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ACTIVATED CARBON FROM INDIGENOUS INFERIOR WOODS

Part -IV. Adsorption of Copper, Zinc and Hexavalent Chromium-optimum Contact Time and Adsorption Behaviour

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The effect of contact time, amount of carbon and general adsorption behaviour of copper, zinc and hexavalent chromium has been determined from their aqueous solutions by an activated carbon prepared from Eucalyptus (*E. camaldulensis*). It has been found that in each case, amount of carbon has no significant effect on the optimum contact time required for maximum metal adsorption. However, carbon dose significantly affects the amount of metal adsorbed. The adsorption of copper is found to be thrice that of zinc and chromium on the basis of initial metal ion concentration using the same amount of carbon. The results further show that when two or three metals are in the same solution, they compete for adsorption sites. However, the adsorption of zinc is hindered and reduced by 50% in the presence of Cu and Cr^{+6}.

Key words: Copper, Zinc, Hexavalent chromium, Activated carbon, Eucalyptus, Adsorption.

Introduction

The continuous discharge of metals and other chemicals in the aquatic environment particularly to potable water sources has been a matter of great concern over recent years. The high concentration of metals in waste water is generally caused by discharge of industrial waste to the sewer or by the passage of water through deposits of metal bearing minerals. The actual toxicity of a metal to stream life depends on different factors like the particular metal present, pH and synergistic effects of different metals [1].

Due to a growing awareness of environmental pollution, substantial research work has been done on the removal of several heavy metal species from aqueous solutions by powdered activated carbon [2,3]. It has been reported that hexavalent chromium is highly toxic and causes lung cancer. Copper and Zinc are not toxic to that extent but poses problems of taste and digestion. The AWWA goal set for Cr^{+6}, Cu and Zn in potable water is 10 ppb, 200 ppb and 1 ppm respectively [4].

The present investigation is in continuation of our previous studies [5,6], describing the preparation of activated carbon from different indigenous woods and their general adsorption behaviour. In a previous study [7], carbon of an inferior hardwood namely Eucalyptus was generally found to be more effective than others for optimum adsorption of certain trace metals like Cu, Zn and Cr^{+6}. It was also concluded that the optimum pH for maximum metal adsorp'ion in case of Cu and Zn is 4 whereas it is 2 for Cr^{+6}.

The present study describes the effect of contact time on the removal of these trace metals from their aqueous solutions, together with their adsorption behaviour either alone or in the presence of other metals.

Experimental

Activated carbon from Eucalyptus (*E. camaldulensis*) and optimum pH *viz.* 4.0 selected for maximum adsorption of Zn and Cu have been utilized in the present investigations. Although the optimum pH selected for Cr^{+6} was 2.0, pH 4.0 has been used in the present study as at this pH, its adsorption is almost maximum i.e., 97% and is detectable in contrast to 100% adsorption at pH 2.0 and 3.0.

Aqueous solutions of copper, zinc and hexavalent chromium having different concentrations (mg/liter) were prepared from copper sulfate, zinc sulfate and potassium dichromate respectively, adjusted to their optimum pH values and then filtered through Whatman No. 41 (filter paper). A representative sample from each metal solution was taken as 'control' to determine its exact metal concentration by LKB spectrophotometer (NOVASPEC) [8]. Exactly 50 ml of the sample solutions were placed in 250 ml conical flasks fitted with quickfit stoppers containing 0.1 gm activated carbon in each case. The flasks were then shaken for varying time periods of 15-150 mins on an orbital shaker to determine the minimum contact time required for maximum metal adsorption. The final metal concentration in each filtrate was then determined.

Blank tests with the same metal concentration but without carbon were run simultaneously to test whether metal was removed by some other mechanism during the process.

A second set of experiments with two metals in the same solution and a third one containing all the metals in the same solution were performed with varying doses of carbon from 0.075 to 0.20 gm.

