Waste Water Remediation using an Adsorbent Material

Israa M. Al-Tameemi¹, Manar B. Hasan², Zainab Munaf Abdulkareem Al-Rawaf³

¹Department of Environmental Engineering, College of Engineering/ Mustansiriyah University, Bab Al Muadham, Baghdad 10047, Iraq, orcid.org/0000-0003-4098-8052

²Department of Environmental Engineering, College of Engineering/ Mustansiriyah University, Bab Al Muadham, Baghdad 10047, Iraq, orcid.org/0000-0002-1331-5293

³Department of Environmental Engineering, College of Engineering/ Mustansiriyah University, Bab Al Muadham, Baghdad 10047, Iraq,

Abstract: Function of lemon peels as a natural and affordable sorbent to remove Ni(II) ions from simulated aqueous solution were examined by using batch adsorption experiment. A cluster of parameters which influence on adsorption process were studied including pH, quantity of sorbent and the time of agitation which required to reach to equilibrium in order to meet the optimum circumstances for Ni(II) ions removal. Isotherm study was conducted to describe the sorption process. The maximum elimination percentage was 86.5 at pH 6.5, 1.5 g of lemon peels and 1-hour contact time. Freundlich isotherm was best to describe the results.

Keywords: Nickel, Adsorption, Low-cost Adsorbent, FTIR

1. Introduction

Water pollution with heavy metals regards one of the most problems, which effect on environment in general and human beings in particular. The pollution of water was increased significantly in last few years because of industrial development. The term "heavy metals" refers to the chemical element, which own high density, and regards poison and toxic even at low concentrations [1].

Heavy metals such as Cobalt, Lead, Nickel are existing naturally in earth crust at a certain concentration. If their concentrations increase by discharging into water, they have a dangerous effect on organisms such as plant, animals and human because of its non-degradable nature lead to accumulate inside them resulting in diseases and disorder [2, 3, 4].

Wastewater resulting from various industrial processes regards as a main source of Nickel pollution, like electroplating, connecter, plastics manufacturing, lead frame, metal finishing, fertilizers, Tableware, nickel-cadmium batteries, pigments, metallurgical and mining operations.

Water polluted with Nickel regards as carcinogen as well as it causing deleterious effects on public health to human kind such as damage to kidneys, lungs and digestive system [2, 5].

Because of the dangerous effects of Ni II, Therefore, It is necessary to find out an effective method in order to remove it. There are many methods could apply to eliminate Ni II from wastewater such as Adsorption, Ion Exchange, Biological Methods, Electrocoagulation and Electro dialysis, Floatation, Coagulation and Flocculation and finally Membrane Separation [6]

Adsorption is one of the most important techniques for treating heavy metals pollution because of its high efficiency in this field as well as the simplicity of the technology used for this purpose besides its economic cost compared to other methods. In recent years, several studies have been conducted with a focus on highly selective substances of natural origin, whose its usage does not lead to further contamination [6, 7]

The most common natural adsorbent includes coconut peels, bark, zeolite, lignin, molluscs, citrus peel, minerals, natural clay, microorganisms (bacteria, molluscs, fungi, yeast). In this research, lemon peels powder was used as a natural adsorbent material to extract nickel ions because lemon fruit is available in low-cost materials, where the peels are thrown into waste and are not utilized [5, 6, 8]

To identify the major functional groups in citrus fruits peel analysis the FTIR spectra was carried out. The OH stretching vibrations occur within a broad range of frequencies indicating the presence of —freel hydroxyl groups and bonded OH bands of carboxylic acids. Products rich in pectin have been considered in capabilities to bind metal as well as contain bi-valence cations [9].

Factors influencing the adsorption process were examined such as pH, adsorption time and the dose of adsorbent material. Data, which obtained were evaluated by using adsorbent equilibrium isotherms models.

2. Methods and Material

The stock solution was prepared by dissolving the calculated weight of nickel salt Ni(NO₃).6H₂O in 1000 ml of distilled water by using the following equation:

$$W = V * C \frac{M.wt}{At.wt}$$

Where; W is the weight of Nickel salt (mg); V is solution volume (L); C is the initial concentration of metal ion in solution (mg/L); M.wt is the molecular weight of metal salt (g/mole); and wt= atomic weight of metal ion (g/mole).

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To synthesize the sorbent, a few kilos of lemon fruit were bought from market, and then the peels were collected, washed with distilled water and dried at room temperature in the open air for three days. After that, they dried in an 80° oven for 24 hours. As a final step, the dried lemon peels were crushed by using electric grinder and sieved (particles sizes 0.6mm). The powder was kept in a closed container in order to avoid any humidity.

In order to find the optimum circumstances for the best removal of Nickel. Batch experiments executed. Factors such as pH; amount of lemon peels; contact time; temperature; equilibrium and kinetics isotherms were examined in this research to meet the goal of best Ni(II) elimination. Influences of all these factors identified while keeping other variables constant. (50) ml of Simulated aqueous solution with concentration of Nickel 50 mg/L was added into flask with different quantities of lemon peels powder changing (0.5, 1, 2 and 2.5) g. Adjustments of pH executed by 0.1N HCl, and 0.1N NaOH from (2 to 9), then stirred a solution at 200 rpm in a predetermined period of time from (0.5 to 2) hours. After the mixing process, the filtration process was carried out (Whatman 70mm filter paper) and samples were analyzed by Atomic Adsorption Spectrometer (AAS).

