Adsorption Characteristics of Cadmium [Cd (II)] ION by Iron Powder & Oxidized Iron Powder

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Abstract— The aim of current study was to develop the adsorption characteristics and removal efficiency of adsorbent Iron Powder & Oxidized Iron Powder. The effect of various physico-chemical characteristics such as pH, retention time, dose of adsorbent, temperature and concentration of adsorbent on the Adsorption of Cadmium ion in wastewater were investigated, batch experiment was design for adsorption process and it validate Langmuir isotherms. Optimum adsorption of Cadmium ion for wastewater is achieved 91 & 94% with help of Iron Powder and Iron Oxide Powder respectively.

Key words: Oxidized Iron, Iron Powder, Cadmium, AAS, & Adsorption

I. INTRODUCTION

By now, it is very much clear that cadmium is a dangerous toxic metal and environmental pollutant. An extensive report on the health effects of exposure to Cadmium the primary adverse health effects which have been observed are lung cancer and kidney damage. In extreme exposure cases pulmonary edema may develop and cause death. Severe cadmium-induced renal damage may develop into chronic renal failure. With the rapid development of industries such as fertilizer, tanneries, metal plating, battery, paper and pesticide, heavy metal wastewater is discharge directly to the environment increasing the pollution at every level on environment in developing country specially. Srivastava (2008) Removal of cadmium from wastewater is essential to prevent unacceptable damage to the human health and ecology. All pairs of atom and molecules experience the Universal London dispersion forces and this force varies inversely as the third power of the distance. Ion-dipole or dipole-dipole interactions may be the other component of the van deer Wall's forces. Lambe (1953) and Rosenqvist (1955).Living organisms require varying amount of heavy metals like iron, cobalt, cadmium, copper, zinc, etc., but excessive amount can be harmful to the organism. Other heavy metals such as mercury and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the body of organism can cause serious illness (Wang et al., 2007). Certain elements that are normally toxic are, for certain organisms or under certain conditions beneficial. Unlike organic pollutants, heavy metals do not decay (Chen et al., 1998). Heavy metal contamination of wastewater streams, a matter of concern in the overall field of environmental remediation, enters the environment through a variety of avenues like mining, nuclear power plants, industrial processing plants, etc. Even some natural waters contain high level of metals (Wang et al., 2007). Heavy metals can defined more strictly as the metals heavier than the rare earth metals, which are at the bottom of the periodic table (Thakur et al., 2008)., removal of cadmium by the process of adsorption using different low cost adsorbents other than Iron & Iron Oxide, and removal of different heavy metals including cadmium by the process of adsorption using Iron & Iron Oxide as the adsorbent. Adsorption is the most popular method for wastewater treatment due to its easy and inexpensive operation (Rao et al., 2001). There is a selective use of lime, directed towards soils with a low pH. Where lime is used, it may add higher amounts of cadmium to agricultural soils (Huang et al., 2003). Treatment of wastewater from another industry could be helpful not only to environment in solving the solid waste disposal problem, but also the economy.

The amount of adsorbed metal was calculated using equation 1 and the removal efficiency was determined by computing the percentage adsorption using equation 2.

$$\text{The amount of adsorbed metal } (q_0) = [(C_0 - C_e) \times V]/m \quad (1)$$

$$\text{Percentage removal } q_e = [(C_0 - Ce) \times 100]/C_0 \quad (2)$$

Where, q_0 is the adsorption capacity at equilibrium (mg of ions/g of egg shell). V is the volume of the aqueous solution (mL), C0 is the concentration before adsorption (mg/L), Ce is the equilibrium concentration after adsorption (mg/L) and m is the mass in gram of the adsorbent.