Results and Discussion

The first set of experiments was performed to determine the minimum contact time required for maximum removal of copper, zinc and hexavalent chromium from their aqueous solutions (Figs. 1-3). It was, thereafter, observed that 120 mins appeared to be sufficient for optimum adsorption of all three metals. It was also noted that in all these cases, the rate of adsorption is very rapid during the initial 15 mins. contact time and then proceeds slowly until it reaches an optimum level. To further observe the adsorption behaviour of one metal in the presence of others, experiments were also carried out with two and three metals in the same solution with varying amount of carbon and contact time (Figs. 4-12).

Removal of copper. In Fig. 4, Cu in the presence of Zn, it has been observed that with lower amounts of carbon *viz.* 0.075-0.15 gm, adsorption proceeds at a very slow rate and reaches an optimum level with contact time of 90 -120 mins. whereas comparatively longer contact time of 150 mins is required with higher dose of 0.2 gm. It has further been observed that with a lower amount of carbon, 80-83% of Cu is removed whereas with maximum amount, complete removal is attained in 150 mins.

In Fig. 6, Cu in the presence of Cr^{+6}, a regular pattern of copper removal is observed and it ranges between 73 to 100% in minimum and maximum amounts of carbon. It has also been

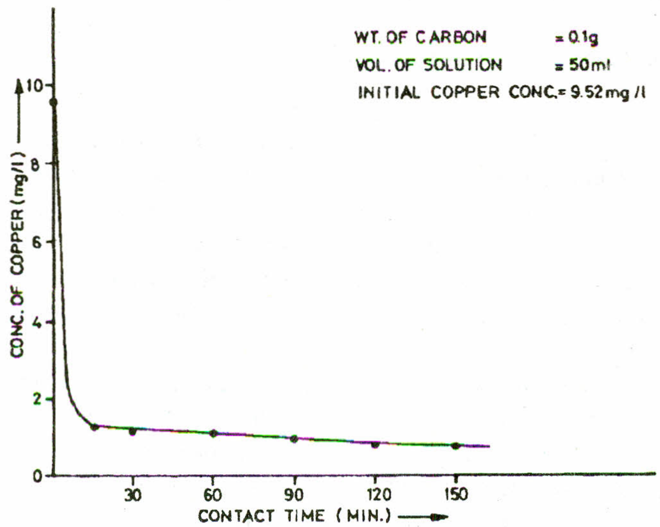

Fig. 1. Copper conc. vs contact time with carbon at pH=4.0

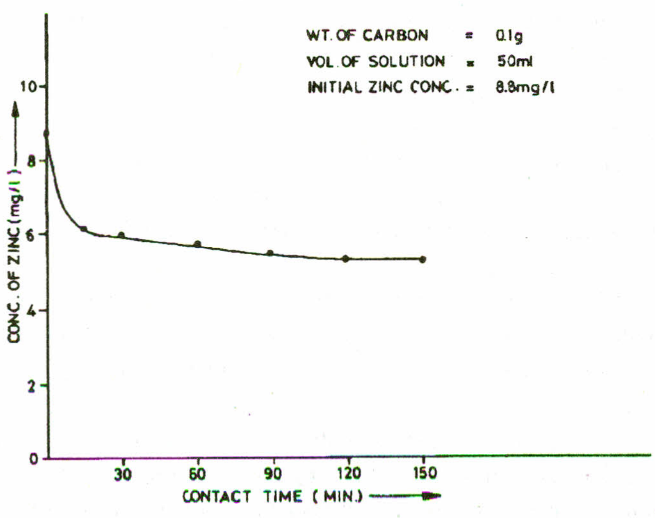

Fig. 2. Zinc conc. vs contact time with carbon at pH=4.0

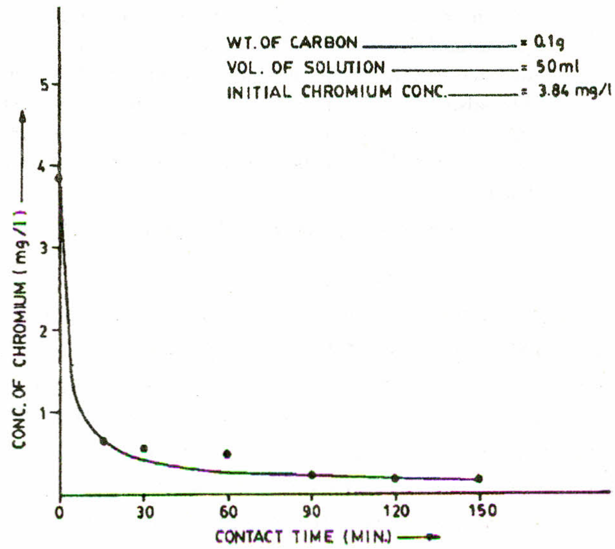

Fig. 3. Chromium conc. vs contact time with carbon at pH=4.0

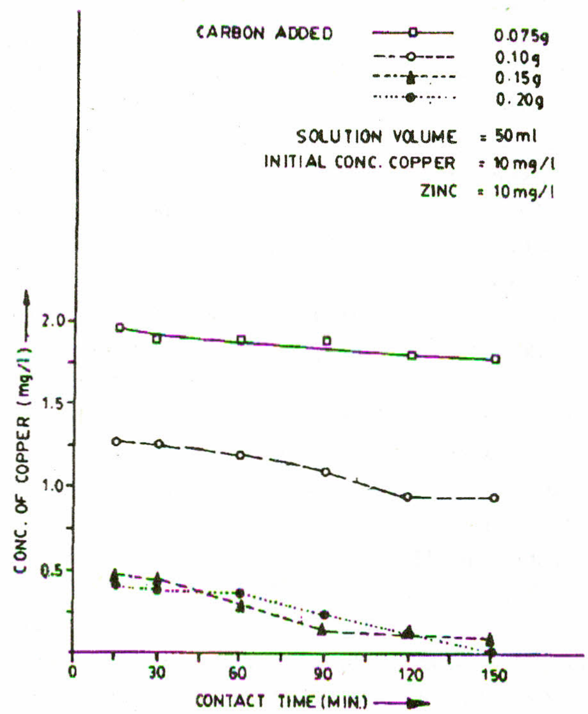

Fig. 4. Copper conc. vs contact time in the presence of zinc at pH=4.0

observed that comparatively more contact time is required to attain equilibrium in this particular case.

In the case of Cu in presence of Zn and Cr^{+6} (Fig. 10), it is noted that Cu removal is not substantially affected by the presence of others and a pattern similar to that of Fig. 6 is obtained. Further it is noticed that metal removal in this case is rather rapid and reaches an optimum level with a minimum contact time of 30 mins both with high and low amounts of carbon.

Removal of zinc. In Fig. 5, Zn in the presence of Cu, it is observed that the adsorption of Zn is not hindered by the presence of Cu and percentage removal in amounts of 0.075 - 0.2 gm carbon ranges from 28-44%. The contact time also has no significant effect in this particular case.

In Fig. 8, Zn in the presence of Cr^{+6}, it may be seen that an adsorption pattern similar to that of Fig. 5 with a very slight hindrance is obtained and removal of Zn ranges from 21 to 48%.

