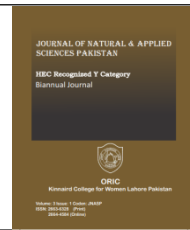




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CHROMIUM (VI) REMOVAL FROM TANNERY WASTEWATER UTILIZING ACTIVATED POTATO PEEL POWDER AS BIOADSORBENT

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Abstract

The most common pollutant in tannery effluent is hexavalent chromium (Cr (VI)), which should be eliminated from wastewater before being released since it is harmful to both the environment and human health. The purpose of this study was to unearth the potentiality of potato peel as a bio-adsorbent for eliminating Cr (VI) ions from tannery wastewater. To accomplish this, potato peel adsorbents were made into natural and activated forms through stepwise processes, including drying, carbonization, and grinding. To evaluate how parameters such as adsorbent dose, pH, and contact time affect the adsorption process, batch studies were carried out using synthetic solutions, and the optimum condition was found at pH 4. An adsorbent dosage of 3 g and a contact time of 60 minutes for the highest showed a removal efficiency of 75.12% and 95.63% Cr (VI) from tannery effluent, respectively, at the optimum condition. The Fourier transform infrared (FTIR) analysis and isotherm model of Langmuir and Freundlich were also followed, which suggest that potato peel can be a cost-effective alternative biosorbent for efficient reduction of Cr (VI) from wastewater where the removal capacity of activated peel is greater than that of natural peel.

Keywords

Tannery effluent, Chromium (VI) extraction, potato peel powder, etc.



1. Introduction

In the era of globalization and rapid industrialization, the persistence of heavy metals in industrial wastewater has become a pressing concern due to their severe adverse effects. These heavy metals, being non-biodegradable, tend to bioaccumulate in living organisms even at trace levels, posing a significant threat to the food chain (Zhao *et al.* 2018, Hossain *et al.* 2022). Among these metals, hexavalent chromium (Cr (VI)) stands out as a particularly detrimental contaminant, with the United States Environment Protection Agency (USEPA) labeling it as the most harmful (Mane *et al.*, 2016; Ahmed & Mokhtar, 2020). The extensive exposure of Cr to the environment is a result of the release of chrome-contaminated effluent into water bodies through various industrial activities like electroplating, refractory, metallurgy, textile, and leather tanning (Hoang *et al.*, 2020; Saha and Orvig, 2010; Saravanan *et al.*, 2017; Tumolo *et al.*, 2020). The highly toxic and oxidizing agent Cr (VI) poses significant health risks, including skin diseases, cancer, respiration problems, genetic alteration, immune system destruction, and other disorders associated with the liver and kidney (Te Chuan *et al.*, 2018; Mane *et al.*, 2016; Ahmed & Mokhtar, 2020). According to World Health Organization (WHO) guidelines, the maximum permissible limit of Cr (VI) in potable water is 0.05 ppm (Jiang *et al.* 2013). Therefore, it is crucial to effectively remove the Cr ion from wastewater due to its toxicity before discharging it into the environment (Mouhamadou *et al.*, 2023). Various techniques, such as reduction and precipitation (Mahajan 1985), ion exchange (Tiravanti *et al.* 1997; Petruzzelli *et al.* 1995), reverse osmosis (Ozaki *et al.* 2002), ultrafiltration

(Ghosh and Bhattacharya 2006), electro dialysis (Mohammadi *et al.* 2005), and membrane separation (Kozłowski and Walkowiak, 2005), have been used to remove Cr (VI) from wastewater. However, these methods are expensive and associated with residue disposal problems (Shrivastava and Gupta, 2015, Hossain *et al.* 2023).

However, adsorption appears to be a promising alternative to the current techniques used to extract metal ions from effluents (Ho *et al.* 2000). The adsorption treatment method is widely used because it is more affordable and successful at eliminating Cr⁶⁺ ions from wastewater than other traditional approaches, (Raut *et al.* 2015; Shahnaz *et al.* 2020). A variety of waste biomass sources found in nature have shown experimental adsorption properties, such as rice husk, sawdust (Argun *et al.* 2007; Meena *et al.* 2008) leftover coffee and tea (Mahvi *et al.* 2005, Hossain *et al.* 2023), peanut shells (Kadirvelu *et al.* 2001), orange peel (Ferda Gönen 2012), and *Azadirachta indica* (neem) leaf powder (Venkateswarlu *et al.* 2007). The efficacy of various adsorbents in removing heavy metal ions has been studied in the past, including activated alumina (Gupta and Tiwari 1985), wood charcoal (Prathima and Ramakrishnaiah 2020), moss peat (Sharma and Forster 1993), rice straw (Samanta *et al.* 2000), corncob (Nigam and Rama 2002), carbon slurry (Singh and Tiwari 1997), coconut shell carbon and bituminous coal, (Nagesh and Krishnaiah 2002), bagasse, activated charcoal, (Rao *et al.* 2002), agricultural byproduct (Bishnoi *et al.* 2004), food industrial waste (Selvaraj *et al.* 2003), paper mill sludge (Ahluwalia *et al.* 2004), rose waste biomass (Iftikhar *et al.* 2009), diverse biowaste substantial (Banerjee *et al.* 2004) and shell (Anandkumar and

