INTRODUCTION
One of the heavy metals that have been a major focus in water and wastewater treatment is chromium and the hexavalent form of it has been considered to be more hazardous due to its carcinogenic properties. Chromium has been considered as one of the top 16th toxic pollutants and because of its carcinogenic and teratogenic characteristics on the public, it has become a serious health concern (Torresdey et al., 2000). Chromium can be released to the environment through a large number of industrial operations, including metal finishing industry, iron and steel industries and inorganic chemicals production (Gao et al., 2007). Extensive use of chromium results in large quantities of chromium containing effluents which need an exigent treatment. The permissible limit of chromium for drinking water is 0.1 mg/L (as total chromium) in EPA standard (EPA, 2007). In addition, National Iranian standard for Cr (VI) concentration in drinking water is 0.05 mg/L (ISIRI number 1053, 1991). There are various methods to remove Cr (VI) including chemical precipitation, membrane process, ion exchange, liquid extraction and electro dialysis (Verma et al., 2006). These methods are non-economical and have many disadvantages such as incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that require disposal or treatment. In contrast, the adsorption technique is one of the preferred methods for removal of heavy metals because of its efficiency and low cost (Li et al., 2007). For this purpose in recent years, investigations have been carried out for the effective removal of various heavy metals from solution using natural adsorbents which are economically viable such as agricultural wastes including sunflower stalks. Eucalyptus bark (Sarin and Pant, 2006), maize bran (Singh et al., 2006), coconut shell, waste tea, rice straw, tree leaves, peanut and walnut husks. The obtained results showed that the adsorption of chromium (VI) by Aloevera has considerable numbers of heterogeneous layer of pores sphere is a good possibility for metal ion to be adsorbed.

ABSTRACT
In this research, adsorption of chromium (VI) ions on Aloevera has been studied through using batch adsorption techniques. The main objectives of this study are to 1) investigate the chromium adsorption from aqueous solution by Aloevera, 2) study the influence of contact time, pH, adsorbent dose and initial chromium concentration on adsorption process performance and 3) determine appropriate adsorption isotherm and kinetics parameters of chromium (VI) adsorption on Aloevera. The results of this study showed that adsorption of chromium by Aloevera reached to equilibrium after 180 mts and the change of chromium removal efficiency was observed. Higher chromium adsorption was observed at lower pHs, and maximum chromium removal (60 %) obtained at pH of 2. It is clear that Aloevera has considerable numbers of heterogeneous layer of pores sphere is a good possibility for metal ion to be adsorbed.

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MATERIAL AND METHODS
Preparation of adsorbent
The Aloevera was ground and particle sizes between 75 and 300 microns were obtained by passing the milled material through standard steel sieves. Then, they used for experiments without washing or any other physical or chemical treatments.

Batch sorption experiments
The sorption studies were carried out at 30 ±1°C. Solution pH was adjusted with H2SO4 or NaOH. A known amount of adsorbent was added to samples and was agitated by jar test at 250 rpm agitation speed, allowing sufficient time for adsorption equilibrium. Then, the mixtures were filtered through filter paper, and the Cr(VI) ions concentration were determined in the filtrate using DR/4000U spectrophotometer by colorimetric techniques according to the standard method No. 3500-Cr B (standard methods, 1992). The effects of various parameters on the rate of adsorption process were observed by varying contact time, t (30, 60, 120, 180 and 180 min), initial concentration of chromium ion, Co (20, 40, 60 and 80 mg/L), adsorbent concentration, W (0.5, and 1.5 g/100 ml) and initial pH of solution (2, 3, 5, 7, 9 and 11). The solution volume (V) was kept constant (50 ml). The chromium removal (%) at any instant of time was determined by the following equation

\[ \text{Chromium removal (‰) } = \frac{C_0 - C_t}{C_0} \times 100 \]

Where, Co and Ct are the concentration of chromium at initial condition and at any instant of time, respectively.