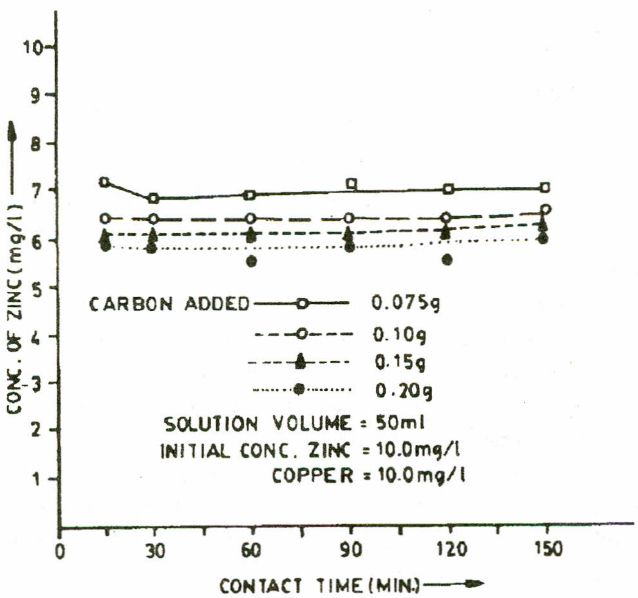

Fig. 5. Zinc conc. vs contact time in the presence of copper at pH=4.0

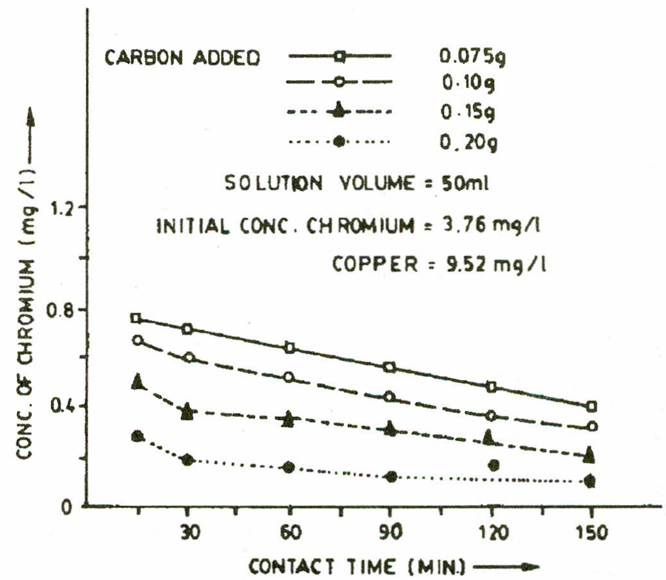

Fig. 7. Chromium conc. vs contact time in the presence of copper at pH=4.0

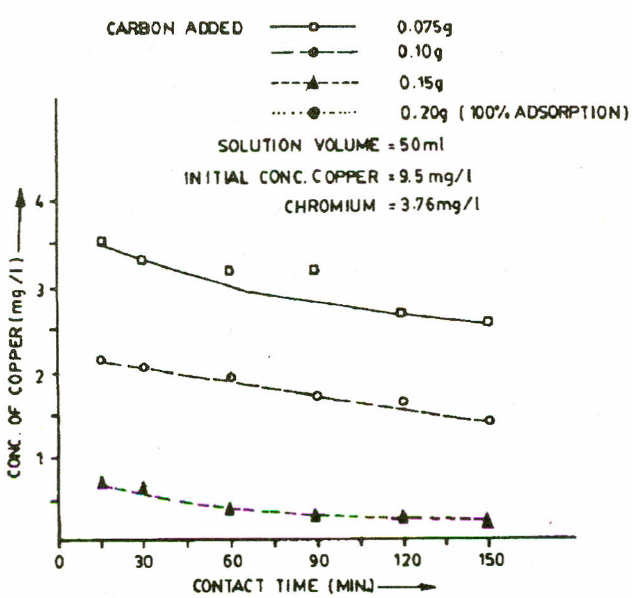

Fig. 6. Copper conc. vs contact time in the presence of chromium at pH=4.0

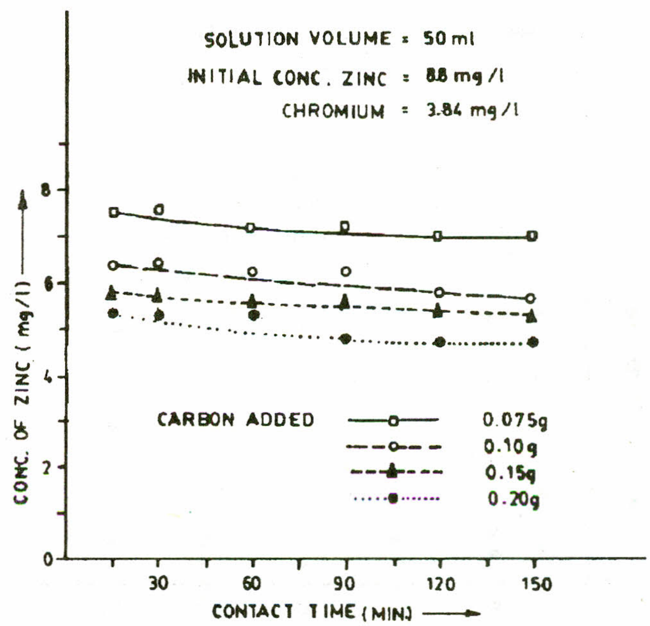

Fig. 8. Zinc conc. vs contact time in the presence of chromium at pH=4.0

In Fig. 11, Zn in the presence of Cu and Cr^{+6}, the time of contact has no pronounced effect on the removal of Zn. However, the influence of amount of carbon is significant and its percentage removal in maximum time is enhanced from 9 to 55%. Moreover, its adsorption is reduced by 50% in the presence of Cu and Cr^{+6} using the same amount of carbon.

Removal of hexavalent chromium. In Fig. 7, it is observed that the presence of Cu has no significant effect on the adsorption of Cr^{+6}. Furthermore the variables of carbon weight and contact time both have their own influence in this case. The percentage removal ranges from 79-89% and 92-97% with low and high amounts of carbon respectively.

A similar pattern follows with Cr^{+6} in the presence of Zn (Fig. 9) and Cu and Zn (Fig. 10), where adsorption is very slightly affected by the presence of one or two other metals and percentage removal ranges from 77-97%.

Figures 13, 14 and 15 show the pattern of removal of Cu, Zn and Cr^{+6} respectively either alone or in the presence of one or two metals in the same solution. These figures suggest that metals are generally adsorbed on the same sites. However, when two or three metals are present in the same solution, they compete for adsorption sites [9].

Conclusions

The optimum contact time required for maximum metal adsorption is not much affected by increasing the amount of carbon.

Approximately three times as much Cu is removed than Cr^{+6} and Zn using the same amount of activated carbon, if calculated on the basis of initial metal ion concentration.

When two or three metals are in the same solution, they compete for adsorption sites.

The adsorption of Cu and Cr^{+6} is not greatly affected in the presence of other metals. However, adsorption of Zn is hindered and reduced by 50% in the presence of Cu and Cr^{+6} using the same amount of carbon.

