Removal of Nickel Ions Using Adsorption onto Activated Carbon Prepared From Cactuses Plant

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Submission date:- 22/7/2019	Acceptance date:- 30/10/2019	Publication date:-24/11/2019

Abstract

The technique of adsorption is one of the most important processes which are widely used in the treatment of water and wastewater. The technique of adsorption which is a very effective and efficient method in the treatment of pollutants. One of the disadvantages of the process of adsorption using activated carbon is expensive, and this has made researchers think of finding cheap alternatives to reduce the cost this process. In the present study, activated carbon was prepared from the cactus plant for the purpose of its use to remove Ni^{+2} ions. Batch tests were conducted to evaluate the ability of Cactuses plant in the removing of Ni^{+2} ions from wastewater. The results showed that activated carbon developed from Cactuses has good ability to remove Ni^{+2} ions. It was found that the maximum removal efficiency reached to a value of 99.68 % under pH equals to 6.

Key word: Nickel, Adsorption, Cactuses Plant, Activated carbon.

1- Introduction

Some of heavy metals such as lead, cadmium, nickel, cobalt, chromium, arsenic, iron and zinc were considered toxic. Heavy metals are major cause for toxicity in living organisms. The most of heavy metals releasing to the environmental are from tannery, electroplating, textile, fertilizer, pesticide and metal processing industries as well as mining sectors. These toxic metals are major pollutants of freshwater reserves. Most of the metals are non-biodegradable, highly toxic and carcinogenic in nature. Toxic heavy metals reach through various food chains and cause toxic effects on the ecosystem as well as humans and animals. Therefore, it is necessary to treat metal-contaminated wastewater before its discharge into the environment, as cited by [1]. Numerous have been conducted to evaluate the removal efficiency of adsorption process in the treatment of water and wastewater.[2] refereed that activated carbon is a perfect adsorbent for color removal, it's widespread use is restricted due to its relatively high cost which led to the researchers on alternative non – conventional and low cost adsorbents.[3] investigated the ability of cactus powder for removal of Cd+2 and Pb+2 from water sample. The results revealed that adsorption for Pb and Cd increased as the dose of adsorbent increased at a certain limits.[4] showed that cactus (biomaterials) could be used as coagulant/flocculant, as biosorbent and as packed material for biofilter. The removal of pollutant from wastewater using different cactus preparations explained very high and promising pollutant removal efficiency. [5] Studied the of Ni (II) ions through adsorption on activated carbon. In addition, Freundlich and Langmuir isotherms are studied to investigate whether the experimental data fits either of the isotherms or not. [6] investigated the effect of two activated carbons were prepared from Lapsi seed stone which act as potential low cost adsorbents by treating with concentration H2SO4 and a mixture of H2SO4 and HNO3 in the ratio of 1:1 by weight for removal of Ni(II) ions. The optimum removal efficiency for Nickel was obtained at pH=5. [7] Used batch experiments to test the ability of activated carbon, silica and silica activated carbon composite for the removal of lead, cadmium, nickel and zinc from water. The results indicated that silica/ activated carbon (2:3) composite was more efficient in the removal of nickel ions than activated carbon and silica nanoparticles. [8] Evaluated the performance of the rice husk for the removal of Cd, Pb and Cr metals from aqueous solutions. The results showed the following removal efficiencies (97.96% for Cd, 90% for Pb, and 84% for Cr).

The present study aims to determine the removal efficiency of nickel using cactuses as a plant based materials to produce the activated carbon.

2. Experimental work

2.1 Materials

In the present study batch tests were performed to evaluate the possibility of activated carbon derived from cactuses plant to remove the nickel ions from the contaminated solution. The carbonation process of raw materials that be taken from cactuses plant is started by grinding raw materials in a stainless container to obtain powder form of activated carbon. Different mixtures of cactuses materials with sodium hydroxide was used in different ratios (2:1, 1.5:1, 1:1, 0.5:1) as a weight ratios according to practical method by [9].

To prepare a solution with Ni concentration equal to 50 ppm was dissolved of Ni(NO3)2.6H2O in the distilled water.

2.2 Batch experiments

Adsorption of Ni (II) using of activated carbon derived from cactuses plant was carried out using batch experiments. The mixture from the activated carbon derived from cactuses plant and 100 ml solution contaminated with Ni (II) was agitated using orbital shaker at (rpm) for 60 min. with initial pH 7 at ±25 °C temperature of lab. The Ni (II) remained was measured by atomic absorption spectrophotometer (AAS).

