Batch Adsorption Studies of Cadmium in Wastewater on Bentonites

NASEEM ZAHRA*, SHAHID TUFAIL SHEIKH AND KHALID JAVED
Materials Science Research Center, PCSIR Labs. Complex, Lahore-54600, Pakistan.

(Received (16th September 2006, accepted in revised 18th December 2006)

Summary: This study describes the batch adsorption process for the removal of cadmium from wastewater using natural bentonites taken from various areas of Pakistan. Bentonite contains montmorillonite, which has the quality to adsorb inorganic and organic materials. Relying upon atomic absorption spectroscopy, the quantities of toxic metals before and after the treatment of their standard solutions with different samples of bentonite were determined at room temperature and -200 mesh particle size. The percentage adsorption for cadmium on bentonite samples was determined.

Introduction

Cadmium is one of the most toxic elements and is used in chemical industries, in manufacturing of pesticides, herbicides and fungicides. The adsorption of cobalt, copper and cadmium from aqueous solutions has been studied on bentonite activated by sulphuric acid [1]. Sengutta [2] studied the adsorption of lead and cadmium by clay minerals to evaluate the behaviour of these toxic elements, by comparing and optimizing atomic absorption spectral methods. Zhang *et al.*, [3] reported the adsorption capacity and selectivity of bentonites for trace metals and investigated the feasibility of using bentonite as adsorbent for water purification. The result showed that bentonite is a good adsorbent for trace metal ions with adsorptive capacity of 35-40 mmol/100g. Al-Duri *et al.*, [4] introduced the adsorption process in water purification. Bereket *et al.*, [5] used adsorption process for the removal of lead, cadmium, copper and zinc from aqueous solutions. For all metals maximum adsorption was observed at 20°C. Egerer [6] determined the adsorption capacity of clay minerals and sands. Experimental data was related to the adsorption of zinc, nickel, cadmium, copper and manganese, significant in evaluation of soil pollution by heavy metals. Shujing *et al.*, [7] provided a review with 36 references on the research progress in the application of bentonite in wastewater treatment. Andrade *et al.*, [8] evaluated the use of special clays for heavy metal removal from wastewater. The heavy metal contents in solutions were analyzed before and after the water had circulated through the clay beds. The sepiolite and the magnesic bentonite were effective in reducing the heavy metal concentration of the industrial wastewater samples. Oral *et al.*, [9] studied the adsorption and desorption of toxic heavy metal cations *i.e.* cadmium (II) and zinc (II) on natural bentonite. The ability of untreated bentonite to remove cadmium and zinc from aqueous and acidic solutions at different pH values has been studied for different metal concentrations by varying the amount of adsorbent, temperature, stirring, speed and contact time. The highest adsorption for zinc and cadmium was 99.85 and 96.84% respectively. The present work describes the removal of cadmium in wastewater by adsorption process using bentonites taken from various areas of Pakistan *i.e.* Khushab, Quetta, Attock, Azad Kashmir, Peshawar and Jehlum. The main object was to develop the cheap technique for water purification.

Results and Discussion

In the present investigation, the adsorption behavior of various samples of bentonites was studied for cadmium in wastewater. The absorbances of cadmium standards from 0.5-2 ppm were noted by using atomic absorption spectrometer (as shown in Table-1)

Table-1: Absorbance of cadmium standards.

No. of obs.	Concentration (ppm)	Absorbance
1	0.0	0.00
2	0.5	0.119
3	1.0	0.180
4	1.5	0.270
5	2.0	0.347

The calibration curve was plotted between the concentration and absorbances of cadmium standards.

The adsorption of cadmium in 2 ppm solution was studied on these samples when time

*To whom all correspondence should be addressed.

taken for adsorption was one hour. The concentration of cadmium after treatment was noted by inserting these values of absorbance (Table-2) of each solution in calibration curve after treatment with different bentonite samples using atomic absorption spectrometer Model "Perkin Elmer A Analyst 100". Then calculating the percentage adsorption.

Table-2: Absorbance of filtrates after adsorption of 2 ppm cadmium solution.

No. of obs.	Solutions from bentonite samples	Absorbance
1	Blank[dist. Water	0.000
2	Khushab sample	0.169
3	Jehlum sample	0.071
4	Attock sample	0.080
5	Quetta sample	0.041
6	Azad Kashmir sample	0.092
7	Peshawar sample	0.090

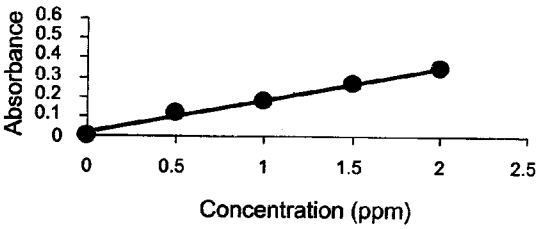

Fig. 1: Calibration curve for cadmium.

The %age adsorption of cadmium on Khushab bentonite was 54 %, on Jehlum 82.50 %, on Attock 79 %, on Quetta 90 %, on Azad Kashmir 74 % and on Peshawar 76 % (as shown in Fig. 2)

The best results were obtained using 50 mL. of cadmium solution with 25 gram of bentonite. With this amount maximum cadmium was removed and this was verified by "Atomic absorption spectroscopy". The experimental work was performed in beakers (batch adsorption process) because small amount of bentonite can be used. Equilibrium can easily be maintained in beakers as compared to continuous process where the flow rate has to be low for complete equilibrium. The time required is minimum with greater recovery of detoxified water. Temperature effects cannot be determined by using continuous adsorption column while this can be done in batch process.

