# Experimental investigation of the removal of cobalt heavy metal from aqueous solutions using thermally modified dolomite powder

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**A B S T R A C T**

This research aims to make a thermally modified dolomite absorbent with stable properties and high porosity to increase the capacity and efficiency of removing cobalt from water bodies. First, raw dolomite was thermally modified and then washed with a buffer borax solution, and boric acid for MgO was removed from the newly created pores. This treatment led to changes in the chemical composition of the surface and the porosity of natural materials that increased the active surface and absorption properties of dolomite. The results showed that unmodified dolomite has a limited adsorption capacity with a final residual cobalt concentration of 0.852 mg/L. FTIR, SEM, and BET analysis adsorbent surface properties, permeable morphology, and qualitative phase identification. Also, the effect of three operational parameters of initial solution concentration, contact time and temperature was evaluated in the ranges of (10-20-30-50-70-100-200 ppm), (5-10-20-30-45-60-90-240 min) and (30-40-50 °C), respectively. The experiments showed the maximum removal efficiency at a concentration of 10 ppm, a time of 240 min, and a temperature of 30 ºC. In addition, increasing the contact time from 5 to 240 minutes leads to the maximum cobalt removal percentage of 99.218%. The investigation of equilibrium isotherms is in good agreement with the Langmuir model, and kinetic and thermodynamic studies showed that the absorption process follows pseudo-second kinetics and is exothermic.

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## 1. Introduction

Cobalt, manganese, selenium, nickel, molybdenum, iron and zinc are required for the normal daily functioning of the body and are all part of heavy metals (Gunatilake, 2015). However, the entry of heavy metals into the body in excess of the permissible limits causes poisoning. Pollution of water resources with heavy metals, including cobalt, is one of the serious environmental and health challenges in the world today. Due to its widespread use in various industries such as battery manufacturing and alloys, cobalt is increasingly entering water resources and has destructive effects on

human health and the environment. Conventional methods for removing cobalt, including the use of magnetic nanoparticles, the use of activated carbon prepared from agricultural waste, the use of nanoceramics and coagulants and multi-walled carbon nanotubes or biosorbents, although they are highly efficient, are associated with challenges such as high operating costs, complexity of the separation process and the production of secondary pollution. These materials can create limitations for industrial applications (Mitra et al., 2022).

In recent years, due to the increase in industries, population growth and expansion of industrial activities, heavy metal ion pollution in water resources has increased. The entry of heavy metals such as cobalt and other metals of this group into running waters and surfaces through the effluent of these industries is a subject that has attracted the attention of the officials of these production units as well as the environmental organization. Therefore, the removal of toxic metal ions from aqueous solutions is of interest from environmental, economic and public health perspectives (Zamora-Ledezma et al., 2021). Several purification technologies such as adsorption, solvent extraction, precipitation, membrane filtration and ion exchange have been developed to remove metal ions from aqueous solutions. Among these methods, adsorption is a useful and practical method for metal ion removal compared to other processes (Saleh et al., 2022). In the adsorption method, various natural and synthetic adsorbents have been used to remove metal ions. Synthetic adsorbents such as activated carbon are widely used in wastewater treatment applications worldwide. Despite their useful use, synthetic adsorbents are still expensive materials, but the quality of these adsorbents is higher. This situation makes their widespread use in small and low-scale industries no longer attractive due to cost inefficiency. Due to the problems mentioned earlier, interest in researching alternative adsorbents instead of expensive adsorbents has increased in recent years (Qasem et al., 2021). Attention has been focused on various adsorbents that have metal binding capacity and can remove unwanted heavy metal ions from polluted water at low cost. Natural materials or in other words, mineral adsorbents, the subject of our study, are classified and introduced as cheap adsorbents due to their cheapness and local availability. Many different natural minerals such as perlite, chitosan, zeolite and clay or some waste materials from industrial activities such as fly ash, coal and mineral oxides are available, which have high adsorption capacity and can remove metal ions from water. With reasonable removal costs, low-cost adsorbents are still needed and should be easily produced and disposed of without lasting environmental impacts (Eniola et al., 2023). So far, various scientific reports and articles have reported and emphasized a review of natural and synthetic adsorbents and their potential applications for the removal of harmful metal ions.

