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Removal of Multi Heavy Metals in One Batch System onto Surface of Activated Palm Kernel

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Abstract

This paper investigating the ability of palm kernel as a natural adsorbent for the removal of multi heavy metals from polluted real sample. Batch method of extraction was applied to determine the physic-chemical properties of adsorbent material. Results showed maximum removal of 70.5% (pH 3), 80.5% (pH 5) 73.5% (pH 9) for Cr (IV), Cu(II) and Pb(II) metal ions, respectively. The method was applied for the removal of the studied metal ions from a real water sample, and the recovery was recorded in the order Pb(II) > Cu(II) > Cr(VI). These findings conformed the potential ability of palm kernel as a good adsorbent for the removal of Cr (VI), Cu (II) and Pb(II) from real sample.

Keywords: *Batch method of extraction, palm kernel, Removal of heavy metals.*

1. Introduction

Over the past several decades, the population and social civilization expansion has over changed and affected life styles. The continuing progress of industries with the rising awareness of their activities has intensified numerous deteriorations on several ecosystems and seriously threatens the human health and environment [1]. The introduce of industrial materials by man into environment causes hazards to human health, harm to living resources and ecological systems, damage to structures or amenity, or interference with legitimate uses of the environment.

Water is essential for life used for various purposes in community life such as cooking, drinking, washing, watering gardens, etc. However, the demand of water is developed with population has increased. In addition, a huge amount of water is required to run industries. The contamination of water with the rapid industrialization has been taking place which reduces its usefulness to humans and other organisms in nature. The most commonly water pollution is associated with the discharge of effluents from sewers or sewage treatment plants, drains and factories. The control and prevention of water pollution have been wide spread attention in the recent years by researchers, agencies and governments due to the toxicological importance in the ecosystem, agriculture and human health [2].

Many strategies have been developed especially for treating heavy metal wastewater such as chemical precipitation, the ferrite method, oxidation, ion exchange, adsorption, membrane separation, the electrochemical method and the electro-dialysis method [1,3]. Adsorption is one of the alternative treatment processes used [4]. Recently, much attention has been paid to investigate the cost efficient sorbents using in real designing experiments by materials locally available in large quantities such as natural materials, clays, agricultural waste or industrial byproducts [5]. The present study is focused on removal of chromium (VI), copper (II) and lead (II) on the low-cost abundant adsorbent such as palm kernel.

2. Materials and Methods

2.1 Instrumentation and Reagents

2.1.1 Instrumentations

Lab-Line reciprocating water bath shaker (15-250 cycles per minute, Temperature controller up to 65°C), pH meter OAKTON 510 Series, flask shaker (Stuart), and Thermo AA spectrometer/M series supplied with GF95- graphite furnace with auto sampler, Iso-temp Oven (fisher scientific, Model 255G) were used in this study.

2.1.2 Chemical Reagents

$K_2Cr_2O_7$, $CuSO_4$ and $Pb(NO_3)_2$ were obtained from Fisher Scientific, hydrochloric acid (HCl), Honeywell, trace metal grade, sodium hydroxide (NaOH), Fisher Scientific, analytical grade, nitric acid (HNO_3) 70%, Analar, 2% H2SO4, Sigma Aldrich, 2% $NaHCO_3$, pH buffers (4, 7 and 10) were obtained from Fisher Scientific. All chemicals were used as received. Raw material of palm kernel was collected from Sirte city, Libya.

2.1.3 Preparation of the Adsorbent

Palm kernel sample was collected from Libya and used as adsorbent for removal of Cr(VI), Pb(II) and Cu(II) metal ion from aqueous using batch method of extraction. Sample preparation was conducted according to Ragwan *et. al*. [5]**.** The adsorbent material was firstly washed with distilled water to remove fines and dirt and dried at 110°C for 24 h. Then, it was crushed and sieved to a particle size of 0.5 mm, and stored in desiccator till its use in the adsorption experiments.

2.1.4 Chemical modification of adsorbent surface

The previously described method [6] with slight modification was employed. The adsorbent was washed with deionized water until any leachable impurities due to free acid and adherent powder were removed. The samples were then treated with 2% H2SO4 (v/v) in an incubator at 110 C for 24 hand soaked with deionized water until the solution pH was stable. Afterwards, the adsorbent was soaked in 2% NaHCO3 (w/v) till any residual acid left was removed. The acid-treated adsorbent was then dried overnight in an oven at110 C, cooled at room temperature, and stored in a desiccator.

