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Purification of Aqueous Solutions from Chromium Using Glass Sand

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Abstract

This study aims to determine the ability of glass sand to absorb chromium from aqueous solutions. Glass sand samples were collected from the Rutba Formation (Cenomanian age) in the Western Desert of Iraq. Numerous laboratory experiments were conducted to test the effects of time and concentration on adsorption. For a duration of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 minutes, four initial chromium concentrations (20, 40, 60, and 80) were tested. Glass sand to chromium solution ratio was 2 grams to 30 ml. Total dissolved solids (TDS), electrical conductivity (EC), and pH values were measured at 30ºC. The equilibrium time is determined as 20 min in most concentrations. The equation of Freundlich showed that the adsorption intensity (n) is equal to 0.0603, the constant of the Freundlich equation (Kf) = 59.06, Langmuir equation showed the sorption capacity (Qo) equivalent to 1.0989 mg/g, (KL) is 0.0487. The absorption of chromium was modelled using both the Langmuir and Freundlich equations. It was discovered that glass sand had the highest efficiency in chromium adsorption for solutions with a concentration of 20, reaching 74.54, and clarified how glass sand material could benefit from reducing the chromium concentrations from aqueous solutions protecting the environment.

Keywords: Glass sand, Chromium, Adsorption, Aqueous solutions

تنقية المحاليل المائية من الكروم باستخدام رمل الزجاج

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الخلاصة

تهدف هذه الدراسة إلى تحديد قابلية الرمل الزجاجي على امتصاص الكروم من المحاليل المائية. جمعت عينات الرمل الزجاجي من تكوين الرطبة (العصر السينوماني) في الصحراء الغربية من العراق. تم إجراء العديد من التجارب المختبرية لاختبار تأثير الوقت والتركيز على الامتزاز للأزمنة 5، 10، 15، 20، 25، 30، 35، 40، 45، و 50 دقيقة، تم اختبار أربعة تراكيز أولية للكروم (20، 40، 60، و 80). كانت نسبة الرمل الزجاجي الى محلول الكروم 2 جرام الى 30 مل. تم قياس المواد الصلبة الذائبة الكلية (TDS)، الموصلية الكهربائية (EC)، وقيم الرقم الهيدروجيني عند 30 درجة سيليزية. تم تحديد وقت التوازن ب 20 دقيقة في معظم التراكيز. أظهرت معادلة فروندليتش ان شدة الامتزاز (n)تساوي 0.0603, ثابت معادلة فروندليتش (Kf) =59.06، معادلة لانجميور أظهرت قدرة الامتصاص (Qo) تعادل 1.0989 ملجم/جم، 0.0487 (KL). تطابقت قيم امتصاص الكروم مع معادلات لانجميور وفريندليتش. تبين ان افضل كفاءة

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لرمل الزجاج في امتزاز الكروم للمحاليل ذات التركيز 20 هي 74.54, كما تم توضيح كيفية الاستفادة من مادة رمل الزجاج في تقليل تراكيز الكروم في المحاليل المائية لحماية البيئة.

1. Introduction

The pollution of heavy metals is one of the most important issues influenced on the environment and human health due to the increase in human and industrial processes, which increases the amounts of waste generated [1, 2]. The continuous pollution of the water has increased significantly, which has negatively affected its quality. It has been noted that there is an apparent deficiency in the traditional treatment system used to remove toxic metals from the water. Therefore, it was necessary to explore new ways to purify the water and remove toxins from it by using them. Cheap and inexpensive ways to raise the level of purity of water and obtain better results than the methods currently used. This research focuses on finding another new material with high efficiency in the adsorption of chromium from the aqueous solutions taking into account the available material cost in our local environment, for example, palm leaves, sunflowers, and Nile flowers, and some types of clay. Its quantities are abundant. The previous treatments are simple and uncomplicated and can be performed on raw products, which gives an economic and health dimension to dealing with such materials [3]. This research used material, available in Al-Anbar Governorate (glass sand), to remove chromium metal from aqueous solutions. Chromium is one of nature's most important toxic elements [4]. It is a man-made contaminant in groundwater and surface water [5]. Soil, sediment, and groundwater can become contaminated with chromium [6]. Cr^{3+} is soluble and has low toxicity due to its lack of the oxidizing power that damages cells, while $Cr^{6+}$is highly soluble and carcinogenic. Due to the different geochemical behaviours of Cr^{3+} and Cr^{6+}, it is possible to remediate Cr^{6+} contamination by reduction, which can be caused by several processes, including adsorption [7].

Hence, the importance of ridding the environment of chromium in the aquatic environment. There are several ways to reduce concentrations of heavy metals; one of these is sorption, which plays a significant role in removing heavy metals and undesired components [8], [9] and [10]. Several synthetic or natural substances can reduce concentrations of heavy metals in aqueous solutions [1]. The glass sand was used in this research as an adsorbent to remove chromium from aqueous solutions. Large quantities of glass sand in the Umm Er Radhuma quarry amounted to (10.6 million tons). It consists of 95% quartz, the purest vitreous sand in the world. It is located 16 km southwest of Al-Rutbah in the Umm Er Radhuma region. Glass sand is used in industrial processes (white cement, glass, access roads, walkways, and garden paths; this sand looks good and shines like crystal in sunny weather) [11]. Because of its widespread availability in the surrounding environment, the use of various types of sand in the field of adsorption represents a viable and powerful tool that leads to a superior improvement in pollution control and environmental preservation [12]. Glass sand has been tested as an adsorbent for removal of chromium from aqueous solutions because it is a cheap and abundant materials. The effectiveness of inexpensive adsorbents in eliminating metal ions from aqueous solutions or wastewater has been amply demonstrated by earlier research. Many researchers developed an adsorbent material derived from transistor screen liquid crystal display (TFT-LCD) manufacturing waste. TFT-LCD screens commonly contain photoresist residues that were leveraged here for adsorptive applications. Specifically, the photoresist material's functional groups impart a net negative charge profile capable of strong electrostatic interactions with metal cations across a wide pH range. Prior work has shown such functionalities adsorb metals efficiently via ion exchange mechanisms. Later, researchers thus postulated the TFT-LCD-based adsorbent could sequester metals through this ion exchange functionality. Initial characterizations indeed revealed adsorption capacity peaked between pH 1.5-7.0, suggesting the photoresist-derived material presented viable negatively-charged sites to attract and immobilize metallic contaminants through electrostatic attraction forces dependent on pH conditions [13]. The effectiveness of inexpensive adsorbents such as transistor screen liquid crystals (TFT-LCD) and some types of clay in eliminating metal ions from aqueous solutions or wastewater has been amply demonstrated by earlier research. This study aims to eliminate chromium from an aqueous solution using glass sand collected from the glass sand mine in the Western Desert of Iraq.