Kinetic studies were conducted with various of pH (3, 4, 5, 6, and 7), different values of initial concentration of Ni+2 (50, 100, 150, and 250 mg/l), different amounts of activated carbon derived from cactuses plant (1, 2, 3, 4, 5, 6 and 7 g), according to practical methods adopted by [10]. the amount of heavy metal removed from solution (mg/kg) was computed as equation [11]:

$$q_e = (C_o - C_e)\frac{V}{m} \qquad (1)$$

where qe is the amount of heavy metal removed from solution (mg/g), Co is the initial concentration of heavy metal in the solution before mixing with reactive material (mg/l), Ce is the equilibrium concentration of heavy metal left in the solution at the end of the experiment (mg/l), V is the volume of solution in the flask (l), and m is the mass of reactive material in the flask (g) [11].

3-Results and Discussion

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The influence of the weight for activated carbon for adsorption Ni (II) was studied using varying activated carbon prepared from Cactus Plant weights 1 to 7 g at a constant other parameter such as; initial concentration, mixing time, pH and mixing speed. Figure 1 shows removal efficiency for Ni (II) as function of varying activated carbon weights. It can explained that increasing removal efficiency of nickel with increase adsorbent dosage. This was expected due to the fact that the higher dose of adsorbents in the solution, the greater availability of sorption sites, as cited by [10].

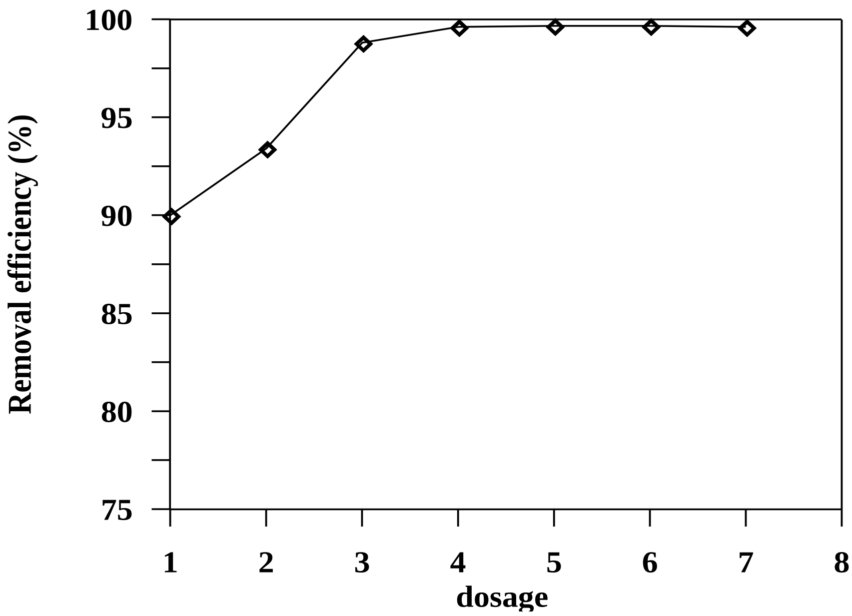

Figure (1): Changing of nickel removal for varying adsorbent dosage at C_o=50 mg/L, pH=6, speed of mixing, time of mixing= 60 min.

3.2 Influence of pH for the contaminated water

Figure (2) illustrates the influence of pH solution on removal efficiency for Ni+2 ions from the contaminated water using activated carbon prepared from Cactus Plant, was tested at pH solution ranged from 3 to 8, at a constant other parameter. Increasing of the pH solution from 3 to 8 was corresponded to increase the removal efficiency for Ni+2 ions from the contaminated water, and achieved a maximum value at an initial pH of 6. The increase in the metal removal as the pH increases can be explained on the basis of a decrease in competition between proton and metal species for the surface sites, and the decrease in positive surface charge, which results in a lower columbic repulsion of the sorbing metal, as cited by [10].