2.1.5 Adsorbate solution

A 1000 mg/L stock solution of Cr(VI) was prepared by dissolving 2.83 gm of $K_2Cr_2O_7$ in deionized water. A 1000 mg/L stock solution of Cu(II) was prepared by dissolving 2.51 gm of $CuSO_4.5H_2O$ in deionized water. The stock solution (1000 mg/L) of Pb(II) as [$Pb(NO_3)_2$] were obtained from Fisher Scientific. Stock solutions of different concentrations (mg/L) required for the adsorption studies were prepared by serial dilution of the stock solutions.

2.1.6 Waste water sample

Waste water sample was collected from El-Souif waste crater plant, Alexandria, Egypt. 3 drops of HNO_3 were added to the collected sample in order to prevent metal precipitation. The sample was then transferred to the laboratory.

2.2. Experiments

2.2.1 Removal processes

A 1.0 gm of palm kernel adsorbent and 150 mL of sample solution were used for each experiment divided the same volume for each metal. The initial concentrations of metal ions were 0.411, 0.424 and 0.86 gm/L for Cr(VI), Cu(II) and Pb(II), respectively. The pH was adjusted for each experiment to pH 3, 5, 7 and 9with using HCl (0.1N) and NaOH (0.1N). The mixture was shacked at 200 rpm for 60 min and after that a sample filtered. The residue of heavy metal cations in solutions was then measured by AAS. The same procedure was applied for the real water sample. A 150 ml of the sample was treated with 0.05 g of adsorbent and agitated on a mechanical shaker at 25°C (± 2), for a speed of 200 rpm for 60 min. The reaction stopped and the solution allowed settling down, filtered and the filtrate was analyzed for the residual amounts of metal ions using AA-spectrophotometer.

2.2.2 Data processing

The percentage (%) removal of metal ion which is the ratio of the difference in metal concentration before and after adsorption, was calculated using Equation 1.

$$\text{Metal removal (\%)} = \frac{C_o - C_e}{C_o} \times 100 \qquad (1)$$

Where: C_o and C_e are the initial and equilibrium concentrations (mg/L) of metal ion after adsorption had taken place over a period of time t.

The equilibrium adsorption capacity (q_e) mg/g of adsorbent was calculated using Equation (2):

$$\text{Equilibrium adsorption capacity } (q_e) = \frac{(C_o - C_e)V}{m} \qquad (2)$$

Where: V and m are the sample volume (mL) and the amount of adsorbent (gm) used, respectively.

3. Results and Discussion

3.1 Waste water sample

In order to demonstrate a practical application value of heavy metals removal, the adsorbent was used to treat a real waste water sample. Firstly, the sample was filtered and its pH value was measured and found equals to 7, salinity 2.68mg/L, conductivity 557ms, Tss 200mg/L, and TDS 430mg/L. For the other investigations, the pH was adjusted using HCL and NaOH (0.1N each). The maximum pH value was 7.00, which is not harmful for ecosystems and human use according to United States Environmental Production Agency (US-EPA) as listed in Table 1. The recommended level of pH by WHO and LSDW was between 6.5-8.5 [7]. The initial concentration of Cr(VI), Cu(II) and Pb(II) in the filtered sample were 0.181, 0.144 and 0.28 mg/L, respectively, as listed in Table 1.

Table 1. Physicochemical properties of El-souif waste water

Test	Unit	WHO	Libyan Standards	El-Souif waste crater [6]
pH	---	6.5-8.5	6.5-8.5	7.00
Ec	ms/cm	---	0.800	557
TDS	mg/L	500	500-1000	430
TSS	mg/L	--	--	200
Salinity	mg/L	--	--	2.68
Cr(IV)	mg/L	0.05	0.05	0.18
Cu(II)	mg/L	---	0.01-0.1	0.14
Pb(II)	mg/L	0.01	0.05	0.28

3.2 Removal study

3.2.1 Removal of heavy metals

After 60 min, the maximum removal for studied heavy metal ions {Cr(VI), Cu(II), and Pb(II)} onto palm kernel surface was studied and plotted in Figure 1. In order to study the effect of the pH value on the metal ion removal by palm kernel adsorbent, the pH value of the sample solution was adjusted to 3, 5, 7 and 9 using HCl and NaOH solutions.