Mandal, 2009). However, commercial adsorbents cannot be reused for further adsorption due to their complex regeneration process and limited use of wastewater treatment. This has led to the need for the development of bioadsorbents that are economical, sustainable, and efficient at the same time. Bioadsorbents have been researched during the past few decades to address heavy metal contamination (Iftikhar *et al.* 2009, Hossain *et al.* 2023) because there is a substantial body of data on the efficacy of various biosorbents for heavy metal removal (Uysal and Ar 2007). Natural resources with minimal costs like agricultural leftovers (Pollard *et al.* 1992), various non-living biomass like orange peel (Demirbas 2008), potato peel (Abdullah *et al.* 2013), unprocessed coffee and tea grounds (Azouaou *et al.* 2010), crab shell (Vijayaraghavan *et al.* 2005), as well as living biomass, such as insect and microbial cells (Gopal *et al.* 2002) are increasingly being encouraged for use as chromium adsorbents. As an agricultural byproduct, potato peels are thrown away and useless worldwide. It is a readily available and cheap substance derived from every household chore. Knowledge is scarce regarding the adsorptive capacity of potato peel despite the wide range of biosorbents currently accessible for metal ion removal. Thus, the primary objective of this study was to assess the efficacy of both natural and activated potato peels as bio-adsorbents in eliminating Cr (VI) ions from tannery wastewater. Batch studies were also conducted to determine the optimum parameters for effective adsorption, including contact time, pH, adsorbent dosage, and initial metal ion concentration. Later, the experimental results were also analyzed using the Langmuir and Freundlich isotherm model to

determine the optimum match for the Cr (VI) adsorption process.

2. Materials and Methods

2.1 Adsorbent (*Natural potato peel*) preparation

Potato peel is a common agricultural waste product. Waste potato peel is widely available and reasonably priced. The potato peel has several functional groups that work well as chelating agents and, as a result, as binders for different metal ions. As a result, it can handle wastewater with heavy metal ions. For the study, potato peels were gathered from homes and hotels in Dhaka, Bangladesh. In Bangladesh, potato peels are particularly interesting because they are widely available and reasonably priced, unlike other adsorbents. The collected potato peel was exposed to the sun until all moisture had been removed. Then, it was sieved from 20 to 200 meshes after being reduced to powder by a crushing machine.

2.2 Adsorbent (*Activated carbon potato peel*) preparation

The ground potato peel was subjected to a thorough pre-carbonization process for 1 hour at 150° C in a furnace. Then, the powder was weighed and mixed thoroughly at a ratio of 1 (potato powder): 1 (2 M KOH). The powder was mixed into the solution and left to soak for a full 24 hours. Later, we heated the solution until it was completely dried. After that, the carbonization process was carried out in a furnace with a carefully maintained 700° temperatures for a duration of 1 hour. Finally, the adsorbent was ground and stored in a secure glass container.

2.3 Standard solution preparation

A volumetric flask was filled with 1000 (standard solution) parts per millions of chromium. Experimental solutions of the necessary concentrations were created through a series of

dilutions using the dilution theory ($V_1S_1= V_2S_2$), where V_1 denotes the starting volume, S_1 the starting concentration, V_2 the final volume, and S_2 the final concentration of the solution.

2.4 Adsorption experiment using stock solution (Hossain et al. 2022)

Conical flasks were used for the adsorption studies, which used standard chromium solution and the necessary quantity of adsorbent. A shaker rotating at 150 rpm continually shook the flasks for an appropriate amount of time until equilibrium was established. The mixtures were filtered using filter paper, and the remaining Cr (III) concentration was determined using an atomic absorption spectrophotometer. The solution's volume (V) remained constant (20 ml). Equations 1 and 2 were utilized for the selected adsorbents to calculate the capacity and percentage of chromium removal for a given contact time.

$$\text{Chromium removal (\%)} = \frac{C_o - C_f}{C_o} \times 100 \quad (1)$$

$$q_e = (C_o - C_f) \times V / m \quad (2)$$

Where C_o = initial concentration (mg/L) and C_f = final concentration (mg/L), q_e = metal uptake (mg/g), V = volume of effluent, and m = mass of adsorbent (g) taken. Variations in the initial pH of the solution (2, 4, 6, 8), adsorbent concentration (3, 5, 10, 20, 40 g/L), and contact time (30, 60, 90, 120 minutes) were used to examine the effects of different parameters on the rate of the adsorption process. Before adsorption, by adding NaOH or H_2SO_4 , the pH of the mixture was maintained at the appropriate level.

2.5 Details of AAS

- Model: Atomic Absorption Spectrophotometer (AA-7000)
- Manufacturer: Shimadzu, Japan

- Mode: Flame
- Detection limit 0.03 ppm
- Wavelength (s): 185 - 900 nm
- Power Furnace: 6000 VA
- Lamp Type: Hollow-Cathode
- Configurations: Double Beam
- Optics: Monochromatic
- Autosampler: Noncompulsory
- Humidity: 20 to 80%
- Temperature: 10-35°

2.6 Adsorption Isotherms:

In this experiment, we undertook a comprehensive analysis of the data set to determine the adsorbent's sorption ability to remove Cr (VI). To do this, we compared the experimental data with the predictions of the Freundlich and Langmuir isotherm models, which are widely used in such studies (Hashem et al. 2019). The Langmuir adsorption isotherm is based on the supposition that metal ion adsorption occurs in a monolayer on the adsorbent surface. Furthermore, the adsorption system's energy is expected not to change (Batool et al. 2018). Equation 3 represents the Langmuir adsorption isotherm in linear form.