This research aims to investigate its adsorption potential as a low-cost adsorbent from aqueous solution by using the preparation of modified dolomite mineral adsorbent from raw dolomite as a cheap and low-cost adsorbent and investigating different operating conditions to provide a more economical and practical solution for the removal of cobalt. Initially, dolomite was prepared in powder form in a certain amount and then thermal modification was performed on it up to 800 °C in a non-vacuum furnace. By thermal modification and washing with a mixture of borax and boric acid buffer to remove MgO

from the pores, the desired adsorption was achieved. Then, the operating parameters of initial concentration, contact time and temperature were investigated, and then equilibrium isotherms and kinetic and thermodynamic adsorption models were investigated. Heating dolomite causes the conversion of carbonate compounds into calcium and magnesium oxides. This chemical change increases the reactivity and ability to absorb pollutants, especially cobalt. By thermal modification and washing with borax and boric acid buffer, new pores are created in the dolomite structure. These pores provide more active surface area, which helps increase the adsorption capacity. Also, heated dolomite has higher resistance to environmental conditions, which can contribute to better efficiency in water treatment processes. By increasing the adsorption efficiency, the need for repeated use of the adsorbent is reduced, which can reduce the overall costs of the treatment process. In general, thermal modification of dolomite not only increases its adsorption capacity but also improves its efficiency in removing pollutants, which makes it a suitable option for environmental applications.

## 2. Materials and Methods

### 2.1. Materials

Natural dolomite from the Semnan mine was used as the primary raw material. To increase the adsorption capacity of dolomite powder, a thermal modification method was used to remove cobalt from aqueous solutions. All chemicals used to prepare buffer and borax solutions and other experiments were purchased from Sigma with 99% purity. Initially, a stock solution with a concentration of 1000 mg/L was prepared, and subsequent dilutions were made using distilled water. HCL (0.1 M) and NaOH (0.1 M) were used to adjust the required pH.

### 2.2. Adsorbent synthesis
#### 2.2.1. Thermal modification of dolomite adsorbent

Unmodified dolomite powder was sourced from mineral deposits and subjected to thermal modification in a furnace at a temperature of 800°C with a heating rate of 4°C/min for 3 hours. Afterward, the modified dolomite was washed using a borax buffer solution and boric acid to remove MgO from the newly created pores. This treatment led to changes in the chemical composition of the surface and the porosity of the natural material, ultimately increasing the active surface area and enhancing the adsorption properties of dolomite (Ghassabzadeh et al., 2010; Glasson, 1964; Loganathan et al., 2013).

### 2.1.1. Preparation of buffer solution using borax and boric acid

In this experiment, according to the previous research, the borax buffer method was prepared for better absorption. The molar ratio of salt to acid: 1 to 4 (3.06 grams of boric acid and 4.75 grams of borax) was weighed exactly. These materials were dissolved in distilled water and its volume was diluted to 250 ml. Boric acid may take some time to dissolve. Checking numbers and figures in the preparation of solutions using borax, the molar mass of borax is 6.22 times the molar mass of boric acid, so to prepare a buffer solution containing these two substances, it is enough to mix 1.4 moles of borax with one mole of boric acid (this the amount is equal to about 1.5 grams of sodium tetraborate and 1 gram of boric acid). Based on the numbers mentioned above, 75.4 grams of borax should be multiplied by the molecular mass, and the value of 0٠0124 moles of borax is obtained. For acid, if 3٠06 grams of acid is multiplied by its molecular mass, the value is 0٠049 g of boric acid is obtained.

## 2.2. Surface properties of Modified dolomite

The surface characteristics and morphology of the synthesized adsorbent were determined by scanning electron microscopy (SEM) (Tescan vega3 model). The surface functional groups of the samples were determined using Fourier transform infrared spectroscopy (FT-IR) (AVATAR). The adsorbent surface with it was measured using BET analysis (BEL PREP VAC II, Japan).