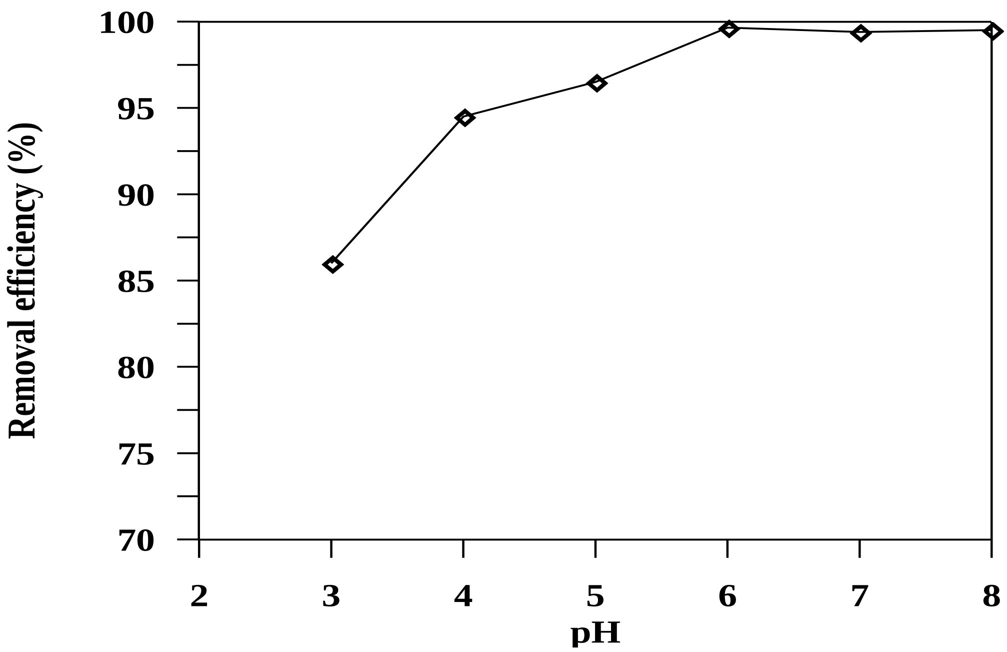

Figure (2): Changing of nickel removal for varying pH of solution at Co=50 mg/l and time of mixing= 60 min.

3.3 Influence of time of mixing

Figure (3) shows the relationship between time of mixing and removal efficiency of nickel from solution, with constant other parameter. It can clear that increasing of contact time will increase the removal efficiency of nickel until it arrives the equilibrium time. This may be due to a decrease in mass transfer coefficient of the diffusion controlled reaction between resin and metal ions. Also this may be due to the presence of large number of resin sites available for adsorption of metal ions. As the remaining vacant surface decrease, the adsorption rate showed down due to the formation of repulsive forces between the metals on the solid surfaces and in the liquid phase, as cited by [12]. Then, the highest removal efficiency of nickel was obtained at optimum contact time = 60 min.

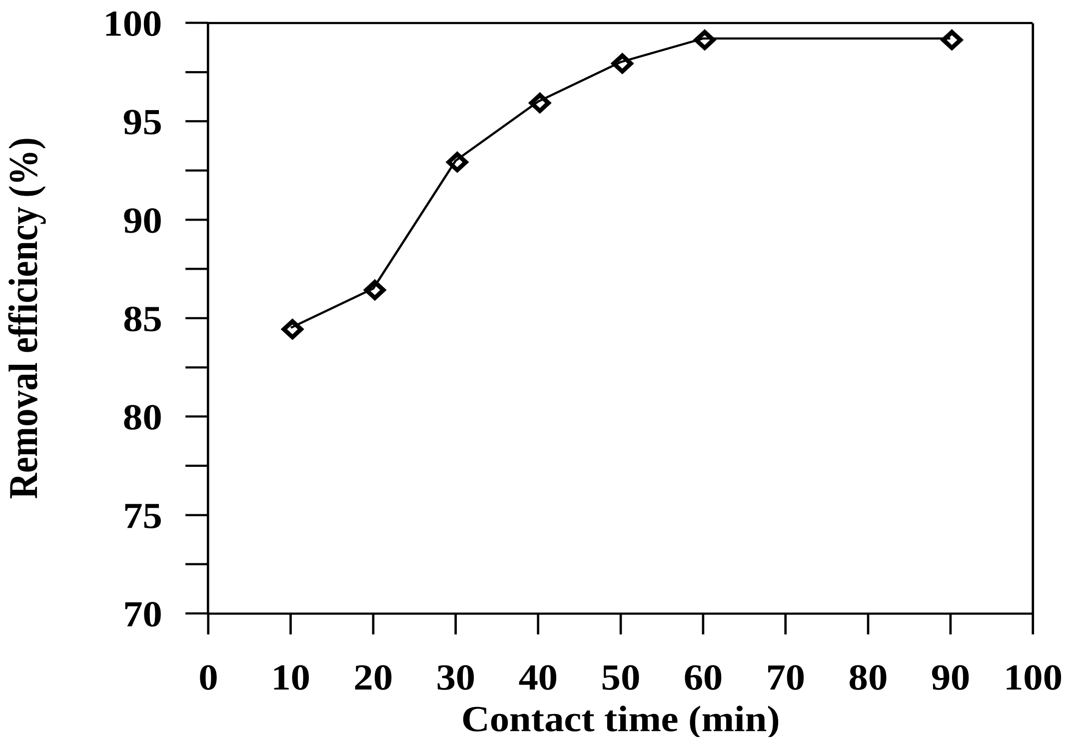

Figure (3): Changing of nickel removal for varying contact time at Co=50 mg/L, and pH of solution=6.