Experimental

Samples

Bentonite samples were collected from Khushab, Attock, Jehlum, Azad Kashmir, Quetta and Peshawar. All bentonite samples were oven dried at

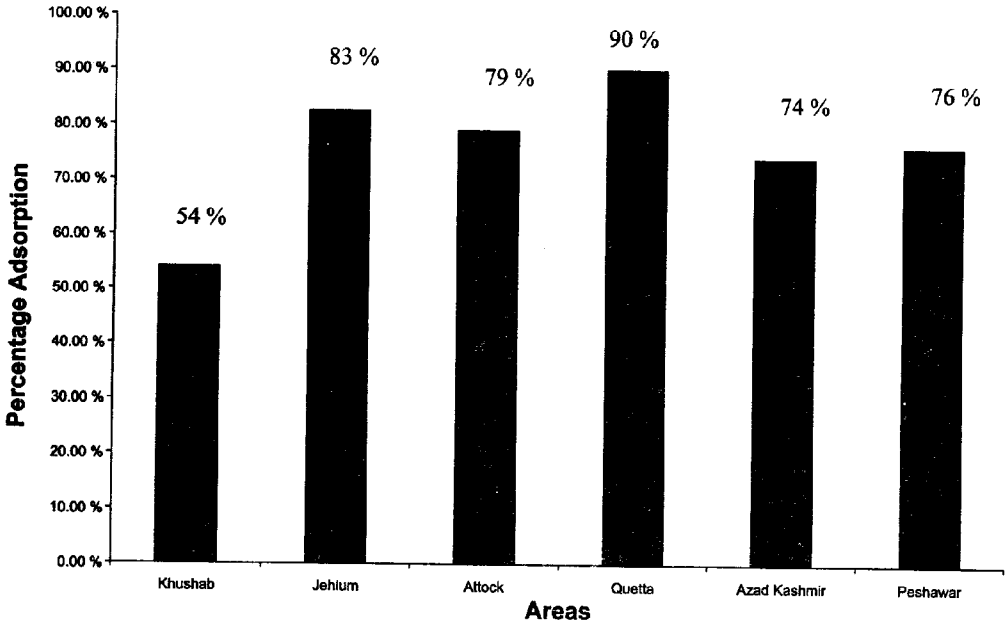

Fig. 2: Order of cadmium adsorption on bentonite samples.

100 °C for 2 hours. These samples were crushed to fine powder. Then fine powder was passed through a -200 mesh sieve.

Contamination Control

All glass wares were washed carefully and rinsed by distilled water and kept in dust free atmosphere without touching their inside.

Reagents

All the reagents used were of analytical grade (Merck). Cadmium nitrate was used to make standards for cadmium determination.

Procedure

2.10 gram of cadmium nitrate was dissolved in de-ionized water and volume was made upto 1000 mL. From stock solution, 0.5 to 2.0 ppm standard solutions were prepared to get a calibration curve. Experiments were carried out at room temperature. 25 gram of each bentonite sample was taken in separate beakers. 50 mL of solution containing metal ions (2ppm) was added to it for adsorption and stirred after 10 minutes interval. Then it was left for an hour in order to complete the equilibrium. After this, solutions were filtered carefully.

Instrumentation

Atomic absorption spectrometer "Perkin Elmer A Analyst" equipped with standard burner and air-acetylene flame was used to determine the concentration of cadmium in each filtrate. The hollow-cathode lamp of cadmium metal was operated at lamp current 3.5 mA and 228.8 nm wavelength. The optimum working range was 0.5-2.0 μg/mL.

Conclusions

From this study it was concluded that bentonite is a good and cheap adsorbent and the batch adsorption process is the best process for removal of cadmium metal in wastewater because it is simple, time saving and low-cost.

Acknowledgements

The authors acknowledge the Prof. Dr. Jamil Anwar Head of Chemistry Department .University of the Punjab Lahore for providing the facilities for carrying out this study.

References

1. Kaya, Mehmet, Akyol, Figen, *Kim Muhendisligi*, Edited by Aydin, Adnan and Marmara, **3**,18 (1992)
2. Sengutta, *Umve. Sch. Forsch*, **5**, 72 (1993).
3. Zhang, Manping, Chen, Decchang, D Qing and Y Bingyun , *Haiyang Huaxue Lun Nenxuan*, Edited by Zhang, Manping, 37-40 (1994)
4. Al- Duri and Bushra, "Waste water", Edited by Mckary Gordan, 1-5 (1996).
5. Bereket, Gozen, Aroguz, A Zehra, Ozel and M Zafar, *J Collid Sci, Interface*, **187**, 338 (1997).
6. Egerer, Frigyes, Namesanszki and Karoly, *J Epitoanyag*, **51**, 66 (1999).
7. Li, Shujing and S .Zhongging, *Huaxue Shijie*, **43**, 211 (2002).
8. L. Andrade, E. F. Covel and F. A. Vega, *Information Technologia*, **16**, 3 (2005).
9. Lacin, Bahar, bayrak, O Korkut, E Sawan, *J. Colloid and Interface Science*, **2**, 330 (2005).