2. Materials and Methods

The glass sand samples were collected from the quarry in the Umm El-Ruduma area (Figure 1). The glass sand mine is located within the Rutba Formation (Cenomanian age) (Figure 2). in the Western Desert, approximately 16 km southwest of the city of Rutba, in a flat area and is defined by the coordinates 32 57 41.28N, 40 08 25.24E, 622m elevation.

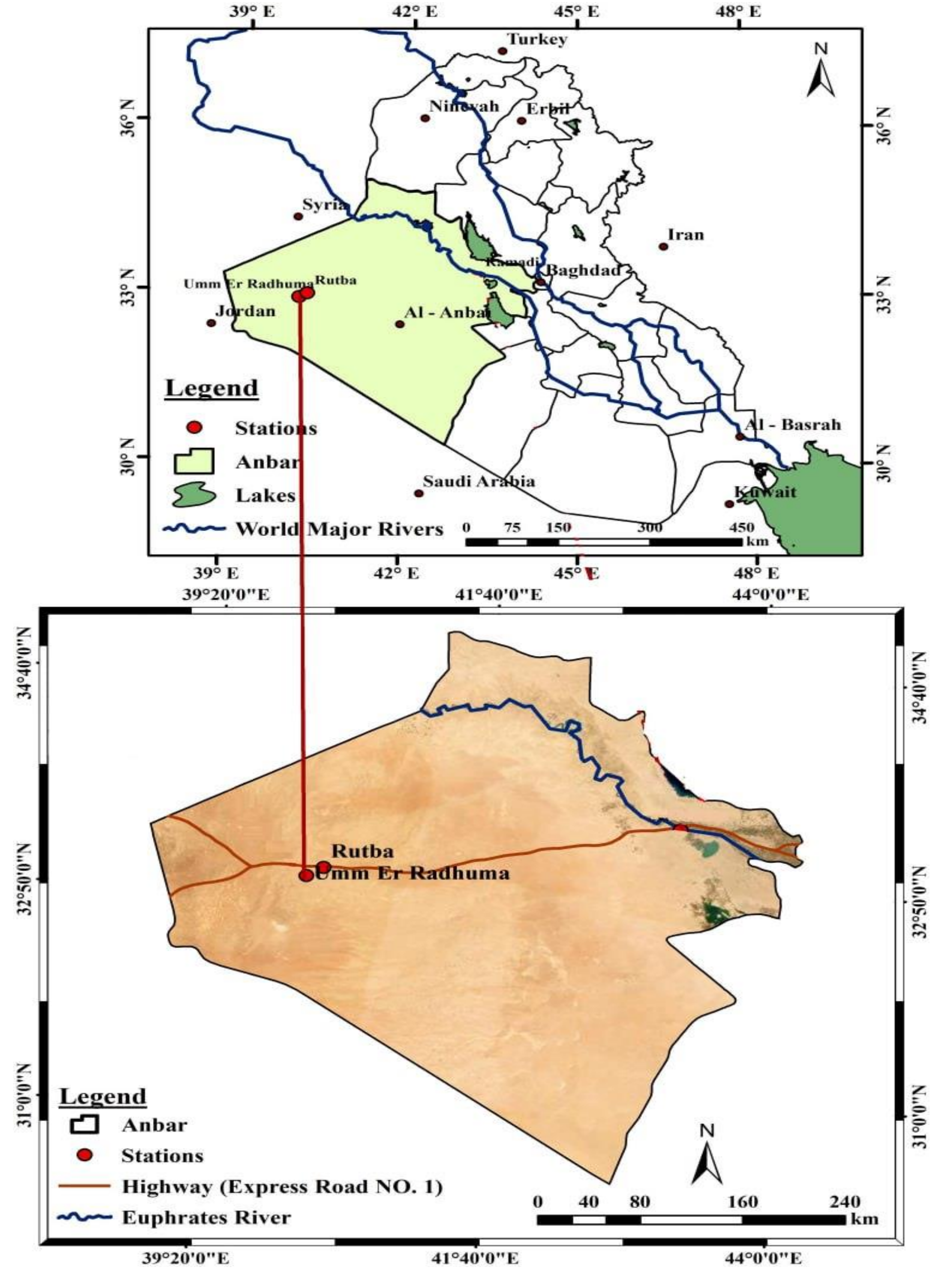

Figure 1: Location maps show the Umm Er Radhuma area as a sampling site

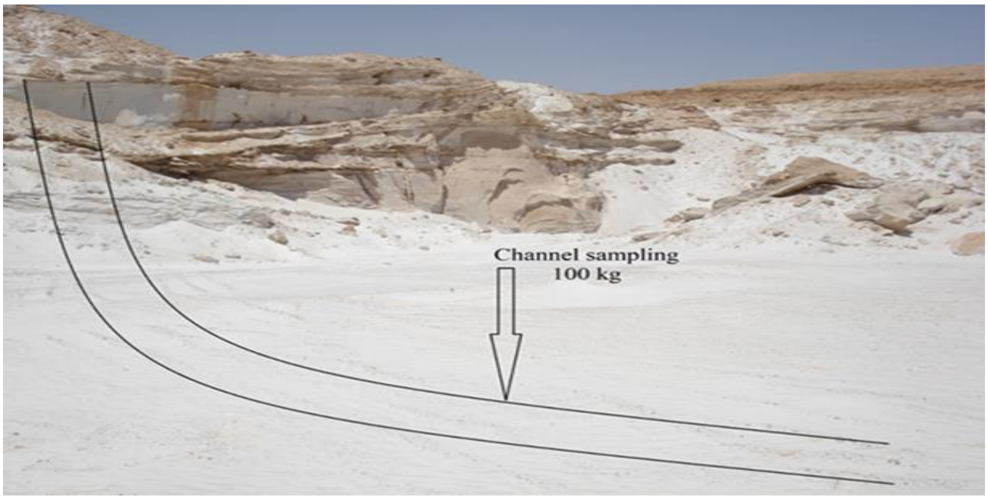

Figure 2: Glass sand mine shows the channel sampling

The samples of glass sand were prepared in the soil and water lab and Chemistry Department at Anbar University. An electric grinder was used to ground the sample after washing and drying. Analyses of grain size followed that. The particle size chosen in diameter as a silt size (0.002 - 0.05 mm at diameter) for test silt particle sizes at the adsorption processes. The powder of the glass waste is shown in Figure 3. The samples of glass sand were checked for chemical analysis by using XRF in the University of Baghdad at the Department of Geology in the Iraqi Germany Laboratory. Mineralogical analysis using XRD in the XRD Laboratory at the Department of Material Sciences in the Ministry of Science and Technology. A 7.6966 g of chromium nitrite was used to prepare 1 litre of distilled water (Figure 4). For preparing chromium solution with a concentration