3.4 Influence of initial nickel concentration

Figure (4) elucidated that the influence of initial concentration solution on removal efficiency of Ni+2 ions from the contaminated water using activated carbon prepared from Cactus Plant was examined at initial nickel concentration values from 50 to 250 mg/l, at a constant other parameter. The results show that there was maximum removal efficiency of nickel was 99.68% at initial concentration=50 mg/l. Then, it was decrease with increasing of the initial concentration. These results indicate that energetically less favorable sites become involved with increasing concentrations in the aqueous solution, as cited by [12].

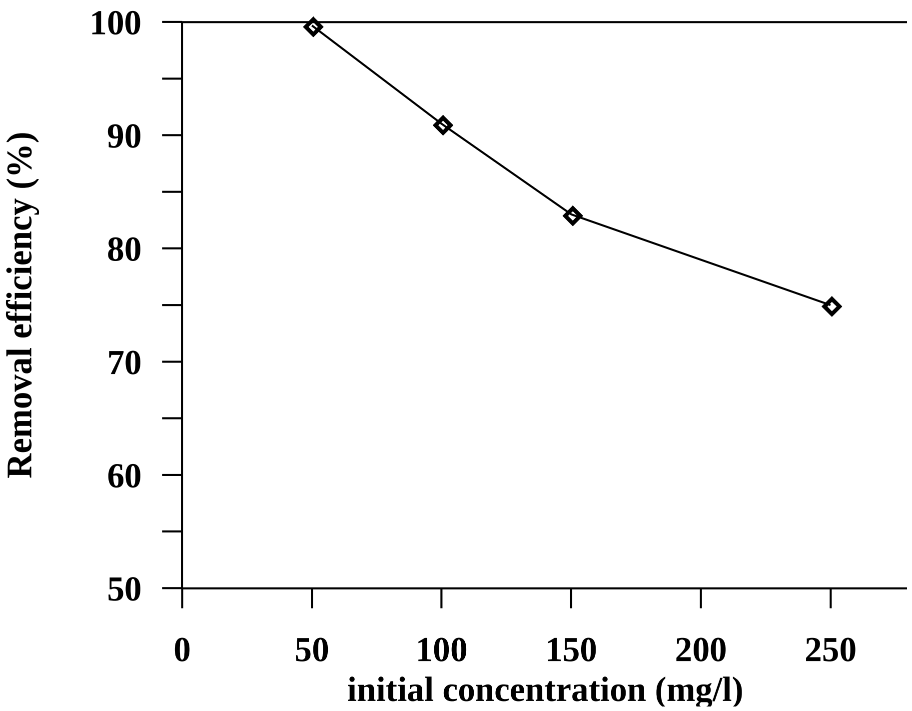

Figure (4): Changing of nickel removal for varying initial concentration, and pH of solution=6 and contact time= 60 min.

4. Conclusions

1- The highest removal efficiency of nickel obtained at an initial pH of 6.

2- The highest removal efficiency of nickel obtained at optimum contact time = 60 min.

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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أزاله أيونات النيكل باستخدام الامتزاز على الكربون المنشط المحضر من نبات الصبار

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الخلاصة

تقنيه الامتزاز هي واحده من أهم العمليات التي تستخدم على نطاق واسع في علاج الماء والمياه العادمة. تقنيه الامتزاز التي هي وسيله فعاله جدا وفعاله في علاج الملوثات. واحده من مساوئ عمليه الامتزاز باستخدام الكربون المنشط مكلفه، وهذا جعل الباحثين يفكرون في إيجاد بدائل رخيصه للحد من تكلفه هذه العملية. في هذه الدراسة، تم اعداد الكربون المنشط من نبات الصبار لغرض استخدامه لأزاله أيونات النيكل. أجريت اختبارات الدفعات لتقييم قدره نبات الصبار في أزاله أيونات النيكل من المياه العادمة. وأظهرت النتائج ان الكربون المنشط المطور من الصبار لديه قدره جيده علي أزاله أيونات النيكل. تم العثور على ان الحد الأقصى لكفاءة الازالة وصلت إلى قيمه 99.68 ٪ تحت الأس الهيدروجيني يساوي 6.

الكلمات الدالة: النيكل، الامتزاز، نبات الصبار، الكاربون المنشط.