removal efficiency.

➢ *Preparation of Stimulated/Synthetic Wastewaster*

Preparation of wastewater in laboratory with required condition. In this research work to prepare synthetic wastewater Copper nitrate & Zinc nitrate hexahydrate were used. Wastewater containing Copper and Zinc, took $Cu(NO_3)_2.3H_2O$ & $Zn(NO_3)_2.6H_2O$ in different concentration (50mg/L & 100mg/L respectively). Took both chemical compounds in equal amount separately, added into 1000mL of distilled water and mixed with the help of agitator for uniform mixing of chemical into the distilled water.

III. ANALYSIS OF SAMPLE

After experimentation part, sample were collected in standard 100mL sample bottles and subjected to UV-Spectrophotometer to identify the final heavy metal concentration under suitable wavelength (ƛ).

$$\% \text{ Removal} = \frac{C_i - C_o}{C_i} \; X \; 100$$

Where,
Ci = Preliminary-concentration of Zn^+ & Cu^+
Co = Ultimate-concentration of Zn^+ & Cu^+

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➢ *Experimental Setup of Fixed-Bed Column*

In a fixed-bed column investigation, the trails performed in borosilicate glass-column of 30mm dia. and 450mm in length, the column was provided with the inlet opening at the top and the flow was downward. Glass wool was placed for the base support and above which the glass beads are place up to height of 2-4 cm above the glass beads the adsorbent was placed with the desired height. Below the column the outlet pipe is provided and the treated solution samples are collected at a regular time interval, the concentration of the collected samples was studied in the spectrophotometer as well as the removal-efficiency of the adsorptive was calculated.

IV. RESULTS AND DISCUSSION

The Copper and Zinc adsorption is done with the help of three types of Animal Bone Char. The adsorption of Copper and Zinc is calculated and the breakthrough curves. The parameters varied in the experiments are Bed height, Flow rate and Influent concentration. Bed height is varied as 1.5cm, 2cm and 4cm, Flow rate varied at 5mL/min, 10mL/min and 15mL/min and Initial concentration is varied as 50mg/L and 100mg/L.

➢ *Effect of Bed-depth on Breakthrough Curves for Chicken Bone Char as an adsorbent*

Cu & Zn adsorption rate is mainly depending on the bed height in the Column Adsorption process. The experiments are performed with the various bed height of 1.5cm, 2cm, and 4cm and the initial concentration and flow1rate are maintained constant1at 10mg/L & 5mL/min1respectively.

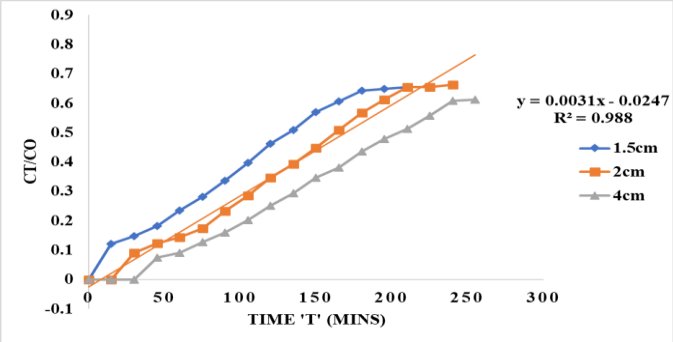

Fig 1 For Copper, Effect of Bed depth on Breakthrough curve for Chicken Bone Char as an adsorbent (Co=10mg/L, Q=5ml/min)

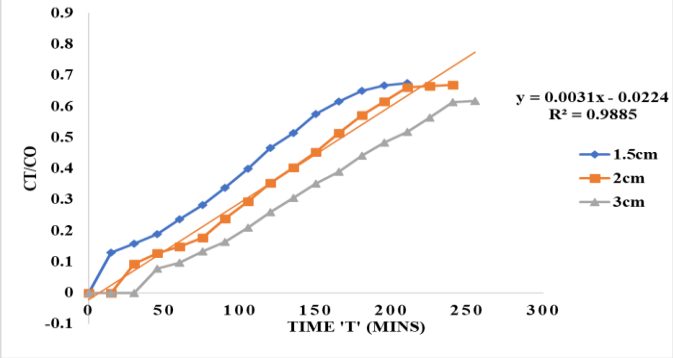

Fig 2 For Zinc, Effect of Bed depth on Breakthrough curve for Chicken Bone Char as an adsorbent (Co=10mg/L, Q=5ml/min)

➢ *Effect of Flow Rate on Breakthrough Curves for Chicken Bone Char as an adsorbent.*

Flow frequency is indispensable to regulate the efficiency of the adsorbent in the lingers fixed bed column experiments are performed with varying rates of 5mL/min, 10mL/min and 15mL/min and the inflowing concentration and Bed depth is kept persistent at 10mg/L and 4cm correspondingly.