II. ADSORPTION ISOTHERMS

Several mathematical relationships have been developed to describe equilibrium distributions between solid and liquid phase, this experiment adopt Langmuir isotherms, the data obtained from experiments were tested for applicability of these isotherms. Langmuir isotherm assumes that the adsorption takes place at specific homogeneous sites within the adsorbent. It assumes monolayer adsorption on the adsorbent surface. It is presented by following equation (Langmuir, 1918):

$$[x/m] = [abc / (1+ac)] \quad (3)$$

Where, x = amount of material adsorbed (mg)
m = weight of adsorbent (mg)
c = concentration of material remaining is solutions after adsorption is completed (mg/l)
a and b = constant

$$[1/(x/m)] = [(1+ac)/abc] \quad (4)$$

$$[1/(x/m)] = 1/b + 1/abc \quad (5)$$

Where, 1/b = Intercept
1/ab = Slope

The equilibrium data obtained from the experiment were plotted for 1/qe vs. 1/Ce will give the values of intercept (1/b), slope (1/ab) and constant a & b.

III. MATERIALS & METHODS

Procedure of Iron Powder Preparation analysis of Iron powder as it is in its form Experiment will be conducted for the removal of Cadmium from aqueous solution by Oxidized Iron powder also. The samples were collected in air tight polythene bags to prevent the chemical changes. To conduct the experiments less than 2 mm particle size had been considered. Before conduct the experiments, sieve analysis of Iron Powder was carried out to prepare particle size distribution curve. The Iron Oxide samples were prepared by natural oxidation process. The powdered sample were moisturized and then allowed to oxidize naturally in the presence of air for approximate one month. There after the samples were crushed using rubber hammer and sieve analyses were carried out. Sieve analysis of the oxide particles has been carried out and the particle size has been restricted up to 2 mm for the experiment.

A. Preparation of Synthetic Cd^{2+} Solution

The stock Cadmium solution was prepared as per Standard Method (17th Edition)-1989. 2.7718g of $Cd(NO_3)_2.4H_2O$ salt was dissolved in 100 ml of distilled water and the volume was made up to 1000 ml to make 1000 ppm standard solution.

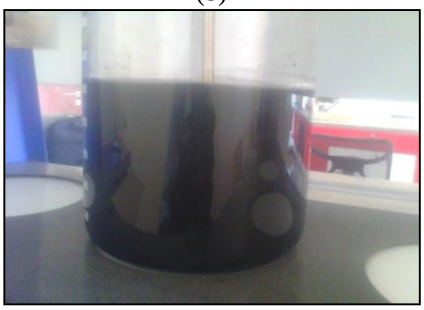
B. Instruments Used in the Tests

The following instruments were used for carrying out adsorption characterization of Cadmium with the help of adsorbent made by Iron & Iron Oxide samples.

- Atomic Absorption Spectrophotometer (AAS)
- Mechanical shaker
- pH meter
- Centrifuge
- Set of standard Sieves

(a)

(b)



(c)

Fig. 1: Adsorption Process & Centrifuge

C. Kinetic Study

In the batch adsorption study, tests were conducted to determine the maximum adsorption capacity of Iron & Iron Oxide Powder. The rate of adsorption is important for designing batch adsorption experiments; therefore, the effect of contact time on the adsorption of cadmium ions using Iron Oxide was investigated. The adsorption of Cd(II) ions increased considerably until the contact time reached 120 min. at room temperature. Further increase in contact time did not enhance the adsorption process; so, the optimum time was selected 120 min. for further experiments. Kinetic experiments were carried out to assess the time needed for the adsorption process to attain equilibrium, the results of which have been shown in Figs. It may be seen that the equilibrium is attained within 120 min. In all subsequent adsorption experiments, otherwise mentioned, 120 min. contact time was maintained.

IV. RESULTS & DISCUSSION

A. Effect of Retention Time

The effect of retention times (from 0 min-280 min) on the cadmium ion removal, contact time was maintained for almost five houre to ensure that equilibriam was actualy achieved in study. The removal effcieny of the Cd(II) is increase sharpaly with respect to time and it constant or slite change after 120 min. there for the optimum removal efficicy of acdmium ion 72-76% with iron powder and iron oxide powder repectively at 120 min.