$$C_e/q_e = 1/K \times q_{max} + C_e/q_{max} \quad (3)$$

Where C_e = concentration of Cr at equilibrium state (mg/L), q_e is the amount of adsorbent adsorbed (mg/g), K = (L/mg) and q_{max} are the constant associated with sorption apparent energy and capacity, which were calculated from the slope and intercept of the linear plot of C_e/q_e vs. C_e . The equilibrium parameter (R_L), also known as the dimensionless separation factor, is the fundamental property of the Langmuir isotherm model and is calculated as follows:

$$R_L = 1 / (1 + K C_o) \quad (4)$$

If $R_L = 1$, then a linear adsorption process took place. Adsorption is unfavorable if $R_L > 1$. Adsorption is referred to as irreversible if $R_L = 0$. According to Al-Ghouti and Da'ana (2020), adsorption is favorable if $0 < R_L < 1$. The Freundlich isotherm was formulated to explain the behavior of a heterogeneous system, explicitly considering the concept of multilayer adsorption occurring on the surface of an adsorbent (Batool et al. 2018). Equation 5 illustrates the Freundlich isotherm model's linear form. $\log q_e = \log K_f + (1/n_f) \log C_e$ (5). Here, q_e = Total adsorbent adsorbed per unit mass (mg/g), C_e = concentration of C_r during the equilibrium state (mg/L), K_f = adsorption capacity = and $1/n =$ intensity of adsorption. We calculated the constant K_f and $1/n$ from the intercept and slope of the linear plot of $\log q_e$ vs. $\log C_e$. If the value of n is between 1 and 10, it indicates favorable adsorption (Goldberg et al. 2018). However, if $1/n < 1$, it indicates normal adsorption, but if it is > 1 , then it indicates cooperative adsorption (Mohan and Karthikeyan 1997).

2.7 FTIR studies

3. Results and Discussion

Table-1 illustrates the FTIR analysis of natural potato peel powder. The analysis revealed adsorption bands at 3254.47 cm^{-1} and 1396.61 cm^{-1} , corresponding to the stretching vibration and bending of O-H, respectively. The strong and broad nature of these bands suggests the presence of hydrogen bonding and possibly multiple OH groups. The hydroxyl group (OH-) plays a crucial role in the adsorption process by facilitating the formation of hydrogen bonds, which direct the polar functional groups into the interior of the adsorbent material,

FTIR analysis was performed on the adsorbents using a spectrophotometer (IR Prestige-21; Manufacturer: Shimadzu). Pellets (press disks) were utilized to measure absorption spectra. For FTIR analysis, the materials were pulverized in a mortar with 200 mg of spectroscopic grade ATR before being pressed into disks with a diameter of 10 mm under less than 10 tons of pressure and high vacuum. Mean of 16 scans for each spectrum with a resolution of 4 cm^{-1} and the spectrum taken between 4000 to 600 cm^{-1} .

2.8 Collection of tannery wastewater for adsorption

Tannery wastewater was collected from the Buriganga River's effluent discharging site in Dhaka to test the effluent's adsorbent capacity. The collected effluent from the discharge site was first sedimented to remove suspended debris. After that, filter paper was used to filter the partially cleared effluent. The cleared solution was kept chilled at 0 to 5 degrees Celsius. From here, the adsorbent solution in each batch was used to demonstrate the effectiveness of the adsorbent in the actual sample.

creating a significant active site that facilitates efficient adsorption (Sudiono et al. 2017). Additionally, medium peaks at 2918.36 cm^{-1} indicate that C-H is present in the structure. In comparison, peaks at 2213.69 cm^{-1} indicate the presence of $\text{C}\equiv\text{C}$. Furthermore, the medium peak at 1625.98 cm^{-1} is due to $\text{C}=\text{C}$ stretching vibration. The firm peaks at 1006.22 cm^{-1} confirm the presence of acid anhydride due to CO-O-CO stretching vibration.

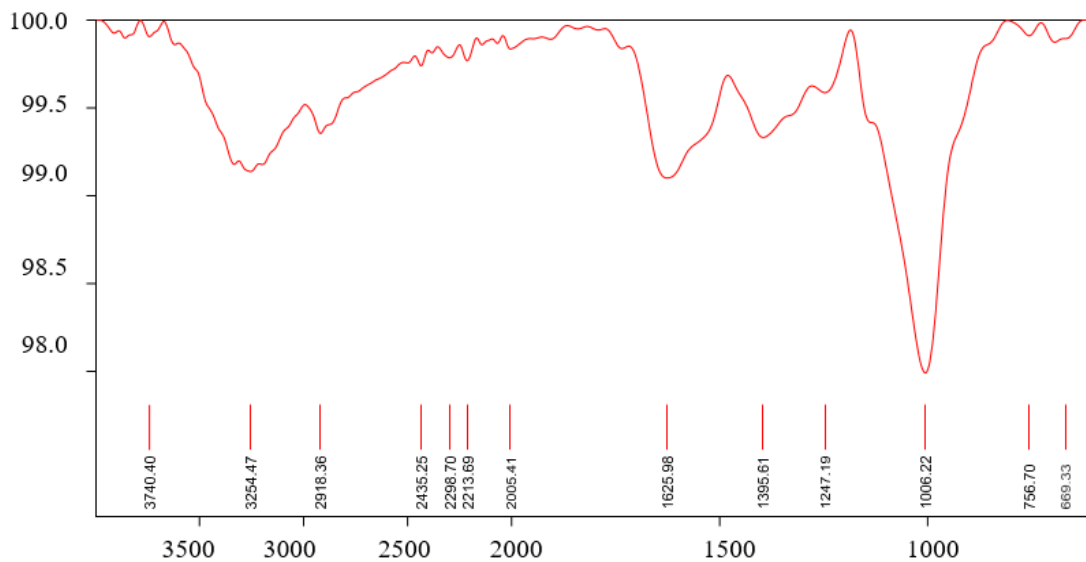


Figure 1: FTIR chart for natural potato peel powder

Table 1: FTIR peaks and group assignment natural potato peel powder

Peak wavelength (cm ⁻¹)	Assign to
1006.22	CO-O-CO stretching, strong, broad
1396.61	O-H bending, medium
1625.98	C=C stretching, medium
2213.69	C≡C stretching, weak
2918.36	C-H stretching, medium
3254.47	O-H stretching, strong, broad