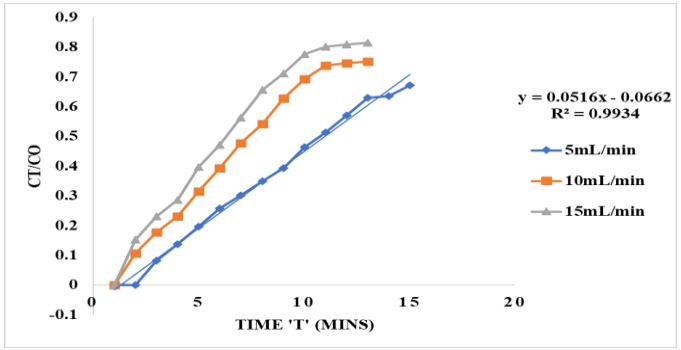

Fig 3 For Copper, Effect of flow rate on Breakthrough curve for Chicken Bone Char as an adsorbent (Co=10mg/L, Z=4cm)

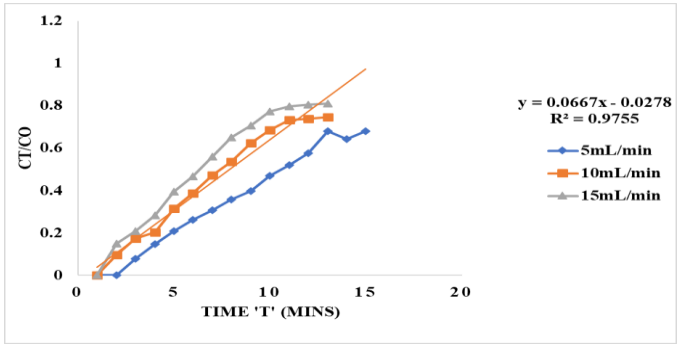

Fig 4 For Copper, Effect of flow rate on Breakthrough curve for Chicken Bone Char as an adsorbent (Co=10mg/L, Z=4cm)

➢ *Effect of initial concentration on Breakthrough Curves for Chicken Bone Char as an adsorbent*

The initial concentration is also playing a major stricture in the column studies, in this the initial or influent concentration of the Copper as well as Zinc is varied as 50mg/L and 100mg/L and the Flow1rate and Bed height are kept constant at 5mL/min and 4cm respectively.

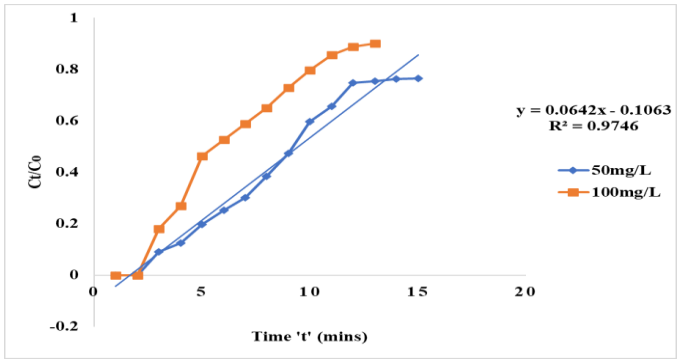

Fig 5 For Copper, Effect of Initial Concentration on Breakthrough curve for Chicken Bone Char as an adsorbent (Q=5mL/min, Z=4cm)

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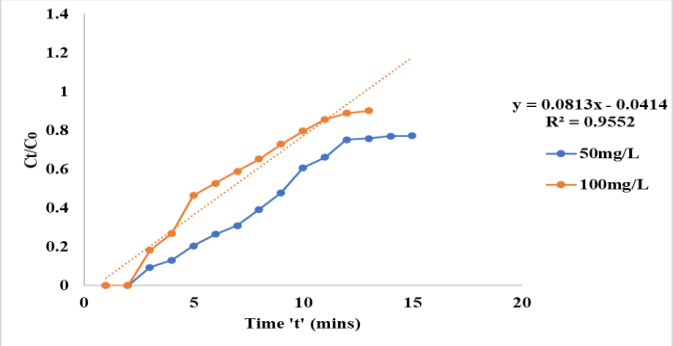

Fig 6 For Zinc, Effect of Initial Concentration on Breakthrough curve for Chicken Bone Char as an adsorbent (Q=5mL/min, Z=4cm)

➢ *Effect of Flow rate on Breakthrough Curve for Goat Bone Char as adsorbent*

Flow rate is essential to determine the efficiency of the adsorbent in the continues fixed bed column experiments are performed with varying rates of 5mL/min, 10mL/min and 15mL/min and the influent concentration1and Bed depth1is kept1constant at 10mg/L and 4cm separately.