of 1000 ppm. From the chromium solution, four concentrations were prepared (20, 40, 60, and 80 ppm). Experiments were carried out using 2 g from powder of glass sand with 30 ml from solution of chromium. TDS, EC and pH were measured before starting each of experiment. There are conducted 40 laboratory experiments during which used an electric shaker to put the solutions at a 30 °C for test the adsorption efficiency for the sample of glass sand. The determined of equilibrium concentration at the time of reaction end between chromium solution and powder of glass sand. The adsorption efficiency was determined by using 10 solutions of concentration 20 ppm, after every 5 min, one sample is taken and filtered using filter paper (Figure 5). This process is repeated every 5 minutes on the ten samples in the electric shaker. The concentration of chromium was identified by using the atomic absorption spectrophotometer, the pH, TDS and EC were measured in the equilibrium state by using pH meter and EC meter (Figure 6). Under the same conditions, the experiments repeated at all concentrations.

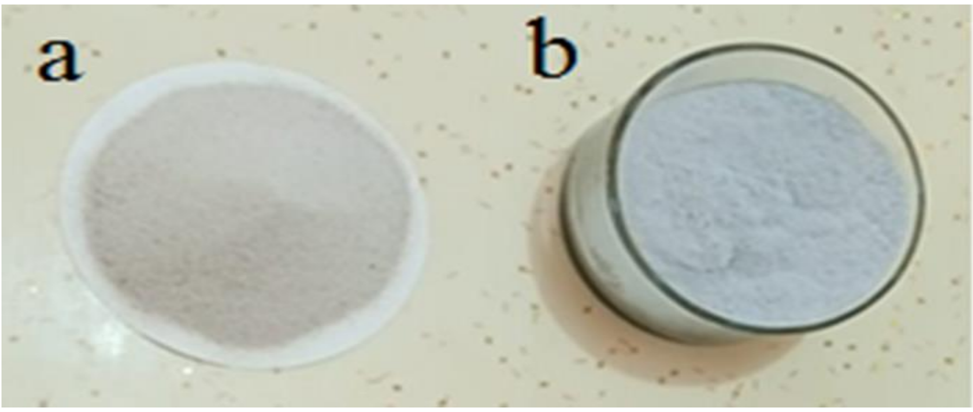

Figure 3: Sample of glass sand (a), glass sand as a silt-size powder (b)

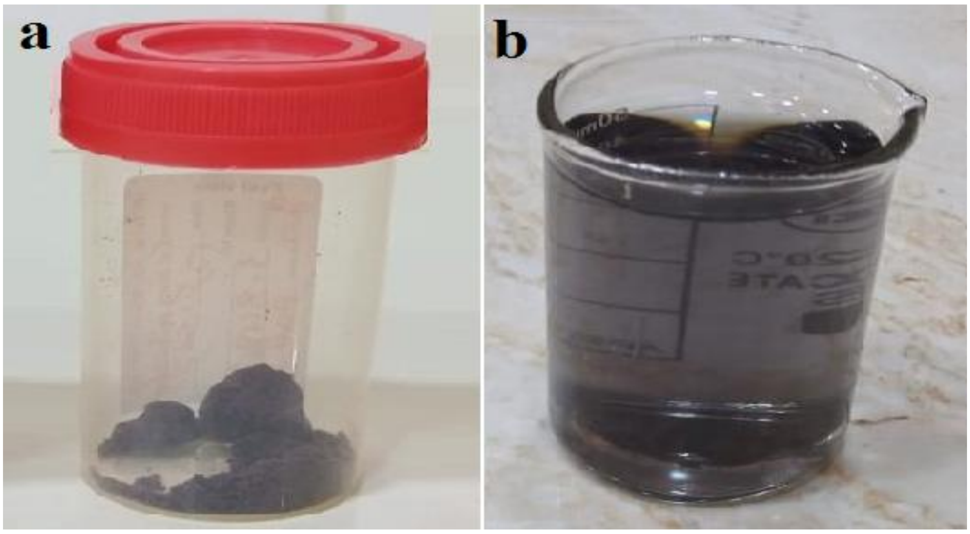

Figure 4: Chromium nitrate (a), Soluble chromium nitrates 1000 ppm (b)

Figure 5: The process of filtration for chromium solution from glass sand after the process of sorption