Table-2 shows the FTIR analysis of activated potato peel powder. O-H bending was found at peak wavelength 1371.96 cm⁻¹ and O-H stretching was found at 3176.23 cm⁻¹ with weak intensity. The study found that the weak and medium absorption bands at 3176.23 cm⁻¹ and 1371.96 cm⁻¹ are due to

the stretching vibrations of the O-H group. The peak at 1644.92 cm⁻¹ is due to C=C stretching vibration, while the strong adsorption band at 928.55 cm⁻¹ is due to C=C bending. The strong adsorption bands at 1257.51cm⁻¹ and 1068.24 cm⁻¹ are C-O and S=O stretching vibrations.

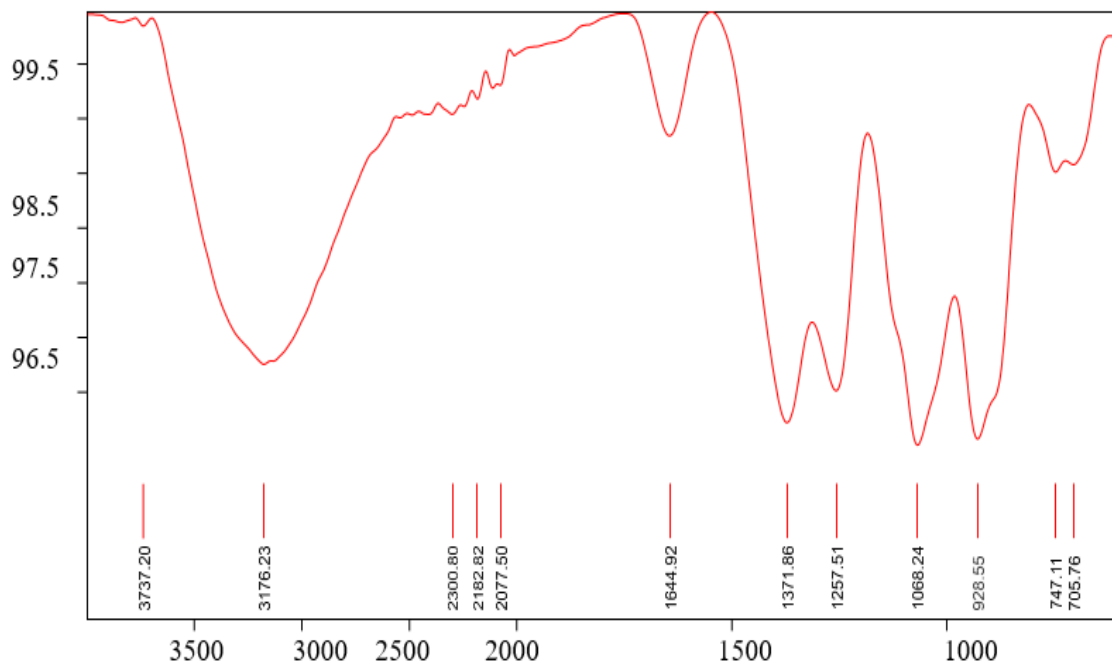


Figure 2: Wave number (cm^{-1}) obtained for activated potato peel powder

Table 2: FTIR peaks and group assignment activated potato peel powder

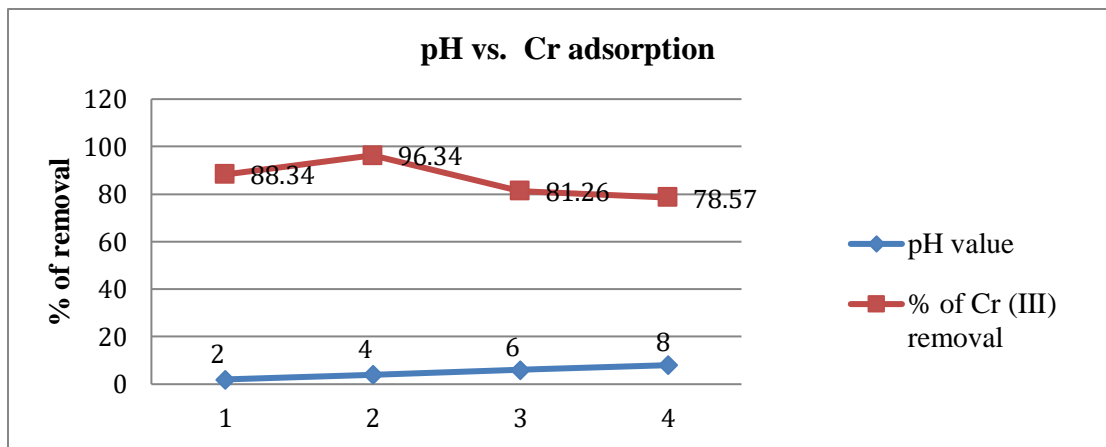
Peak wavelength (cm^{-1})	Assign to
928.55	C=C bending, strong
1068.24	S=O stretching, strong
1257.51	C-O stretching, strong
1371.96	O-H bending, medium
1644.92	C=C stretching, medium
3176.23	O-H stretching, weak, broad