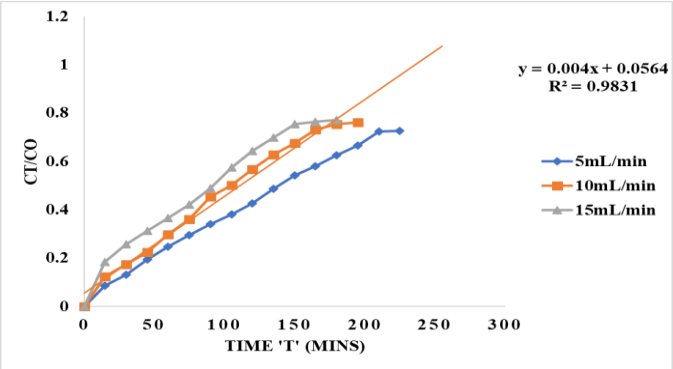

Fig 7 For Copper, Effect of Flow rate on Breakthrough curve for Goat Bone Char as an adsorbent (Q=5mL/min, Z=4cm)

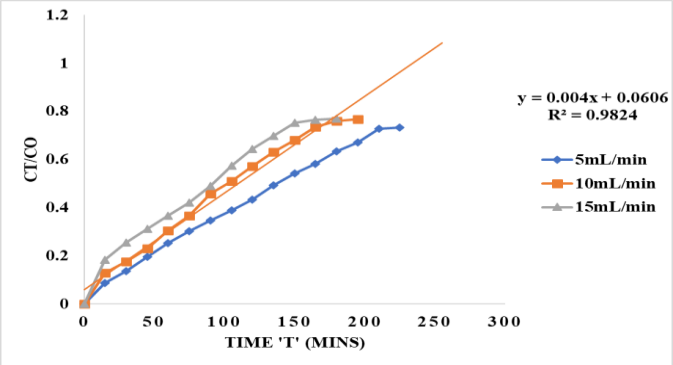

Fig 8 For Zinc, Effect of Flow rate on Breakthrough curve for Goat Bone Char as an adsorbent (Q=5mL/min, Z=4cm)

➢ *Effect of Bed depth on Breakthrough Curves for Goat Bone Char as an adsorbent*

Copper as well as Zinc adsorption is mainly reliant on the bed height in the column. The experiments are performed with the varying bed height of 1.5cm, 2cm, and 4cm. The initial concentration and flow1rate are kept constant as 10mg/L and 5mL/min respectively.

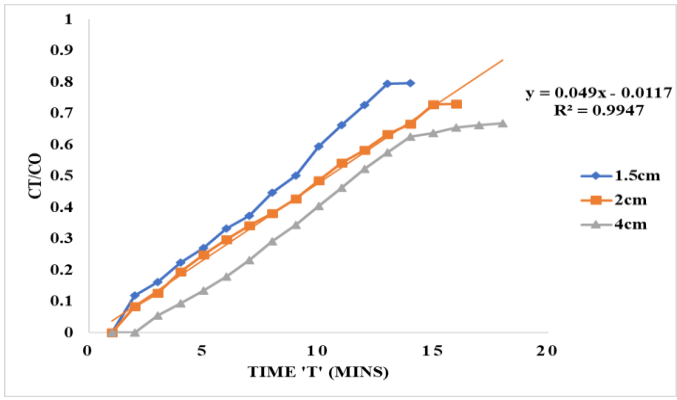

Fig 9 For Copper, Effect of Bed depth on Breakthrough curve for Goat Bone Char as an adsorbent (Q=5mL/min, C_o=10mg/L)