## 2.3. Obtaining absorption quantities

To calculate the values of the absorption process, experiments were carried out in the discontinuous system. First, the mother solution was prepared by dissolving 0.246 grams of cobalt salt in 1000 ml of distilled water. Then by diluting the mother solution, solutions with a concentration of 10 to 200 mg/liter were prepared. Then, a certain amount of adsorbent was added to 100 ml of solution containing cobalt. Shaker with 300 rpm was used to mix the solution and HNO3 was used to adjust the pH of the solutions so that the pH reached 6. After reaching the equilibrium state, the modified dolomite adsorbent was separated from the solution, and after passing the solution through the filter paper, it was sent to the ICP test to obtain the final amount of cobalt.

The amount of percentage removal from the solution and the amount of absorbent capacity $q_e$ were computed based on the following equation:

$$\% \, R = \frac{C_0 - C_e}{C_0} \times 100 \tag{1}$$

$$q_e = \frac{C_0 - C_e}{m} \times V \tag{2}$$

where $C_e$ and $C_o$ are the equilibrium and initial concentration of MB (mg.L$^{-1}$) respectively, V is the volume of MB solution (L) and m is the mass of the adsorbent (g) (Pehlivan et al., 2009; Sackiran & Esen., 2024).

### 2.3.1. Adsorption isotherm

Examining adsorption isotherms can be a description related to the absorption process. The absorption isotherm is the relation between the dye concentration in the solution and the amount of dye absorbed in the solid phase, in the condition that both phases are in equilibrium with each other. The Langmuir isotherm model shows the adsorption of a single layer containing the same adsorption sites, and its adsorption equation is as follows (Ivanets et al., 2014; Khairy et al., 2022):

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \tag{3}$$

$q_e$ is the absorbent capacity at the equilibrium time (mg.g$^{-1}$), $C_e$ is the remaining dye concentration at equilibrium (mg L$^{-1}$), $q_m$ is the Maximum absorbent capacity in mg g$^{-1}$, and $K_L$ is the Langmuir constant which is a measure of energy of adsorption (L.mg$^{-1}$).

The linear form of the Langmuir isotherm can be written as follows (He et al., 2011):

$$\frac{C_e}{q_e} = \frac{C_e}{q_e} + \frac{1}{K_L q_m} \tag{4}$$

The separation factor $R_L$ shows the practicality of using the Langmuir isotherm, $R_L$ is determined using the following equation:

$$R_L = \frac{1}{(1 + K_L \, C_0)} \tag{5}$$

In general, if the value $R_L > 1$ is unfavorable isothermal, $R_L < 1$ is suitable isothermal, $R_L = 1$ is linear isothermal, and $R_L = 0$ is irreversible isothermal. $C_0$ is the initial concentration of the dye (ppm) and $K_L$ is the Langmuir constant (Mouden et al., 2023; Rasheed et al., 2024).

In the Freundlich adsorption isotherm model, a heterogeneous adsorption surface is considered, which has unequal available sites with different adsorption energies. The Freundlich adsorption isotherm model is calculated as follows:

$$q_e = K_F C_e^{1/n} \tag{6}$$

The Freundlich linearized form can be expressed as follows:

$$\ln q_e = K_F + \frac{1}{n} \ln c_e \tag{7}$$

where q_e is the absorbent capacity at the equilibrium time (mg.g$^{-1}$), K_f is the adsorption capacity, n is the constant adsorption intensity for the Freundlich isotherm, and C_e is the equilibrium concentration (mg.L$^{-1}$). Values of n between 1 and 10 indicate optimal absorption (Hamed et al., 2016).