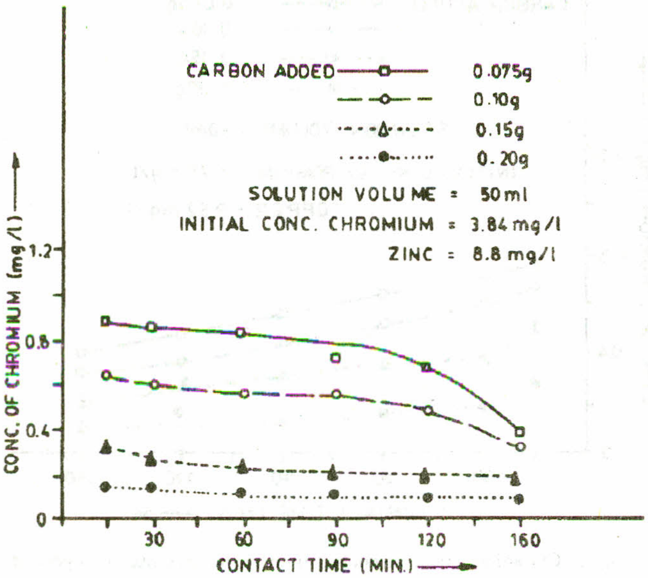

Fig. 9. Chromium conc. vs contact time in the presence of zinc at pH=4.0

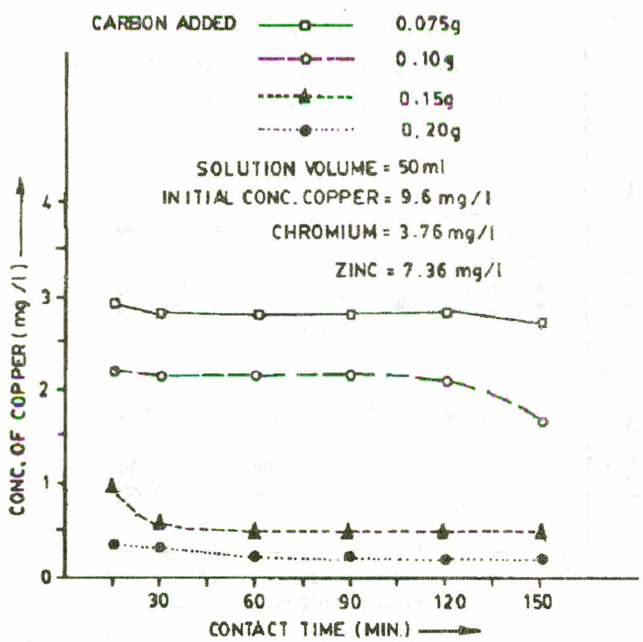

Fig. 10. Copper conc. vs contact time in the presence of chromium at pH=4.0

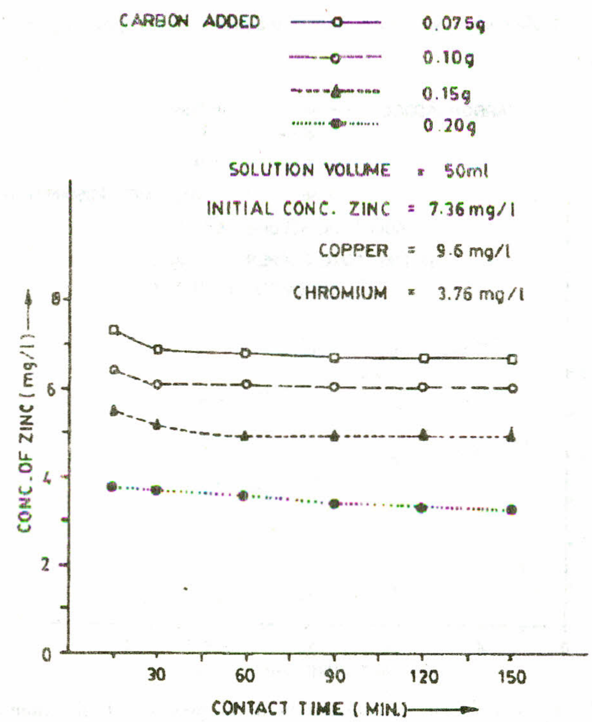

Fig. 11. Zinc conc. vs contact time in the presence of copper and chromium at pH=4.0

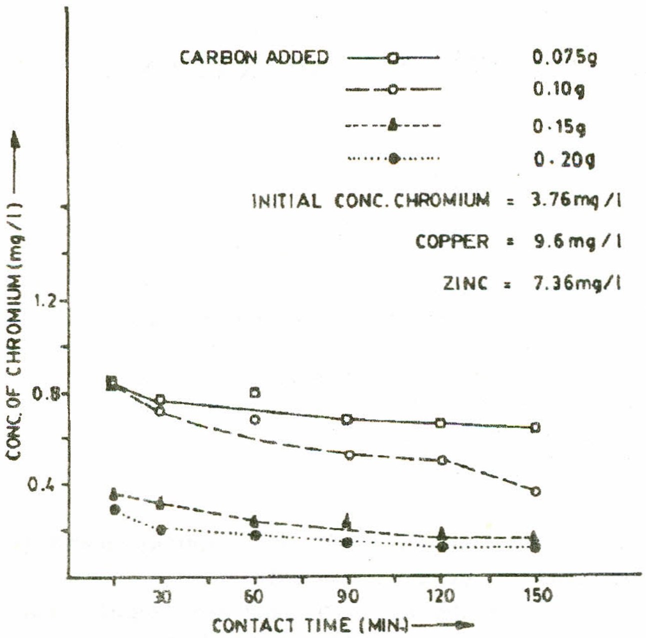

Fig. 12. Chromium conc. vs contact time in the presence of copper and zinc at pH=4.0