RESULTS AND DISCUSSION
Effect of contact time on chromium adsorption
Contact time is one of the effective factors in batch adsorption process. In this stage, all of the parameters except contact time, including temperature (30 °C), adsorbent dose (0.5g/100 ml), pH (2), initial chromium concentration (20 mg/l) and agitation speed (250 rpm), were kept constant. The effect of contact time on chromium adsorption efficiency showed in Fig. 1. As it is shown, adsorption rate initially increased rapidly, and the optimal removal efficiency was reached within about 180 mts to 60 %. There was no significant change in equilibrium concentration after 180 mts and the adsorption phase reached to equilibrium.

Effect of pH on chromium adsorption
The pH of the aqueous solution is clearly an important parameter that controlled the adsorption process. The experiments of this stage were done under the conditions of constant temperature (30°C), agitation speed (250 rpm), contact time (180 mts), adsorbent dose (0.5 g/100 mL), initial chromium concentration (20 mg/L), pH of solution was changed and the chromium removal was investigated. The experimental results of this stage are presented in Fig. 2. As it is shown, the optimum pH of solution was observed at pH of 2 and by increasing pH, a drastic decrease in adsorption percentage was observed. This might be due to the weakening of electrostatic force of attraction between the oppositely charged adsorbate and adsorbent that ultimately lead to the reduction in sorption capacity (Baral et al., 2006). Adsorption of hexavalent chromium varies as a function of pH with H2Cr2O7, HCrO4-, CrO7 2- and Cr2O7 2- ions appear as dominant species (Gaballah and Kilbertus, 1998). At pH of 2, HCrO4 - is the dominant species. The surface charge of Aloevera is positive at low pH, and this may promote the binding of the negatively charged HCrO4 - ions.

Effect of adsorbent dose on chromium adsorption
At this stage, the experiments were done under the conditions described with constant pH of 2 and variable adsorbent dose (.5,1 and 1.5g/100 mL). The effect of adsorbent dose on the adsorption of chromium by Aloevera was presented Fig.3. chromium removal efficiency increased with increase in adsorbent dose, since contact surface of adsorbent particles increased and it would be more probable for HCrO4 and Cr2O7 2- ions to be adsorbed on adsorption sites and thus adsorption efficiency increased (Morshedzadeh et al., 2007).

Effect of initial chromium concentration on adsorption process
Initial concentration is one of the effective factors on adsorption efficiency. The experiments were done with variable initial chromium concentration (20,40,60 and 80 mg/L) and constant temperature (30 °C), pH (2), agitation speed (250 rpm), contact time (180 mts) and 0.5 g of adsorbent dose (0.5 g/100 mL). The experimental results of the effect of initial chromium concentration on removal efficiency were presented in Fig. 4. As in Fig. 4 is shown, chromium removal efficiency decreased with the increase in initial chromium concentration. In case of low chromium concentrations, the ratio of the initial
number of moles of chromium ions to the available surface area of Chromium adsorption by Aloevera.

![Graph showing the effect of contact time on adsorption process efficiency.](image)

**Fig. 1:** Effect of contact time on adsorption process efficiency

![Graph showing the effect of pH on Cr (VI) removal.](image)

**Fig. 2:** Effect of pH on Cr (VI) removal
**Fig. 3:** Effect of adsorbent dose on Cr(VI) removal

- pH = 2
- Initial Cr conc = 20 mg/L
- Temp = 30°C
- Contact time = 180 min

**Fig. 4:** Effect of chromium concentration on Cr (VI) removal

- pH = 3
- Adsorbent dose = 500 mg
- Temp = 30°C
- Contact time = 180 min

**SEM micrographs of Aloevera particle**

**Fig. 5(a):** Before metal sorption
Fig 5(b): after Cr (VI) ion adsorbed

Fig 5(a &b) show that SEM micrographs of Aloevera sample before and after Cr(VI) ion adsorption. It is clear that Aloevera has considerable numbers of heterogeneous layer of pores sphere and it is a good possibility for metal ion to be adsorbed. The surface of the adsorbent, however, clearly shows that covered with metal ion molecules.

CONCLUSIONS

The morphology size distribution of Aloevera presents unimodal distributions at lower temperature. The increasing temperature leads to the decrease of BET surface area, average pore diameter and volume in the mesopore scale. The results revealed the potential of Aloevera, an agricultural waste material, to be a low cost adsorbent for removing metal ion from aqueous solution.

REFERENCES

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