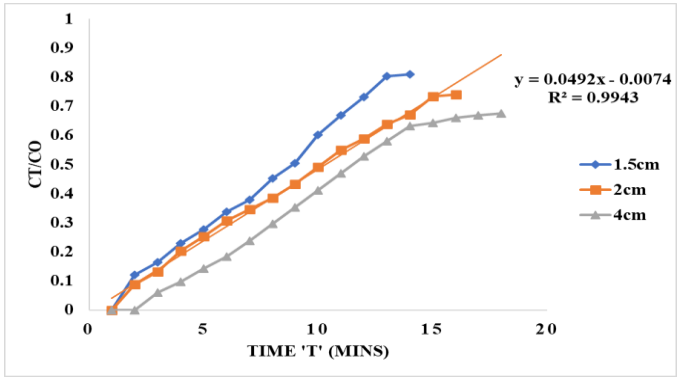

Fig 10 For Zinc, Effect of Bed depth on Breakthrough curve for Goat Bone Char as an adsorbent (Q=5mL/min, C_o=10mg/L)

➢ *Effect of Initial1Concentration on Breakthrough1Curves for Goat Bone Char as an adsorbent*

The initial concentration is also playing major parameter in the column studies, in this the influent concentration of the Copper as well Zinc is varied as 50mg/L and 100mg/L and the Flow1rate and Bed depth are maintained constant1at 5mL/min and 4cm separately.

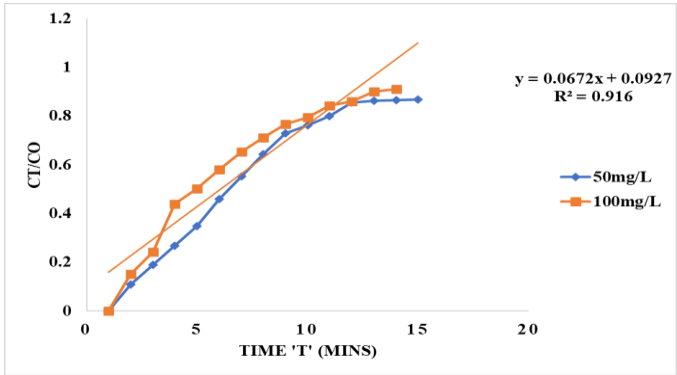

Fig 11 For Copper, Effect of Initial Concentration on Breakthrough curve for Goat Bone Char as an adsorbent (Q=5mL/min, Z=4cm)

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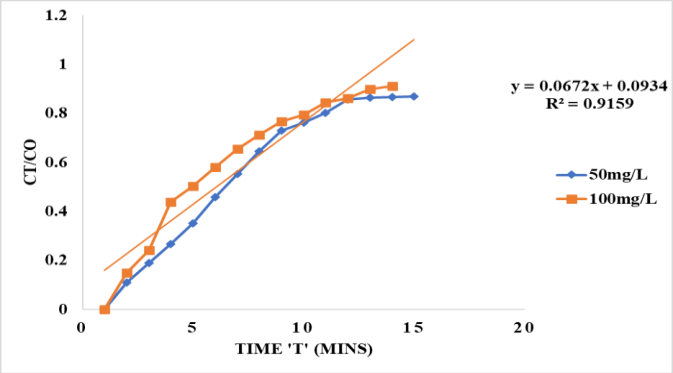

Fig 12 For Zinc, Effect of Initial Concentration on Breakthrough curve for Goat Bone Char as an adsorbent (Q=5mL/min, Z=4cm)

➢ *Effect of Flow1rate on Breakthrough1Curve for Cow Bone Char as adsorbent*

Flow rate is essential to determine the efficiency of the adsorbent in the continues fixed bed column experiments are performed with varying rates of 5mL/min, 10mL/min and 15mL/min and the influent concentration and Bed depth is kept constant at 10mg/L and 4cm separately.

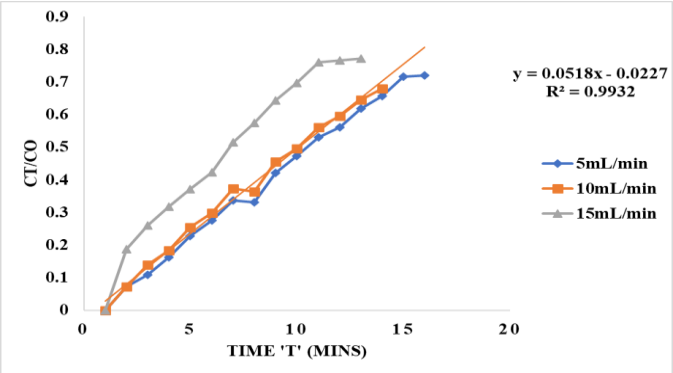

Fig 13 For Copper, Effect of Flow Rate on Breakthrough curve for Cow Bone Char as an adsorbent (Co= 10mg/L, Z=4cm)