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3.1 Influence of pH on chromium adsorption

- a) natural potato peel



b) activated potato peel

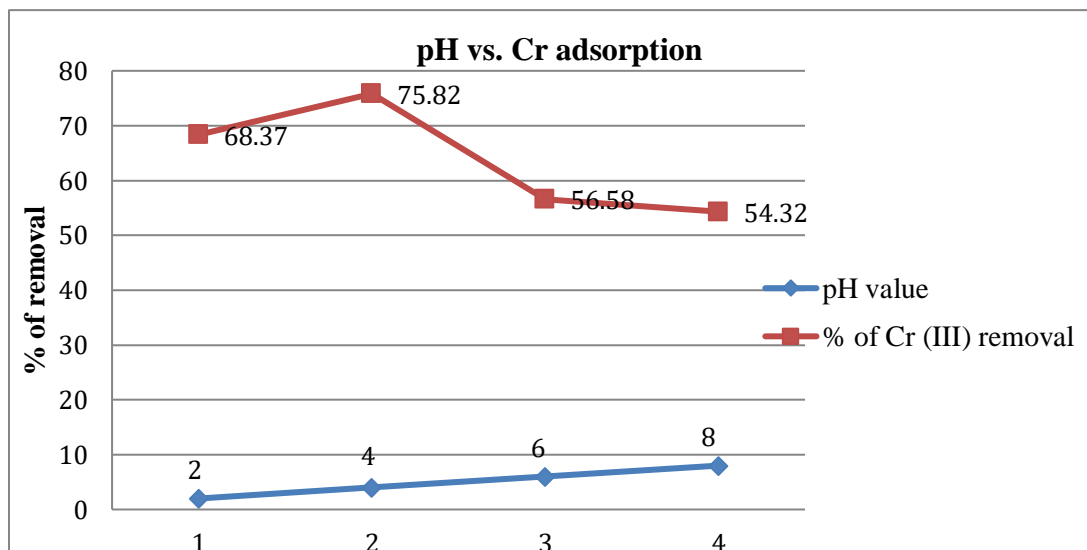


Figure 3: Influence of pH on Cr adsorption for (a) activated potato peel and (b) natural potato peel adsorbent powder.

Adsorption tests were carried out at various pH levels (2.0, 4.0, 6.0, 8.0) in both cases shown in Figure-3, where the ideal contact time was 90 min and the adsorbent dose was 3 g/L. In the case of activated potato peel Fig.-3 (a), the adsorption rose from 88.34 to 96.34 percent at a pH of 2 to 4 and subsequently decreased with an increase in pH up to 8. The highest Cr (VI) adsorption occurred at pH 4, which was 96.34 %. Similarly, from Fig.-3 (b), it was seen that at pH 4, the adsorption of Cr (VI) was highest, with a value of 75.82% for the natural peel, and this adsorption percentage is less than that of the activated potato peel at the same pH. So, it can be

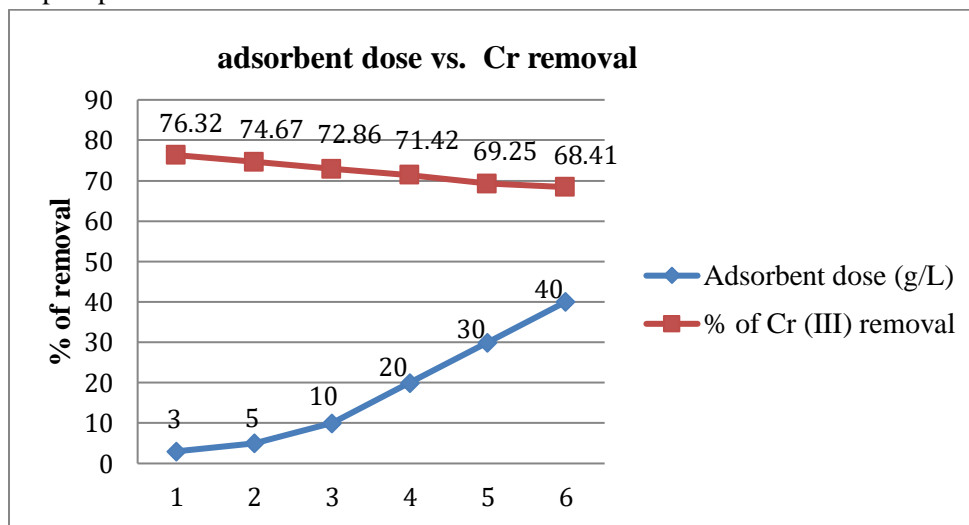
said that activated peel shows more adsorption capacity than natural peel. In both cases, the removal efficiency of the adsorbent increased with low pH because hydrogen chromate (HCrO_4^-) being the dominant anionic form of Cr (VI) between pH 1.0 and 4.0; the favorable effect at low pH may be due to the neutralization of negative charges on the surface of the adsorbents by excess hydrogen ions, thereby facilitating the diffusion of (HCrO_4^-) ion and its subsequent adsorption. It was discovered that the ionic form was preferentially adsorbed on the adsorbent's surface. The $\text{Cr}_2\text{O}_7^{2-}$ ion is oxidized to Cr^{3+} , which could explain the more significant

adsorption in the acidic area (Mise and Manjunatha, 1992; Attia *et al.*, 2010). Due to its small size, it is quickly replaced by positively charged species. So, the highest adsorption of Cr was noted at low pH due to the increasing of H⁺ ions on the adsorbent surface and the presence of (HCrO⁴⁻) ions, yielding an strong electrostatic attraction (Bhutada *et al.* 2016). Besides, from the perspective of other adsorbents, the highest 75% Cr (VI) removal at pH 2 for natural clay (Algamal *et al.* 2018), 70%

removal efficiency at constant pH 8.5 for eggshells (Latif *et al.* 2021) were recorded which are different from the present study. However, in the study of (Ashraf Ali *et al.* 2023) amide, modified biochar showed 97% Cr (VI) removal efficiency at pH 2, which was also somewhat higher than the removal capacity of this research's natural and activated potato peel.