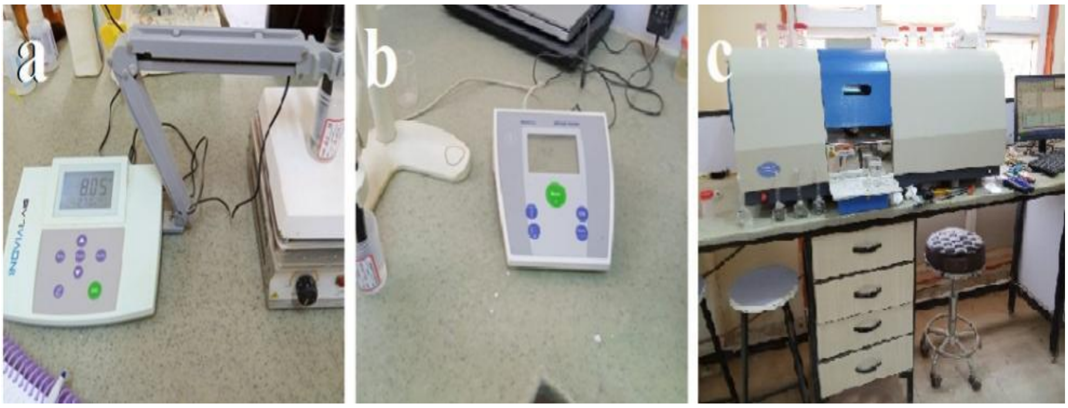

Figure 6: pH meter (a); EC meter (b); Atomic absorption spectrophotometer (c)

3. Results and discussion

3.1 Mineralogy and chemical composition for glass sand

The bulk mineralogical composition of the glass sand was investigated using X-ray powder diffraction (XRD). The diffractogram obtained is presented in Figure 7. The pattern reveals that quartz is overwhelmingly the most prevalent phase present, comprising over 90% of the crystalline material by mass. Minor amounts of additional minerals are also detected but feature much smaller peak intensities relative to quartz. The virtually pure quartz signature is characteristic of commercial glass sands and confirms this sample is dominated by silicon dioxide, the primary component required for glass sand.

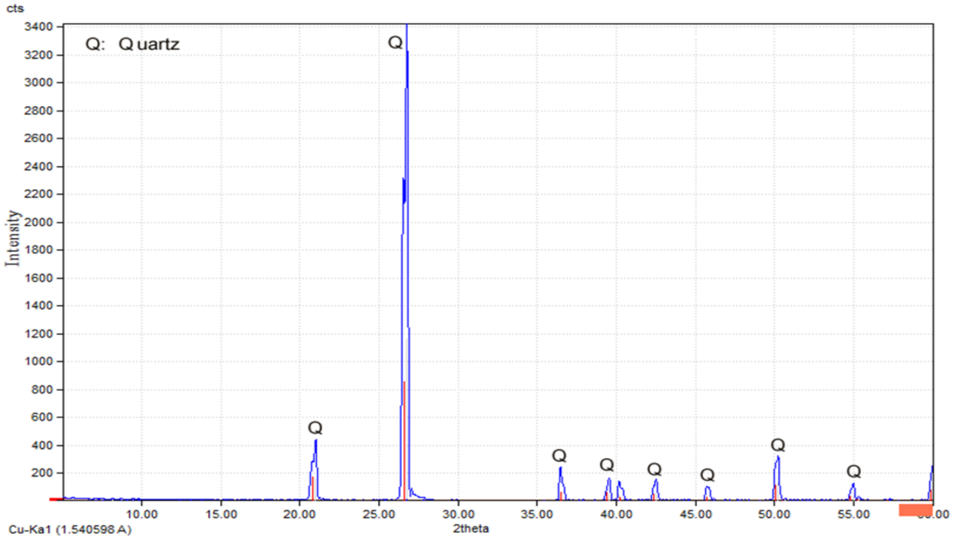

Figure 7: The diffractogram of glass sand material

In terms of geochemistry, the glass sand composed of SiO_2 (94.82), Al_2O_3 (0.88), Fe_2O_3 (0.42), CaO (0.26), TiO_2 (0.2), SO_3 (0.11), P_2O_5 (0.05), ZrO_2 (0.05), Cr_2O_3 (0.05), Cl (0.037), Na_2O (< 0.014) and LOI (2.1). The chemical composition of the glass sand sample is listed in Table 1**.**

Table 1: Composition for glass sand using technique of XRF

Oxides	%
SiO_2	94.82
Al_2O_3	0.88
Fe_2O_3	0.42
CaO	0.26
TiO_2	0.2
SO_3	0.11
P_2O_5	0.05
ZrO_2	0.05
Cr_2O_3	0.05
Cl	0.037
Na_2O	< 0.014
LOI	2.1
Total	98.97

3.2 Sorption efficiency

3.2.1 Initial solution effect

In this study, several key parameters were varied to evaluate their impact on the Cr(VI) sorption process using the synthesized sorbent. The factors investigated included initial chromium concentration (ranging from 20-80 ppm), contact time (determined at regular intervals), solid-to-liquid ratio, and temperature. By systematically modifying these process conditions, the research team aimed to elucidate how they influence sorption efficiency and kinetics. Initial chromium concentration was adjusted to assess sorption capacity across representative low to moderately high contaminant levels. All the experiments were conducted to test the adsorption (%) of glass sand at each concentration as below:

3.2.2 Concentration and time effects

To thoroughly probe the impact of contact time on Cr (VI) removal, a series of 40 laboratory-scale batch experiments were conducted. In these tests, ten discrete time intervals—ranging from 5 to 50 minutes at 5-minute increments-were systematically evaluated while keeping all other experimental conditions constant. Specifically, the sorbent mass was fixed at 2 g, the volume of synthetic solution was maintained at 30 mL, and temperature was regulated at 30°C. These experiments aimed to determine the sorption percent and the equilibrium time, representing the end time of the reaction process. The chromium concentration decreased from 20 to 4.87 ppm, and the chromium sorption (%) was recorded 74.45 % (Table 2). A concentration of 40 ppm remains at 12.11 ppm, and the chromium sorption (%) recorded 68.82 % Table 3. A concentration of 60 ppm remains at 22.09 ppm, and the chromium sorption (%) is recorded 62.5 % (Table 4). Meanwhile, a concentration of 80 ppm remains at 33.64 ppm, and the chromium sorption (%) was recorded 57.56 % (Table 5). The equilibrium concentration for the chromium of 20 ppm existed at 20 min (Table 2 and Figure 8); 40 ppm existed at 20 min (Table 2 and Figure 9); 60 ppm existed at 20 min (Table 2 and Figure 10), at the same time, 80 ppm existed at 25 min (Table 2 and Figure 11).