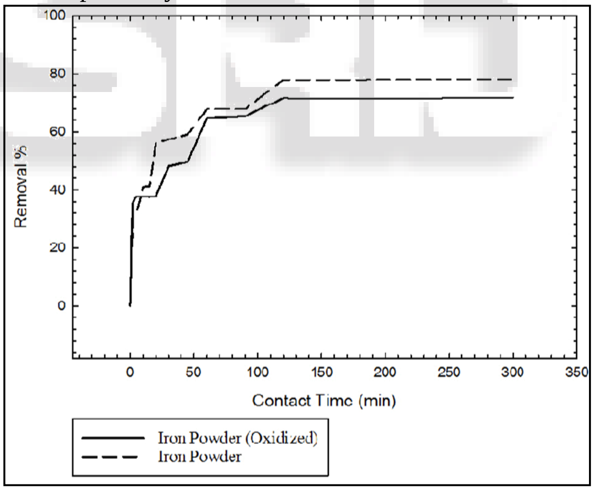


Figure (2) Comparitive Graph b/w Contact Time & Removal Efficiency of Iron & Iron oxide Powder

B. Effect of Adorbent Dosage

Adsorbent play a critical role to affect the adsorption process, to achive the optimum adsorption efficiency, different amount of adsorbent dosesd on different batch experiments which were varrying from 1-10 gm per 100 ml of wastewater, the optimum dose of iron powder and iron powder oxidized is 75 & 83% respectively.

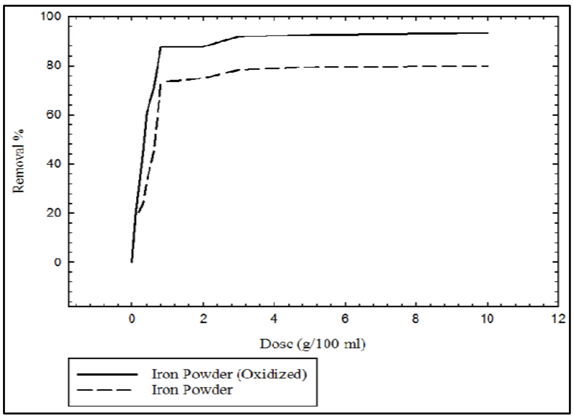


Fig. 3: Comparitive Graph b/w Dose of Adsorbent & Removal Efficiency of Iron & Iron oxide Powder

C. Effect of pH for Cd(II) Removal

pH is mone of the most important and influancing adsorption factor,which refect the metal ion solubility in aqueous solutions. The intial pH concentration of solution affect the adsorption capacity of an adsorbent. The highest adsorption capcity of iron powder and iron oxide power is showes the maximum adsorption efficieny is 90-93 % at 6 pH.

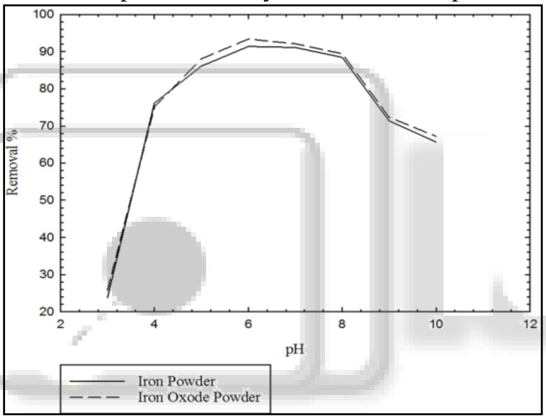


Fig. 4: Comparitive Graph b/w pH & Removal Efficiency of Iron & Iron oxide Powder

D. Effect of Intial Concentration

As the concentration is increase of the metal ion the removal efficieny is increaseing at sudden concentartion and then decrease repiddely. This behavior can be explained due to limitation of active site on the adsorbent surface.