It was found (Fig.1) that the maximum recovery of 70.5% (pH 3), 80.5% (pH 5) 73.5% (pH 9) for the metal ions (Cr, Cu, Pb), respectively. It was also noted that the percentage removal of Cr(VI) ions was decreased with increasing pH values from 70.5 to 13.4%. This could be due to the precipitation of the metal ions from aqueous solution [8]. The maximum removal for Cu(II) onto palm kernel surface was found at pH 5. However, increasing pH value has a slight effect on the removal of Cu(II) ions from the solution. A direct effect of pH was observed for the removal of

Pb(II) ions. These findings proved the ability of the present adsorbent material for the removal of heavy metals from aqueous samples.

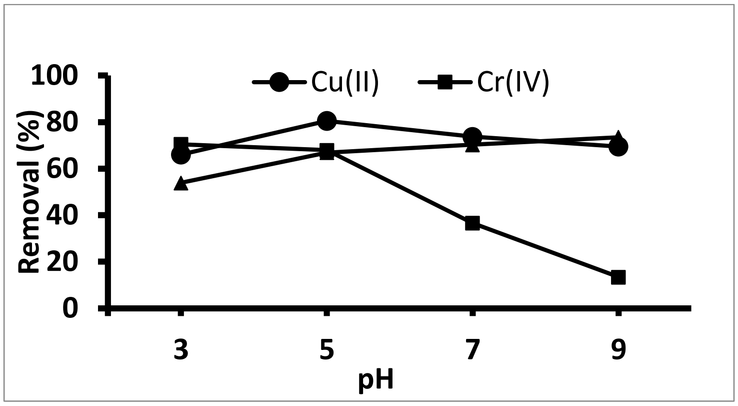

Figure 1. The effect of pH on the removal of heavy metal ions onto surface of palm kernel.

Moreover, the present method was applied for the removal heavy metal ions from real a waste water samples which contain many different metal ions which could be enhanced or affect the adsorption capacity of metal ions onto the adsorbent surface.

Figure 2, shows the removal of Cr(IV), Cu(II) and Pb(II) ions onto the adsorbent surface at the optimum pH for each of the studied metal ions. Results, showed the maximum removal of studied metal ions was in order Pb(II) > Cu(II) > Cr(VI). This may be due to the competition between these metals or due to effect of other species present in the real wastewater crater. Finally, the results above clearly suggest that the used adsorbent material could be used as a natural adsorbent material for heavy metal ions removal from aqueous.

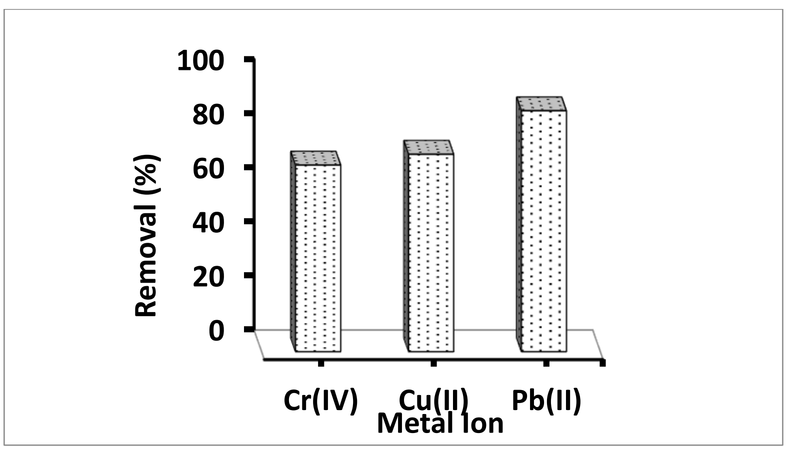

Figure 2. Removal of Cr(VI), Cu(II) and Pb(II) from real waste water sample of pH 7

5. Conclusions

A real application case was performed to demonstrate the practical application value of adsorbents such as palm kernel in order to remove multi heavy metals from polluted real sample. For this purpose, a real sample was collected from El-Souif crater, Alexandria, Egypt. The results showed that the maximum removal of heavy metals in the same batch system onto palm kernel was in order Pb(II)>Cu(II)>Cr(VI) at the same conditions. The findings in this research that the adsorbents used here have high potential to remove Cr(VI), Cu(II) and pb(II) in real sample water.

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