3.2 Effect of adsorbent dose on chromium adsorption

a) natural potato peel powder



b) activated potato peel powder

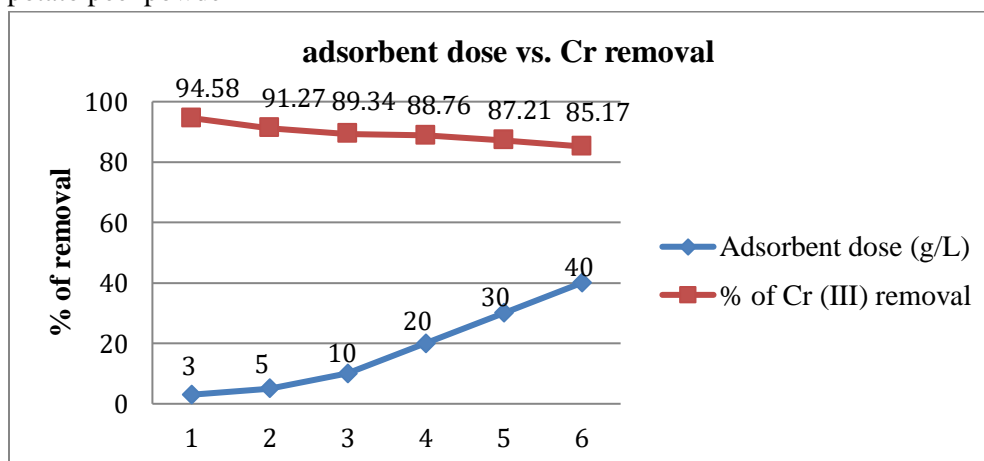


Figure 4: Effect of adsorbent dosage on Cr adsorption for (a) natural potato peel and (b) activated potato peel powder.

Figure 4 represents the influence of adsorbent dosage on Cr removal, which was conducted using

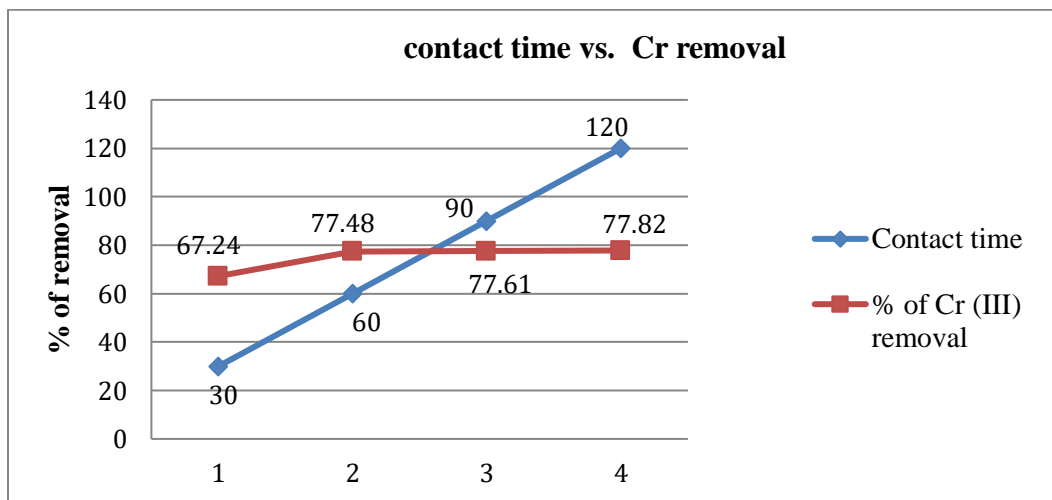
varying adsorbent dosages (3, 5, 6, 10, 20, 30, and 40 g/L) at pH of 4.0 and contact time 90 min. As

illustrated in Figure-4 (a), the highest 76.32% Cr removal was found at 3g/L dosage of adsorbent. The Cr removal capacity decreases with the increase of adsorbent dosages, respectively. It is due to the increased surface area at higher doses that remained free for adsorption at equilibrium could be the cause of the decreased absorption. But in Fig-4 (b), for activated potato peel, the % of Cr removal is even higher at the same dosage 3g/L, which is 94.58%. So, the activated potato peel shows more adsorption

capacity than the natural peel at the exact optimal dosage. However, it is to be noted that potato peel in the analysis of (Mutongo et al. 2014) also showed a maximum removal efficiency at a dosage of 4g, which is very close to the present study's findings. In terms of another study, (Algamal et al. 2018) found a maximum Cr (VI) removal efficiency of 75% using a dosage of 1g for natural clay and 70% efficiency using 6g for eggshells adsorbent (Latif et al. 2021).

3.3 Effect of contact time on chromium adsorption

a) activated potato peel powder.



b) activated potato peel powder.