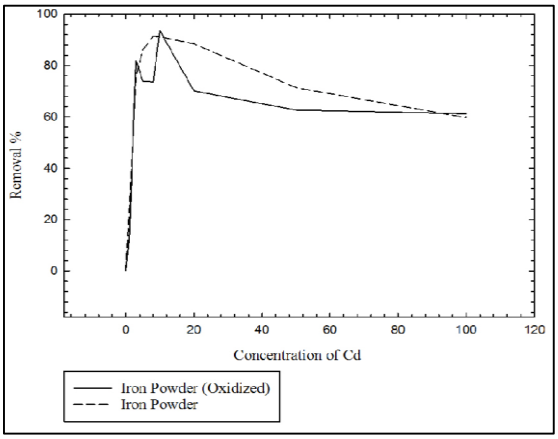
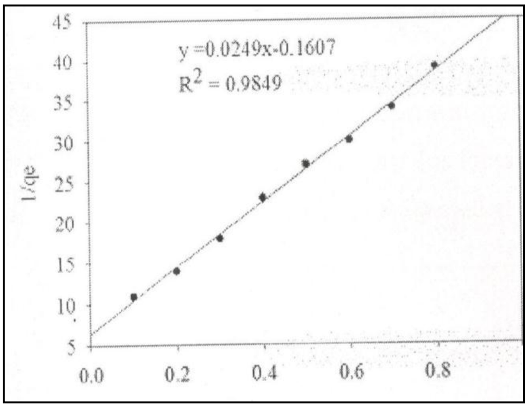
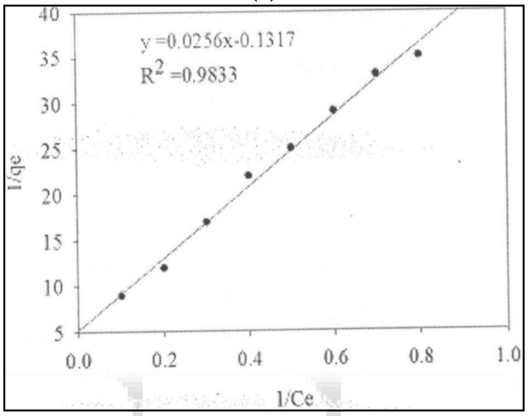


Fig. 5: Comparitive Graph b/w Concentration of Adsorbate & Removal Efficiency of Iron & Iron oxide Powder

E. Isotherms



(a)



(b)

Fig. 6: Isotherms for Adsorbent Iron Oxide & Iron

Langumier isotherm is valid for the optimum adsorption characteristics for the iron powder and iron oxide powder and degree of significance is also aceptable for the adsorption of Cd[II] ions.

V. CONCLUSION

From the current study the conclusion of that work is removal of cadmium ion form wastewater by the iron oxide powder is more efficient then iron powder and both are relevent ecofriendly and economical, the optimum removal charactersitics have been found for both the adsorbent which validate the Langmuir Isotherms, the adsorption of both adsobent reach equilibrium at 120 min at 6 pH and optimum dose is 1gram per 100 ml wastewater. It could be used as a alternative adsorbent for the removal of Cadmium ion.

REFERANCES

[1] Srivastava NK, Majumdar CB (2008) Novel biofiltration methods for the treatment pf heavy metals from industrial wastewater. J Hazard Mater 151: 1-8.
[2] Lambe (1953) and Rosenqvist (1955). Shear Strength of Saturated Remoulded Clay
[3] Chen et al., 1998 Exposures and health outcomes from outdoor air pollutants in China
[4] Wang et al., 2007 Remediation of Heavy Metal-Polluted Agricultural Soils Using Clay Minerals https://doi.org/10.1016/S1002-0160(17)60310-2

[5] Thakur et al., 2008 Adsorption of colored pollutants from distillery spent wash by native and treated fungus DOI: 10.1007/s11356-012-0957-2
[6] Rao et al., 2001 Rao, M., Parwate, A. V. , Bhole, A. G.,. Removal of Cr6+ and Ni2+ from aqueous solution using bagasse and fly ash. Waste Management. 22: 821-830.
[7] Huang et al., 2003 Adsorption of lead(II) from aqueous solution onto Hydrilla verticillata DOI: 10.1007/s10532-009-9252-4 ·
[8] Singh, Pramod (2017) Removal of Cadmium [Cd (II)] ion by Activated Carbon Prepared from Eichhornia crassipes Mart (ACECM) DOI: 10.18090/samriddhi.v9i02.10871