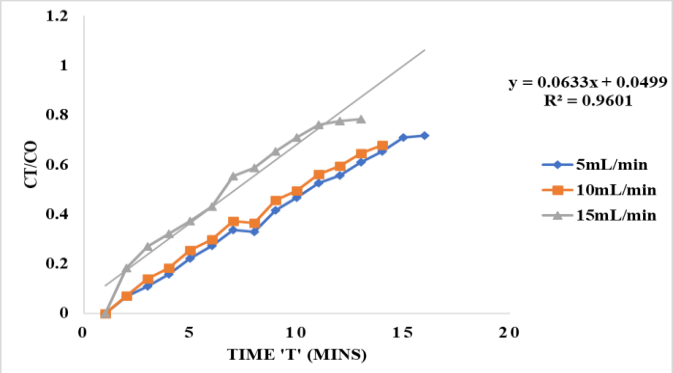

Fig 14 For Zinc, Effect of Flow Rate on Breakthrough curve for Cow Bone Char as an adsorbent (Co= 10mg/L, Z=4cm)

➢ *Effect of Bed depth on Breakthrough Curves for Cow Bone Char as an adsorbent*

Copper as well as Zinc adsorption is mainly reliant on the bed depth in the column. The experiments are performed with the varying bed height of 1.5cm, 2cm, and 4cm. The initial concentration and flow1rate are kept constant as 10mg/L and 5mL/min separately.

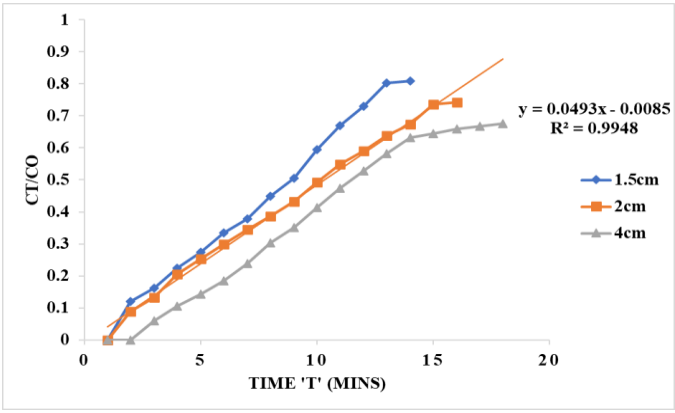

Fig 15 For Copper, Effect of Bed depth on Breakthrough curve for Cow Bone Char as an adsorbent (Co= 10mg/L, Q= 5mL/min)

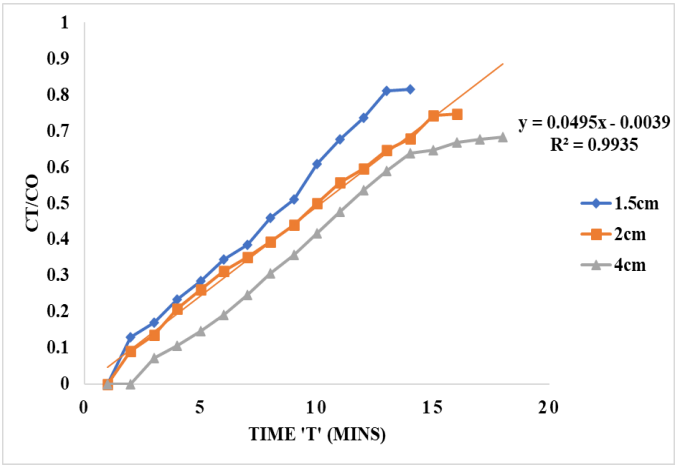

Fig 16 For Zinc, Effect of Bed depth on Breakthrough curve for Cow Bone Char as an adsorbent (Co= 10mg/L, Q= 5mL/min)

➢ *Effect of Initial Concentration on Breakthrough Curves for Cow Bone Char as an adsorbent*

The initial concentration is also playing major parameter in the column studies, in this the influent concentration of the Copper as well Zinc is varied as 50mg/L and 100mg/L and the Flow1rate and Bed depth are maintained constant1at 5mL/min and 4cm separately.

