Supplementary File

Supporting Information: 'Investigation of a Low Cost, Stable and Efficient Adsorbent for the Fast Uptake of Cd (II) from Aqueous Media'

1. Experimental design

The feasibility of the adsorbent was checked by adding suitable adsorbent in the stock solution of cadmium. The Cadmium stock solution was prepared by adding calculated amount of the cadmium nitrate hexahydrate in de-ionized water. This stock solution was further diluted in order to achieve desired initial concentration of the cadmium. Adsorption process was proceeded in the beakers putted on the stirrer plate and the different process parameters was studied such as Initial concentration of the pollutant, dosage of the adsorbent, effect of pH, effect of temperature, kinetic study and effect of shaking speed. First of all the pollutant concentration was checked after regular interval of time by analyzing the clear solution at λ_{max} (228.8nm) with atomic absorption spectrophotometer.

1.1. Kinetic study

The 0.1 g dosage of adsorbent and pure carbon was added in 25 ppm solution of cadmium having volume 100mL separately. The removal by adsorbent and the carbon was checked at 0, 1, 5, 10, 15, 20, 30, 40, 60, 90 and 120 minutes, in order to get the equilibrium point. It was found that after 40 minutes equilibrium had been established.

1.2. pH Study

To investigate the effect the pH on the removal of the pollutant from the solution experiment was performed at pH from 0-10 for the adsorbent and the carbon separately. The 0.1 g dosage of adsorbent and carbon was added in 25ppm solution of cadmium prepared in 100 mL. The maximum removal of the cadmium was investigated at pH 6.

1.3. Dose Study

To explain the effect of the dose on the percent removal of cadmium, dosage of adsorbent and carbon was carried from 0.05 – 0.15g in 25 ppm solution of cadmium having total volume of 100mL. It was observed that 0.1 g dosage is suitable for maximum removal of cadmium

1.4. Concentration study

The effect of the initial concentration of the analyte was explored by running experiment at different initial concentration 15, 20 25, 30, 35 and 40 ppm. The maximum percent removal was observed at initial metal ion concentration of 25 ppm.

1.5. Temperature Study

The effect of temperature was determined by keeping the dosage of adsorbent and carbon as 0.1 and concentration of the cadmium as 25ppm in 100mL of de-ionized water. Experiment was ran at 30, 35 and 40^{o}C and maximum removal was observed at 35 ^{o}C.

1.6. Shaking speed Study

The effect of different shaking speed on the removal percentage of cadmium was checked by changing the shaking speed from 100rpm to 170 rpm. It was observed that at 150 rpm maximum removal was observed after that removal become constant.

1.7. Characterization

The concentration of Cadmium was determined by the Atomic Absorption spectrophotometer. Crystal analysis was performed through the X- Ray Diffraction. The surface properties and topology of the adsorbent was studied by Scanning electron microscope. The energy X-ray dispersive spectroscopy of adsorbent was performed to check the percentage of carbon, nickel and manganese

2. Effect of initial concentration

The initial metal ion concentration gives very important driving force to overcome the mass transfer hindrance of cadmium ion present in the solution and solid state. The experiment was ran by changing the initial metal ion concentration from 15-40 ppm, while other parameters were kept constant such as adsorbent dosage as 0.1 g/ 100 mL, pH at 6, contact time 40 minutes, shaking speed at 150 rpm and the temperature was 35^{o}C.The experiment was ran for adsorbent and carbon. It has been observed that upon raising the initial metal ion concentration the percentage removal of the cadmium ion from the solution increases. In fact the increase in the removal percentage of cadmium ion is because of greater driving force for the mass transfer. The increase in the adsorption capacity was also observed upon increasing the concentration of metal ion. The increase in removal percentage was observe maximum for adsorbent as 80.8% at metal concentration of 25 ppm and maximum removal percentage for carbon was 70% at initial metal ion concentration of 25 ppm as well. After this concentration decrease in the removal percentage was observed. This trend can be explained as, for less or high metal ion concentration the available active sites are constant. At less concentration maximum sites are available hence easily occupied but when concentration increases to large extent much of the metal concentration remains in solution state and found no available site [1].