3. Results and Discussion

Spectroscopy is based on the study of the interactions between matter and electromagnetic radiation. This radiation consists of a particle beam having an undulating motion. All electromagnetic radiation forms the electromagnetic spectrum. Figure 1 shows FTIR analysis of lemon peels to determine the functional groups responsible for Nickle adsorption. FTIR spectrum of lemon peel has listed to get the information related the stretching and bending vibrations of the functional groups which are include in the adsorbate molecules sorption. Intense absorption peaks around 3387-3366 cm⁻¹ due to bonded OH⁻ groups [10]. The OH stretching vibrations occur within a broad range of frequencies indicating the presence of -free hydroxyl groups and bonded OH bands of carboxylic acids. Absorption peaks around. 1729.83-1724.05 cm⁻¹; 1636-1617 are assigned to carboxylic acid and alkyl carbonate C-OH of carboxyl and 1415-1406 cm⁻¹ due to carbonate ion vibrations of lemon peel.

The most essential factor, which plays a main role on process of sorption is pH; in order to study the effect of this parameter in this experiment: 50ppm of Nickel (II) in 50ml were used; with pH range about (2-9). An initial amount of sorbent (lemon peels powder) put to all flasks (0.5 gm) with 200rpm agitation speed for 1h at room temperature. Figure 2 shows the result of efficiency of Nickel removal. It appears that when pH raises, the percentage removal increased; while at low pH, sorption was noticed decreased. Because of high solubility and support of metal ions, medium is Acidic. The sorbent surface becomes more positively charged with high H+ concentration such that the attraction between sorbents and metal cations decrease. on the contrary, when pH increased, the surface area filled with negative charge which encourage to eliminate metal more than when pH is lower [11]. The best removal of Nickel was achieved at pH = 6.5 (R% is 86.5). pH above 8 causes coexist of Nickel ions as $Ni(OH)^2$ OR $Ni(OH)^+$ by micro precipitation. pH 6.5 for Ni(II) was selected for subsequent experiments.



Figure 1: FTIR analysis of lemon peels A) before and B) after adsorption experiment of Ni (II).



The effect of quantity of sorbent on Ni(II) removal was shown in figure (3). To determine the effect of lemon peels dose, the experiment was executed by varying the lemon peels amount (0.5 - 2.5g), whereas the other parameters as: pH 6.5, primary metal concentration 50mg/l, agitating time 1h and stirring speed 200 rpm stayed constant. The results appear that, Ni(II) removal increased when the sorbent amount increased too, until it reach to constant average of elimination at 2.5 g and beyond due to reduction in concentration gradient [12]. The maximum removal was achieved by using 1.5 g/50ml sorbent dosages (Re% = 94)

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The effect of contact time on Ni(II) ions removal from simulated aqueous solution at pH 6.5 with concentration 50 mg/l and dose of sorbent 1.5 g was showed in figure 4. The experiment was executed at different periods of time (30 to 120) minutes. At the beginning, the rate of Ni(II) removal was fast because of availability of free sites on the surface area of sorbent and the gradient in the melted concentration was relatively high [13]. It was noticed that the time is requisite to reach equilibrium with 60 min so that the optimum equilibrium was taken as 1 h (R%86.5).



Figure 4. Effect of contact time on M(II)

A. Isotherm study

Langmuir and Freundlich models were employed to establish sorption-activity. Sorption isotherms estimate the relation between the pressure stabilization or concentration and adsorbate amount which adsorbed by the adsorbent unit mass at a constant temperature. The model of Langmuir is [9, 10]:

$$q_e = \frac{q_m \, La \, C_e}{1 + La \, C_e}$$

Where: qe is the sorbed metal ions on the biomass (mg/g), qm is the highest ability of sorption for monolayer coverage (mg/g), La is the constant related to attraction of binding site (L/mg), and Ce is metal ions concentration in the solution at balance (mg/L). And Freundlich model is represented by the following equation [9, 10]:

$$\log q_e = \log K_r + \frac{1}{n} * \log C_e$$

Where; Kr= constant indicate that proportional sorption ability of the adsorbent (mg/g), 1/n = constant expressive of the strength of the adsorption. The results of the two isotherm models are presented in Table 1. Table I: Langmuir and freundlich isotherm parameters

Langmuir	
\mathbf{R}^2	0.889
$q_m (mg/g)$	6.4921
b (1/mg)	0.115
Freundlich models	
\mathbb{R}^2	0.947
1/n	1.836
$K (mg/g)(1/mg)^{1/n}$	1.436

4. Conclusion

Utilization of lemon peels as a natural adsorbent to remove Ni(II) ions from simulated aqueous solution by batch technique was examined. The optimum factors that meet the maximum elimination of 50 mg/l concentration Ni(II) ions in 50 ml sample were, at pH 6.5 with equilibrium contact time 60 min and 1.5 g of lemon peels where the best removal percentage was 86.5%. Freundlich isotherms was the best to describe the experimental results. This study proved the efficiency of lemon peels as a low cost, natural and available waste to remove Ni(II) from polluted water.

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