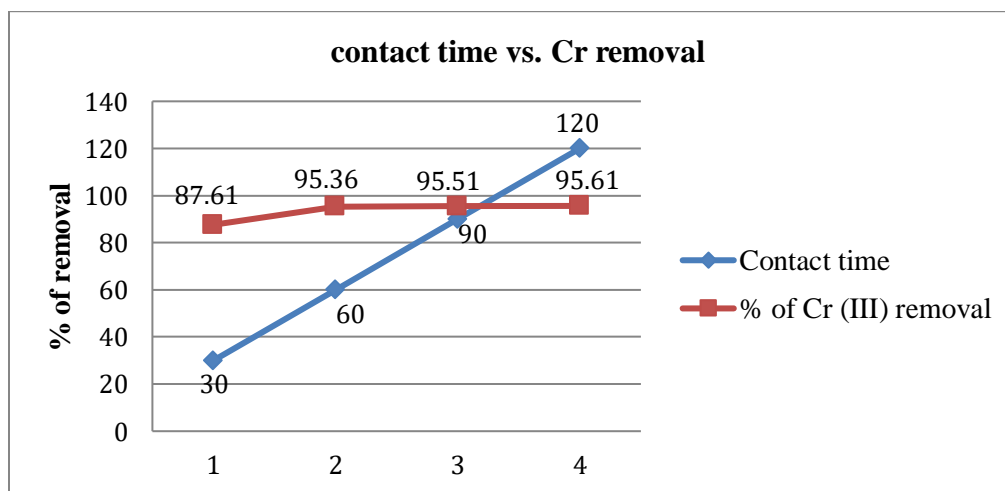


Figure 5: Effect of contact time on Cr adsorption for (a) natural potato peel powder and (b) activated potato peel powder. Figure 5 denotes the effect of the contact time of adsorbent on Cr removal in natural potato peel and

activated potato peel. All of the variables in this stage were held constant, except contact duration, including the adsorbent dosage (3 g/L), pH (4.0), and agitation speed (150 rpm). Studies that lasted 30, 60, 90, and 120 minutes determined the equilibrium contact time. According to the experimental findings, percentage adsorption increased with longer contact times of up to 60 minutes before reaching a stationary phase in both cases; afterward, it tended to decrease. This is because many empty surface sites are accessible for adsorption in the early stages of sorption. The repelling interactions between the adsorbate molecules on the solid surface and in the bulk phase take a long time to fill the remaining empty surface sites (Srivastava and Thakur, 2006). As a result, the adsorption during the later phase slows down. It was seen from Fig.-5 (a) that for natural peel at 60 minutes, the Cr removal is highest, at 77.48%. After that, a slight decrease in the trend was observed. On the contrary, Fig.-5 (b) represents the highest 95.36% Cr removal at 60 min for activated potato peel. So, activated peels have

higher adsorption limits than natural peels at the optimum time. A study by Mutongo *et al.* (2014) reported 48 min for more than 90% Cr (VI) removal with potato peel, which was around the optimum time of this batch experiment, where 97% removal efficiency was achieved within 60 min by amide-modified biochar adsorbent reported in (Ashraf Ali *et al.* 2023) also agreed with the favorable time of this analysis. Besides, 180 min was needed for 94.68% efficiency using Odaracha adsorbent (Birhanu *et al.* 2020).

3.4 Treatment of tannery wastewater with developed adsorbent

a) Using natural potato peel adsorbent

Two wastewater samples were taken, and the initial concentration of chromium was determined and found to be 73 (mg/L) and 9.2 (mg/L) for samples 1 and 2, respectively. Table-3 shows the removal % of chromium at pH 3, adsorbent dose 3 g/L, and with contact time 60 min. According to the findings, the natural peel removed 74.69% of chromium from sample 1 and 75.12% from sample 2.

Table 3: Removal of Cr (III) from tannery wastewater using natural peel powder

Factors	Sample 1	Sample 2
pH	4.0	4.0
Adsorbent dose	3 g/L	3 g/L
Contact time	60 min	60 min
Initial Cr (III) conc.	73 mg/L	9.2 mg/L
Final Cr (III) conc.	18.47 mg/L	2.29 mg/L
Removal (%)	74.69%	75.12%

b) Using activated potato peel adsorbent

Again, both samples were analyzed for chromium removal using activated potato peel adsorbent, and different results were found under the same condition, which is displayed in Table-4. The result

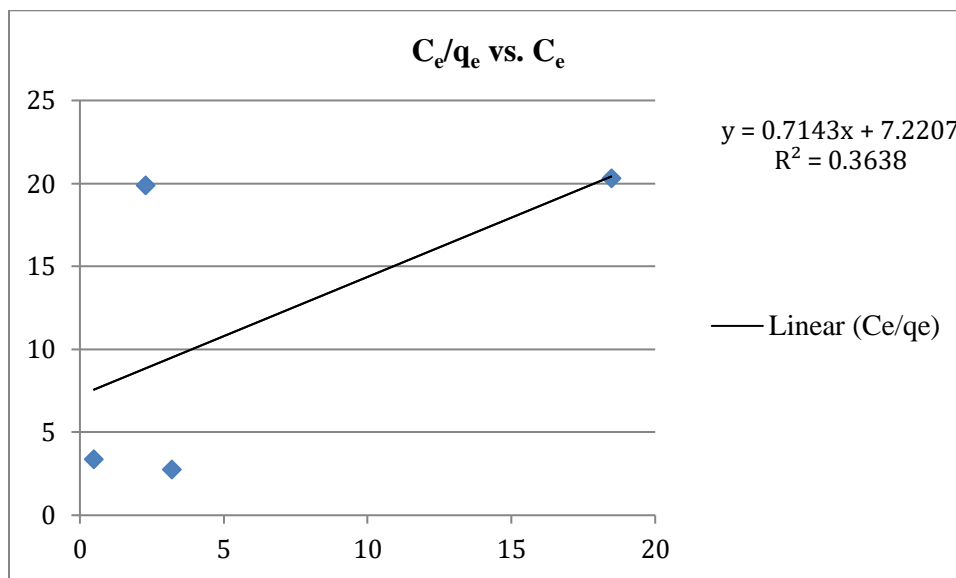
depicted that 95.63% of chromium was successfully removed from sample 1 and 94.62% from sample 2. To sum up, activated potato peel adsorbent was more efficient in eliminating chromium from wastewater than natural potato peel adsorbent.