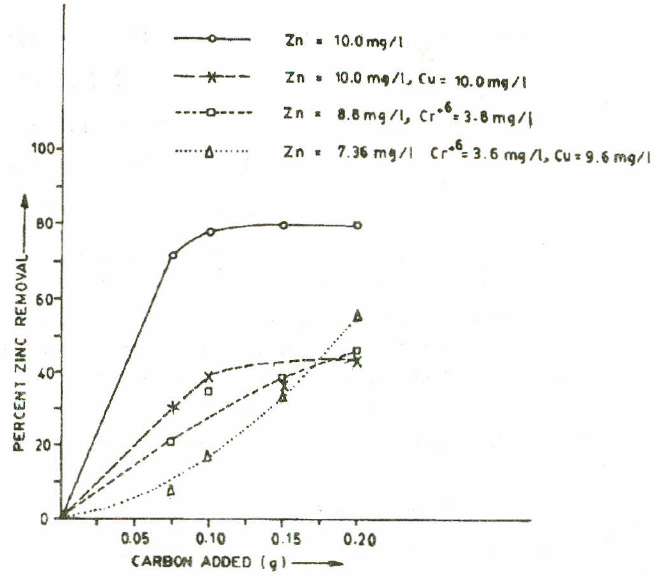

Fig. 14. Zinc removal vs carbon added with or without Cr^{+6} and/or Cu in soln. at pH=4.0 and contact time of 2 hr.

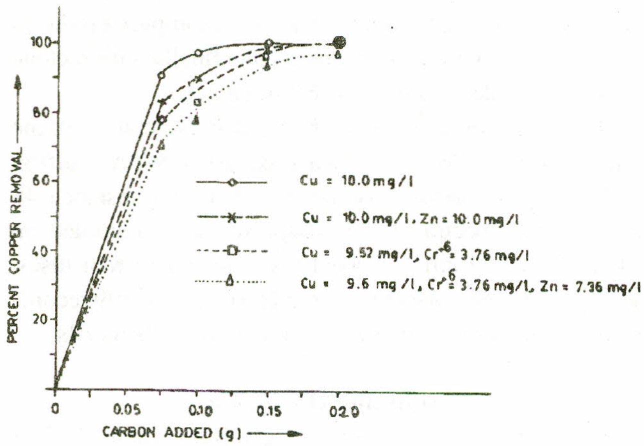

Fig. 13. Copper removal vs carbon added with or without Cr^{+6} and/or Zn in soln. at pH=4.0 and contact time of 2 hr.

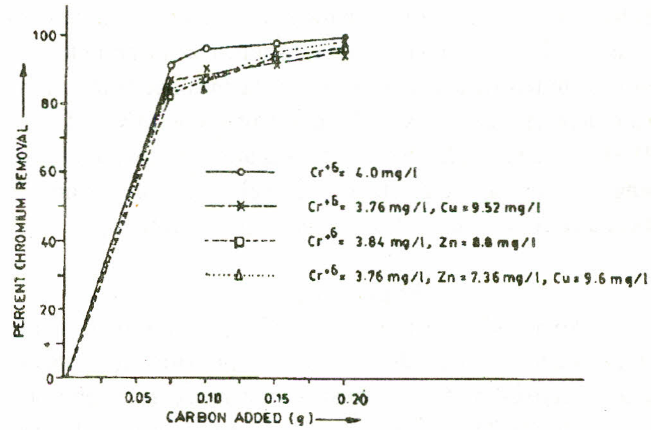

Fig. 15. Chromium removal vs carbon added with or without Cu and/or Zn in soln. at pH=4.0 and contact time of 2 hr.

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