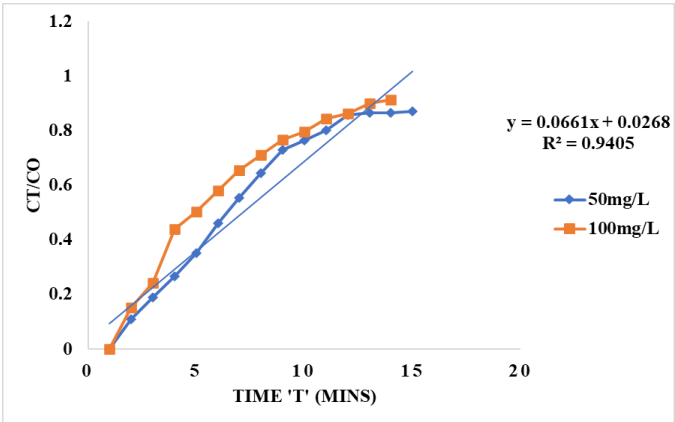

Fig 17 For Copper, Effect of Initial Concentration on Breakthrough curve for Cow Bone Char as an adsorbent (Z= 4cm, Q=15mL/min)

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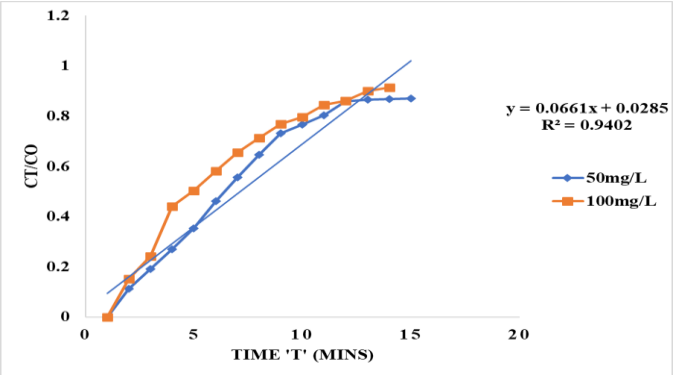

Fig 18 For Zinc, Effect of Initial Concentration on Breakthrough curve for Cow Bone Char as an adsorbent (Z= 4cm, Q=15mL/min)

V. CONCLUSION

- Based on the results of experiments/practical sessions carried out under varying the parameters like Bed-height of the adsorbent, Flow-rate as well as Influent-concentration of metal-ions. And analysis of1the same thereby the following conclusions have drawn.
- The chicken & cow bone char has shown to be more efficient compared to the other two types of bone-chars.
- Removal-efficiency for the Chicken-Bone Char are as a flow-rate is increased from 5mL/min1to 15mL/min1the removal-efficiency for Cu^+ & Zn^+ decreased from 91.90% to 84.70% & from 92.30% to 84.90% respectively. Correspondingly, when the initial-concentration of Cu^+ & Zn^+ increased from 50mg/L1to 100mg/L the removal-efficiency is decreased from 90.90% to 81.90% & from 98.24% to 81.92% individually and for the bed-depth in the column increased from 1.5cm to 4cm the removal efficiency is also improved from 87.90% to 92.60% & from 87.00% to 92.30%.
- Removal-efficiency for the Goat-Bone Char are as a flow-rate is increased from 5mL/min to 15mL/min the removal-efficiency for Cu^+ & Zn^+ decreased from 91.50% to 81.50% & from 91.30% to 81.30% respectively. Correspondingly, when the initial-concentration of Cu^+ & Zn^+ increased from 50mg/L1to 100mg/L the removal-efficiency is decreased from 89.12% to 84.97% & from 89.00% to 84.88% respectively and for the bed-depth in the column increased1from 1.5cm to 4cm the removal efficiency is also increased from 88.10% to 94.60% & from 87.90% to 93.90%.
- Removal-efficiency for the Cow-Bone Char are as a flow-rate is increased from 5mL/min to 15mL/min the removal-efficiency for Cu^+ & Zn^+ decreased from 92.70% to 81.30% & from 93.10% to 81.70% respectively. Correspondingly, when the initial-concentration of Cu^+ & Zn^+ increased from 50mg/L to 100mg/L the removal-efficiency is decreased from 89.04% to 84.89% & from 88.78% to 84.79% respectively and for the bed-depth in the column increased from 1.5cm to 4cm the removal1efficiency is also increased from 88.10% to 94.10% & from 87.10% to 92.90%.

Graphs are plotted to represent the removal-efficiency of all types of Bone-Chars. And the Respective R^2-Values are nearly or equal to 1 ($R^2 \leq 1$).

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