Table 2: Results of the laboratory experiments for chromium adsorption by glass sand at ten times of solutions (20 ppm) at 30ºC

Samples	**Before experiment**				**After experiment**					
	Time	**pH**	**EC (µs/cm)**	**TDS (mg/l)**	**pH**	**EC (µs/cm)**	**TDS (mg/l)**	**Final conc. (ppm)**	**Sorption (ppm)**	**Sorption (%)**
1Cr	5	3.71	582	403.3	5.40	364	245	7.71	12.29	61.45
2 Cr	10	3.71	582	403.3	5.39	330	221	6.67	13.33	66.65
3 Cr	15	3.71	582	403.3	5.41	302	198	5.98	14.02	70.1
4 Cr	20	3.71	582	403.3	5.42	287	192	5.11	14.89	74.45
5 Cr	25	3.71	582	403.3	5.41	276	184	5.05	14.95	74.75
6 Cr	30	3.71	582	403.3	5.43	271	179	4.97	15.03	75.15
7 Cr	35	3.71	582	403.3	5.41	265	170	4.9	15.1	75.5
8 Cr	40	3.71	582	403.3	5.41	262	171	4.91	15.09	75.45
9 Cr	45	3.71	582	403.3	5.42	260	170	4.88	15.12	75.6
10 Cr	50	3.71	582	403.3	5.42	261	168	4.87	15.13	75.65

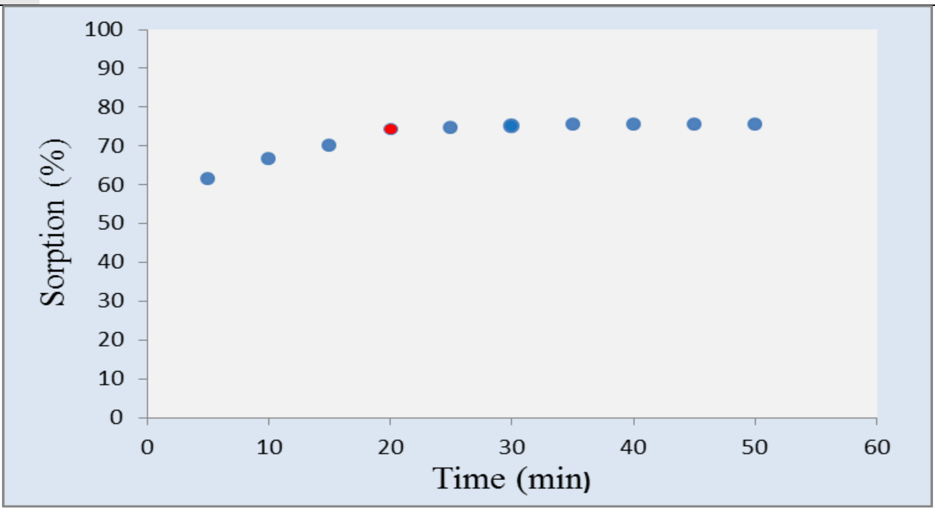

Figure 8: Sorption efficiency and equilibrium concentration for the glass sand in removing chromium from solution (20 ppm) in 20 minutes

Table 3: Results of the laboratory experiments for chromium adsorption by glass sand at ten times of solutions (40 ppm) at 30ºC

Samples	Before experiment				After experiment					
	Time	pH	EC (µs/cm)	TDS (mg/l)	pH	EC (µs/cm)	TDS (mg/l)	Final conc. (ppm)	Sorption (ppm)	Sorption (%)
1Cr	5	3.62	837	601.8	5.22	518	340	17.81	22.19	55.47
2 Cr	10	3.62	837	601.8	5.23	482	315	15.01	24.99	62.47
3 Cr	15	3.62	837	601.8	5.26	455	301	13.76	26.24	65.6
4 Cr	20	3.62	837	601.8	5.26	441	294	12.52	27.48	68.7
5 Cr	25	3.62	837	601.8	5.27	428	289	12.39	27.61	69.02
6 Cr	30	3.62	837	601.8	5.27	419	280	12.13	27.87	69.67
7 Cr	35	3.62	837	601.8	5.27	415	276	12.11	27.89	69.72
8 Cr	40	3.62	837	601.8	5.28	413	274	12.18	27.82	69.55
9 Cr	45	3.62	837	601.8	5.28	411	272	12.28	27.72	69.3
10 Cr	50	3.62	837	601.8	5.28	410	273	12.19	27.81	69.52

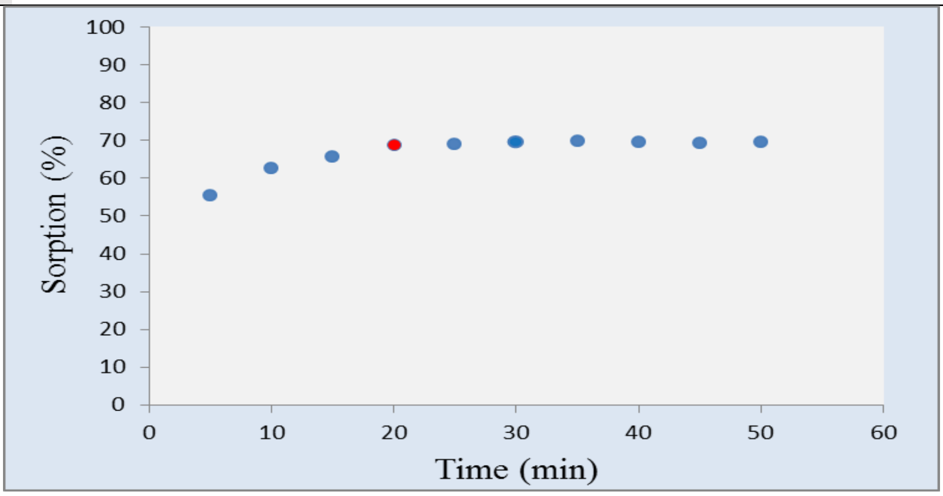

Figure 9: Sorption efficiency and equilibrium concentration for the glass sand in removing chromium from solution (40 ppm) in 20 minutes

Table 4: Results of the laboratory experiments for chromium adsorption by glass sand at ten times of solutions (60 ppm) at 30ºC