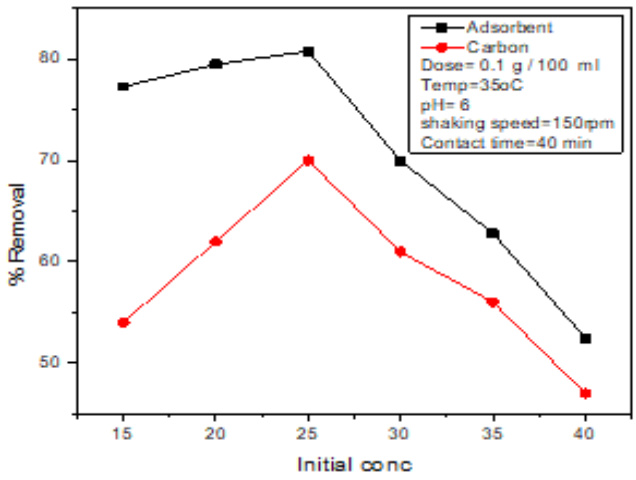

Figure 1. Represent the effect of initial metal ion concentration on percentage removal of cadmium and carbon

3. Effect of shaking speed

The effect of mixing speed on the adsorption of cadmium on the surface of Ni-Mn nano particles and on the surface of carbon was investigated by keeping the other parameters as constant. The pH of the solution was, dosage of adsorbent and carbon as g/100 mL, initial metal ion concentration as 25 ppm, contact time was 40 minutes and temperature at 35°C. Actually selection of an optimum shaking speed is necessary for efficient of dispersion of adsorbent in adsorbate in order to get the highest adsorption capacity, the shaking speed helps in creation of external boundary film. More over very high or very low mixing speed destroy the physical adsorption of adsorbent. The results are shown by graph which illustrate that shaking speed was varied form 100 – 170 rpm. The graph illustrate that upon increasing the shaking speed removal percentage increases, a liner increase in the removal percentage of cadmium was observed for adsorbent and the carbon till 150 rpm. After that there was no change is observed. It can be concluded from the graph that mixing speed greater than 150rpm did not participate in development of interaction between adsorbate and adsorbent. Rise in the mixing speed increases the rate of collision as a result the interaction among the functional groups present on the surface of adsorbent and cadmium ion present in the solution rises. Since collision rate increases maximum molecules interact each other ultimately leads to greater percent removal. As the mixing speed rises the mass transfer coefficient rise, leading to adsorption of cadmium ion on the surface of adsorbent and carbon to greater extent. This occurs because at low agitating rate the large amount of contact time needed to establish equilibrium [2].

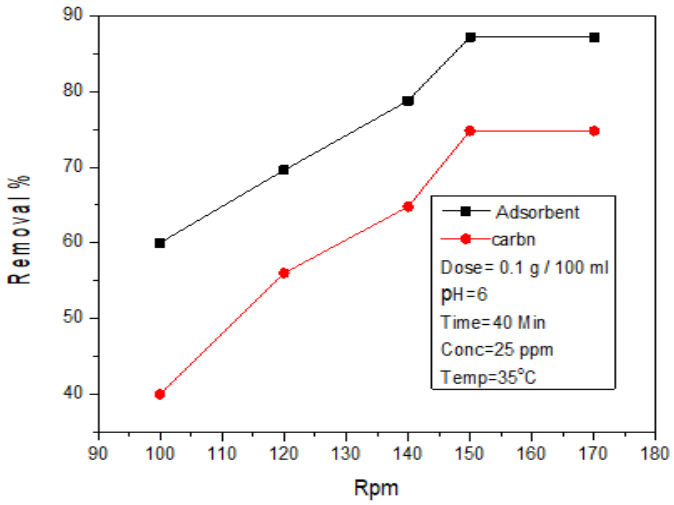

Figure 2. Represent the effect of shaking speed on percentage removal of cadmium and carbon.

References

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2. Ruthiraan, M., et al., *A promising route of magnetic based materials for removal of cadmium and methylene blue from waste water.* Journal of environmental chemical engineering, **2017**. 5(2), 1447-1455

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