Table 4: Removal of Cr (III) from tannery wastewater using activated potato peel

Factors	Sample 1	Sample 2
pH	4.0	4.0
Adsorbent dose	3 g/L	3 g/L
Contact time	60 min	60 min
Initial Cr (III) conc.	73 mg/L	9.2 mg/L
Final Cr (III) conc.	3.19 mg/L	0.49 mg/L
Removal (%)	95.63%	94.62%

3.5 Isotherm analysis:

a) Langmuir isotherm



b) Freundlich isotherm

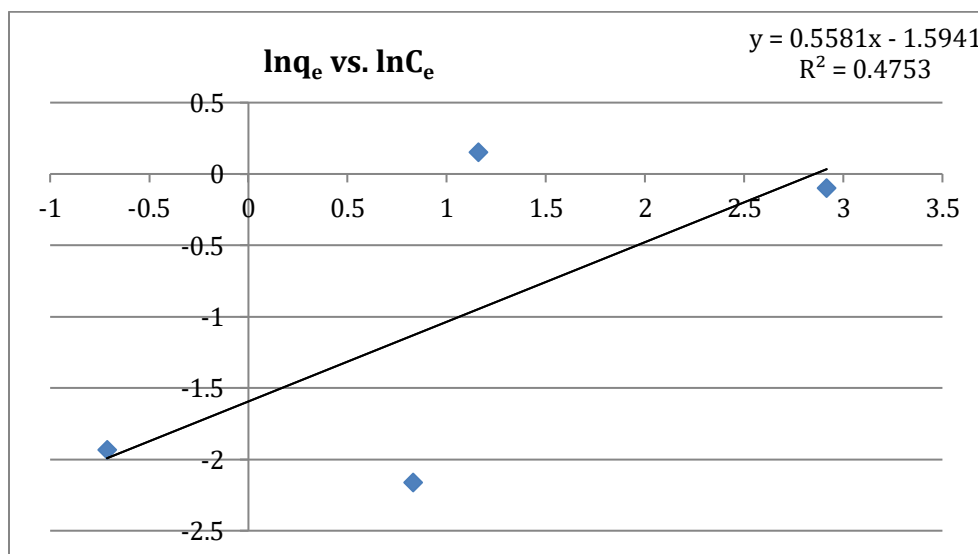


Figure 6: (a) Langmuir isotherm and b) Freundlich isotherm for potato peel powder adsorbent

The Langmuir and Freundlich isotherm plots for both adsorbents are shown in Figure-6. For Langmuir isotherm model fitness, the maximum adsorption capacity (q_m) = 1.400 mg/g and $K_L = 0.098$ L/mg were calculated from the linear plot of C_e/q_e vs. q_e . The separation factor R_L was found to be 0.525, which is within the limit of $0 < R_L < 1$, signifying that the adsorption is favorable by potato peel powder. Besides, the values of q_m for adsorbent pine leaves and sawdust were found to be 0.198 (mg/g) and 0.470 (mg/g) (Aliabadi et al. 2006), for brown sea seed 0.629 (mg/g) (Romero-González et al. 2005) which were less than the adsorption capacity of the studied adsorbent. Moreover, the study of Abdullah et al. (2013) found the q_m value of the potato peel waste to be 8.012 (mg/g) and Mutongo et al. (2014) reported 3.38 (mg/g) for potato peel, which is comparatively higher than the value of the present study. On the other hand, in order to fit the Freundlich isotherm model, the values of $K_f = 0.2031$ and $n_f = 0.558$ were determined from the intercept and slope of the linear plot of $\log q_e$ vs. $\log C_e$. As the value of n_f lies between 0 and 1, it also denoted favorable biosorption. So, it can be said that both isotherm adsorption models are a good fit for the equilibrium data, and potato peel are better adsorbent than pine leaves and sawdust.

4. Conclusion:

Potato peel powder can effectively remove Cr (VI) from the stock solution and tannery wastewater, making them promising bioadsorbents for heavy metal ion removal. The research indicates that the efficiency of Cr (VI) removal is significantly affected by factors such as pH, adsorbent dosage, and contact time. Natural and activated potato peels

exhibited high adsorption capacity and proved the most effective adsorbents for removing Cr (VI) from tannery wastewater in Bangladesh. Both adsorbents are easily accessible, cost-effective, renewable, and environmentally friendly. The study also found that activated potato peel was more effective for Cr (VI) removal than non-activated potato peel. However, both types of potato peel can be considered as potential alternative adsorbents for long-term removal of Cr (VI) from tannery effluent and industrial wastewater treatment. The effectiveness of the bioadsorbents can be ranked as (activated potato peel) > (natural potato peel) based on the findings.

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