Samples	Before experiment				After experiment					
	Time	pH	EC (µs/cm)	TDS (mg/l)	pH	EC (µs/cm)	TDS (mg/l)	Final conc. (ppm)	Sorption (ppm)	Sorption (%)
1Cr	5	3.50	1093	795.7	5.01	690	468	30.73	29.27	48.78
2 Cr	10	3.50	1093	795.7	5.05	647	435	27.79	32.21	53.68
3 Cr	15	3.50	1093	795.7	5.12	620	414	23.92	36.08	60.13
4 Cr	20	3.50	1093	795.7	5.14	604	401	22.37	37.63	62.71
5 Cr	25	3.50	1093	795.7	5.15	590	396	22.46	37.54	62.56
6 Cr	30	3.50	1093	795.7	5.17	579	393	22.09	37.91	63.18
7 Cr	35	3.50	1093	795.7	5.17	574	390	22.11	37.89	63.15
8 Cr	40	3.50	1093	795.7	5.17	570	387	22.1	37.9	63.16
9 Cr	45	3.50	1093	795.7	5.19	568	385	22.1	37.9	63.16
10 Cr	50	3.50	1093	795.7	5.19	567	384	22.11	37.89	63.15

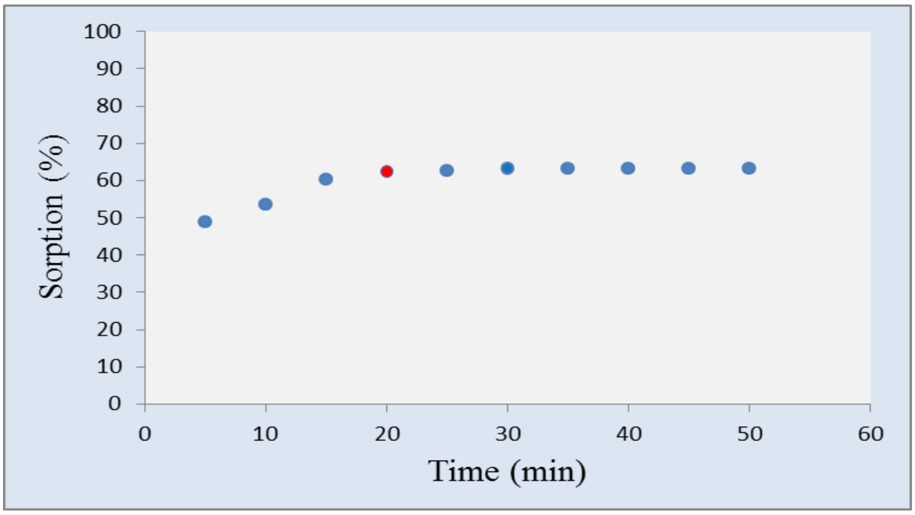

Figure 10: Sorption efficiency and equilibrium concentration for the glass sand in removing chromium from solution (60 ppm) in 20 minutes.

Table 5: Results of the laboratory experiments for chromium adsorption by glass sand at ten times of solutions (80 ppm) at 30ºC.

Samples	**Before experiment**				**After experiment**					
	Time	**pH**	**EC (µs/cm)**	**TDS (mg/l)**	**pH**	**EC (µs/cm)**	**TDS (mg/l)**	**Final conc. (ppm)**	**Sorption (ppm)**	**Sorption (%)**
1Cr	5	3.40	1357	986.3	4.84	867	571	45.64	34.36	42.95
2 Cr	10	3.40	1357	986.3	4.9	812	554	40.71	39.29	49.11
3 Cr	15	3.40	1357	986.3	4.93	780	531	35.92	44.08	55.1
4 Cr	20	3.40	1357	986.3	4.96	761	516	34.36	45.64	57.05
5 Cr	25	3.40	1357	986.3	4.99	746	505	33.95	46.05	57.56
6 Cr	30	3.40	1357	986.3	5.1	738	498	33.64	46.36	57.95
7 Cr	35	3.40	1357	986.3	5.13	735	496	34.09	45.91	57.38
8 Cr	40	3.40	1357	986.3	5.15	733	497	34.13	45.87	57.33
9 Cr	45	3.40	1357	986.3	5.17	732	494	34.19	45.81	57.26
10 Cr	50	3.40	1357	986.3	5.17	730	490	34.16	45.84	57.3

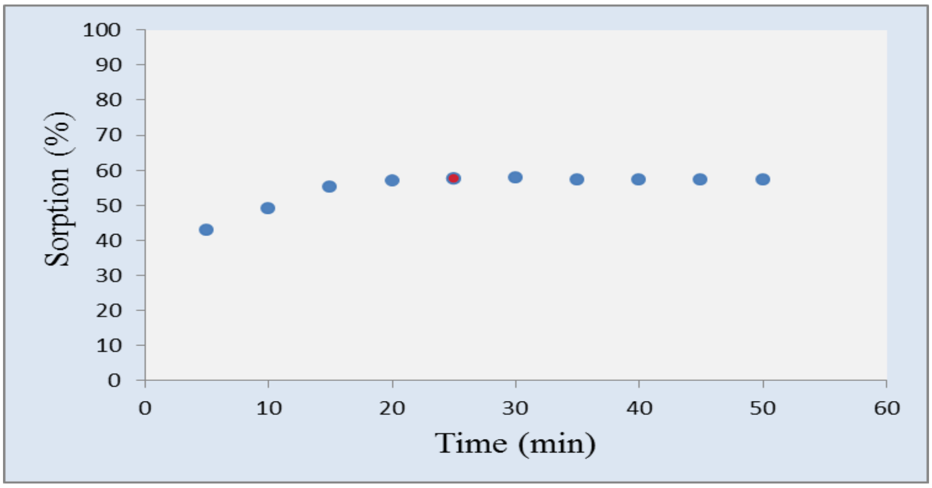

Figure 11: Sorption efficiency and equilibrium concentration for the glass sand in removing chromium from solution (80 ppm) in 20 minutes

The sorption (%) for chromium was studied at four concentrations (20, 40, 60 and 80 ppm), as Figure 12 shows an inverse relationship between the sorption (%) and concentrations (decreased sorption efficiency with increased concentration at the equilibrium concentration). As a result, the best sorption, 74.45 (%), occurred at the chromium solution with an initial concentration of 20 ppm.

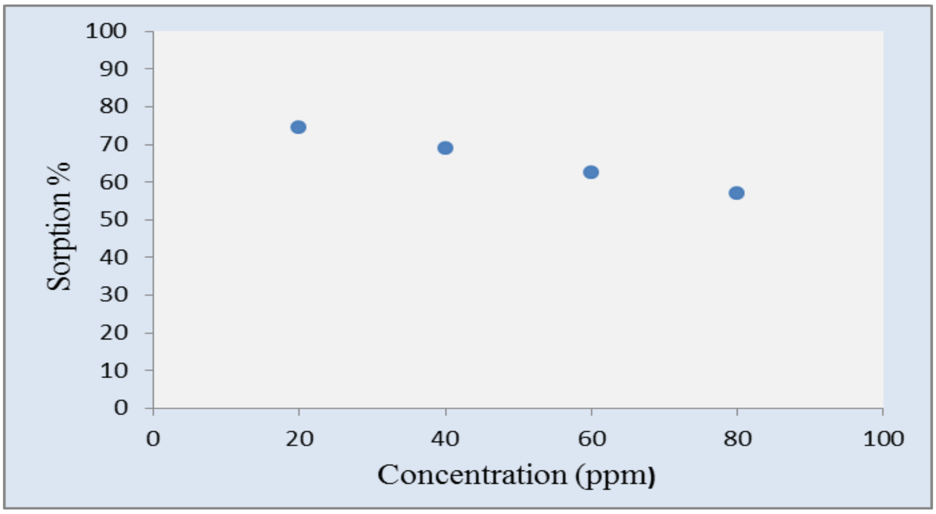

Figure 12: Sorption efficiency (%) of different concentrations of chromium at equilibrium state

4. Modeling of data for adsorption

In this research, the adsorption models have been described by two commonly used models, namely Langmuir and Freundlich. The Langmuir [14] and Freundlich [15], which are the standard equations used worldwide, were applied in this study to understand the sorption intensity, sorption capacity and identify the possibility of compatibility of the adsorption processes with the Langmuir and Freundlich equations. The adsorption equations [16] explain the relationship between the equilibrium concentration at a constant temperature and the amount of adsorbate material (chromium) on the adsorbent surface (glass sand).

4.1. Langmuir Equation

Langmuir explained in the equation that the surfaces of adsorbent materials contain many effective points distributed over the surface area of the adsorbent material so that only one ion or molecule is absorbed at each site on the surfaces of these active sites. In addition, the active sites have a capacity equal to the absorption energy of any site. Otherwise, adsorption is either chemical or physical, between the surface and the adsorbed material, and is independent when interacting with molecules close to it. Langmuir also showed that the adsorption speed increases rapidly at the beginning of the process and then tends to stabilize until it gradually reaches a state of equilibrium. The reason for desorption is the separation of some molecules from the absorbed surface of the solution due to thermal excitation and saturation [17].
Langmuir equation for the sorption can be mathematically represented as:

$$\frac{C_e}{Q_e} = \frac{1}{KLQ_\circ} + \frac{C_e}{Q_\circ} \qquad \text{-------------------- (1)}$$

Where:
C_e = equilibrium concentration for adsorbate (mg/L)
Q_o = the maximum monolayer coverage capacity (mg/g)
Q_e = amount of adsorbed of material per gram for the adsorbent in equilibrium (mg/g).
K_LQ_o: the constants of Langmuir empirical.

By model Ce/ Qe against Ce. It showed a slope with a straight line for $1/Q_o$ and an intersection for the value of $1/K_LQ_o$, where K_L and Q_o were identified from the model's intercept and slope [18], as shown in Figure 12.

The Qo represents the maximum sorption ability, KL is an equilibrium constant representing the bond energy between the adsorbate and adsorbent [18]. The amounts of adsorbent materials were identified based on the equation:

$$Q_e = \frac{V_{sol}\,(C_o - C_e)}{M} \qquad \text{----------------} \ (2)$$

Vsol = adsorbent solution volume (L)

C_o = initial concentration for the adsorbent solution(mg/l).

M = adsorbent mass (gm).

The efficiency of removal was determined by computing the sorption of percentage by the following formula:

$$R\% = \frac{(C_o - C_e)}{C_o} \times 100 \qquad \text{--------} \ (3)$$

R% = percentage of adsorption (sorption efficiency).

Were:

R%= Sorption%.

Where C_o and C_e are the initial and final ion concentrations at the equilibrium concentration, respectively.

Table 6: Sorption (%) for Cr by glass sand at several concentrations and their corresponding values of Qe and Ce

Sample	*Cr* (mg/L)	(*R %*)	*Ce* (mg/L)	*Qe* (mg/g)	*Ce / Qe* (g/L)
1	20	74.45	5.11	0.223	22.878
2	40	68.82	12.52	0.412	30.373
3	60	62.5	22.37	0.564	39.631
4	80	57.05	33.95	0.690	49.149

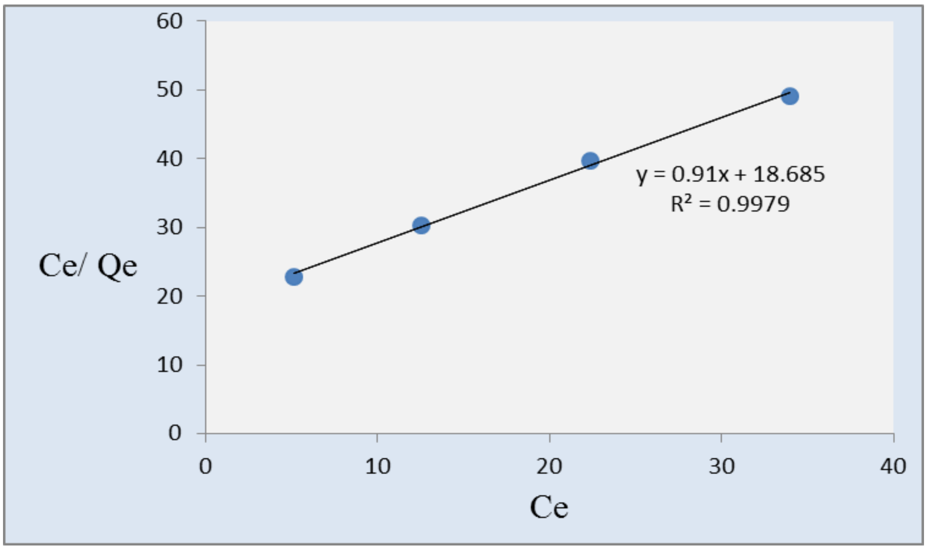

Figure 13: Langmuir model for adsorption of Cr with glass sand

The maximum of the monolayer coverage capacity (Q_o) from the Langmuir model was determined to be (1.0989mg/g). Langmuir constant related to adsorption (KL) energy is (0.0487). The adsorption correlates well with the Langmuir equation, where R^2 is 0.997 Figure 12. This proves that the adsorption data fits with the Langmuir model. Al Nasir and

Mohammed [19] applied the isotherms testing the adsorption of methyl orange using eggshells as adsorbent surface.

4.2 Freundlich Equation

Since sorption is likely to occur at multiple molecular layers (multilayer), the Langmuir equation did not apply to many sorption systems in solutions. Additionally, solid surfaces are heterogeneous due to irregularities in potential energy changes caused by varying energy levels at the adsorption sites [20]. To depict the change in the amount of adsorbed substance per unit area or mass for the adsorbed substance with the equilibrium state (equilibrium concentration), a German scientist named Friedrich developed the following equation [21].

$$Q_e = KfC_e^{1/n} \qquad \text{---------- (4)}$$

Were:

Q_e = amount of metal adsorbed per gram for the adsorbent at equilibrium (mg/g).

C_e = equilibrium concentration for adsorbate (mg/L).

n = intensity of adsorption.

Kf = Freundlich constant (mg/g).

The equation (5) is derived from the previous equation:

$$\text{Log } Q_e = \text{Log } Kf + \frac{1}{n} \text{ Log } C_e \qquad \text{---------- (5)}$$

The n constant represents adsorption intensity, adsorption capacity is roughly indicated by the Kf constant, and the strength of adsorption at the adsorption process is determined by 1/n [22]. Based on the intercept and slope of the Freundlich plot in Figure 13, the values of 1/n and Log Kf were calculated.

Table 7: Sorption (%) for Cr by glass sand of several concentrations and their corresponding values of Log Qe and Log Ce

Sample	*Cr* (mg/L)	(*R %*)	*Ce* (mg/L)	*Qe* (mg/g)	*Log Ce*	*Log Qe*
1	20	74.45	5.11	0.223	0.7084	-0.6516
2	40	68.82	12.52	0.412	1.0976	-0.3851
3	60	62.5	22.37	0.564	1.3496	-0.2487
4	80	57.05	33.95	0.690	1.5308	-0.1611

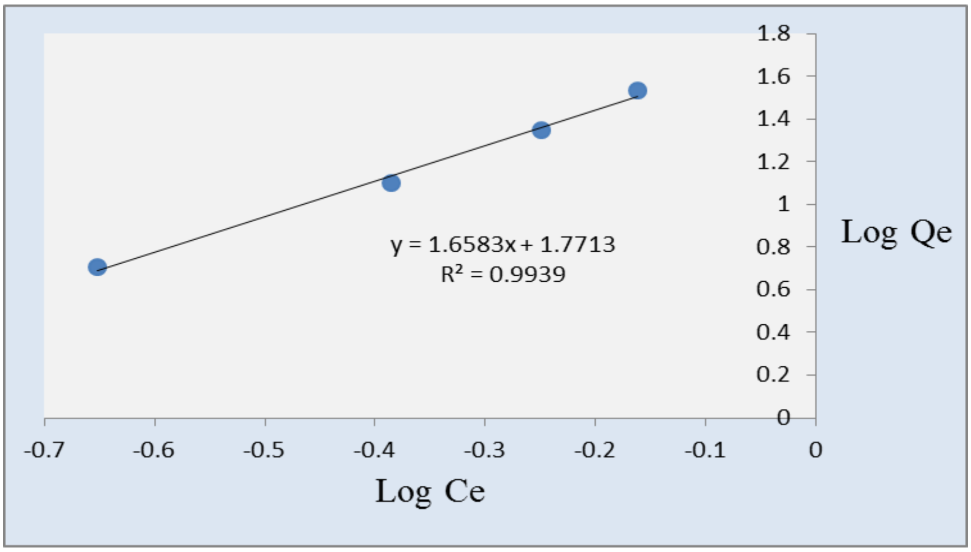

Figure 14: Freundlich diagram for adsorption of Cr with glass sand

From the values in Table 8 and Figure 13, the value $1/n= 1.6583$ means $n=0.0603$, $Kf = 59.06$, and R^2 is 0.993. This shows that the adsorption of chromium is consistent with the Freundlich model. The values of maximum adsorption of the bonding energy obtained and the maximum adsorption capacity are a real guide to the nature of the real interaction between the ions and the sorption surface [23]. Awadh and Fatma (2017) [24] applied the isotherms testing the natural bentonite for purification the aqueous solution form lead.

Conclusions

The research was investigated the ability of glass sand to absorb chromium from aqueous solutions, drawing several significant findings. The research results showed that the equilibrium time for chromium concentrations of 20, 40, and 60 ppm is 20 minutes, while it is 25 minutes for the concentration of 80 ppm. In solutions with high concentrations, reverse adsorption often occurs, which is the release of ions into the solution due to the weak bond between the adsorbent and the adsorbent. Which causes the absorption efficiency to be lower than it was at equilibrium concentration. The decrease in dissolved solids over time and after the adsorption process confirmed the occurrence of the adsorption process, reflecting the efficiency of the increased sand and its ability to adsorption. A significant variation was recorded in the removal percentage, ranging from 74.45 to 57.56%, proportional to the increase in chromium concentration from 20 to 80 ppm. The results is considered the glass sand is a good material for removing chromium from solutions, and applicable for protecting the aquatic environment from chromium worldwide.

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