### 2.1.1. Adsorption kinetics

Adsorption kinetics provides information regarding the mode and mechanism of absorption (physical and chemical) and describes the rate of removal of colored molecules from aqueous solution. For this purpose, the data acquired from adsorption kinetics were reconciled by pseudo-first-order and pseudo-second-order kinetic models, and the constants and correlation coefficient of each were obtained. The integral form of pseudo-first-order kinetics can be calculated as follows (Hamed et al., 2016; Ksiezak et al.,2020):

$$\text{Log}\,(q_e - q_t) = \text{Log}\,q_e - \frac{K_1}{2.303} t \tag{8}$$

The form of the linear integral of pseudo-second-order kinetics can also be calculated as follows:

$$\frac{t}{q_t} = \frac{1}{K_2 q_e^2} + \frac{t}{q_e} \tag{9}$$

Where q_e is the absorbent capacity at the equilibrium time (mg.g$^{-1}$), q_t is the number of absorbed solutes (mg.g$^{-1}$) at a time 't' (min), K_1 and K_2 are the equilibrium adsorption constants for pseudo-first-order and pseudo-second-order equations, respectively (Irani et a., 2011; Taheri et al., 2023).

## 3. Results and discussion

### 3.1. Analysis of adsorbent properties

#### 3.1.1. BET analysis

Porous materials are used significantly in chemical reactions and separation processes. The performance of a porous material is further measured as the specific internal surface area using experimental gas sorption data. In the study of thermally modified dolomite porosity, three specific surface factors, volume and pore size were measured by nitrogen gas absorption and desorption by BET method. The use of borax buffer solution was used in the experiments due to the removal of MgO. This washing process was done with the aim of removing magnesium oxide (MgO) from the newly created pores of dolomite. The removal of MgO is necessary because it can block the active sites in the adsorbent and thus reduce its

effectiveness in cobalt adsorption. The results of BET analysis are shown in Table 1. According to the IUPC rules, the isotherm is type III. Also, the average pore size and their distribution were measured by the BJH absorption diagram and shown in Fig.1 Based on the BJH diagram, it can be seen that the maximum pores are higher than 50 nm, which indicates the distribution of pores in the macro range.
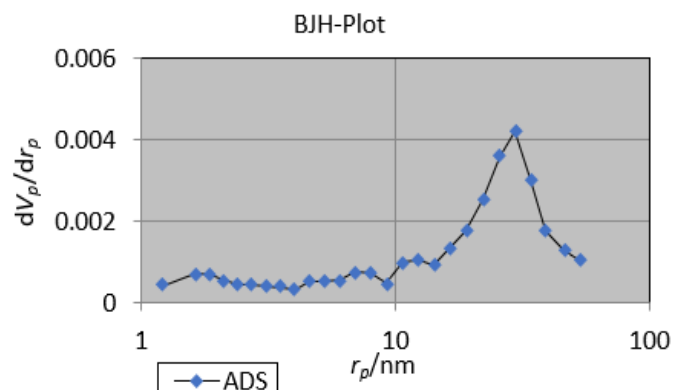


Figure 1. BJH of Modified dolomite

Table 1.BET analysis of Modified dolomite

| sample | Mean pore diameter(nm) | V_total (cm$^3$/g) | BET surface area (m$^2$/g) |
|---|---|---|---|
| Primary dolomite | 22.5 | 0.2983 | 7.46 |
| Modified dolomite | 32.06 | 0.097233 | 16.80 |

#### 3.1.2. SEM analysis

SEM analysis produces two-dimensional images that are used to study the morphology and check the uniformity of dolomite adsorbent. SEM images of dolomite are given in Figure 2. The figures obtained before and after adsorption by SEM analysis show the structure of the adsorbent, the structure of the holes, and the structural changes after adsorption. As seen the space created and the porosity between the holes of the dolomite particles are evident in the images; also white spots In the two fig 2 (c,d)above, represent cobalt adsorbed by thermally modified dolomite.

#### 3.1.3. FT-IR analysis

Analysis of the peak points of two graphs: Dolomite is one of the minerals whose functional groups are identified by FTIR analysis, this method is also useful for identifying the minerals related to the peaks of stone fragments. The FTIR spectra of

minerals show specific features that can be qualitatively related to changes in the constituent minerals.
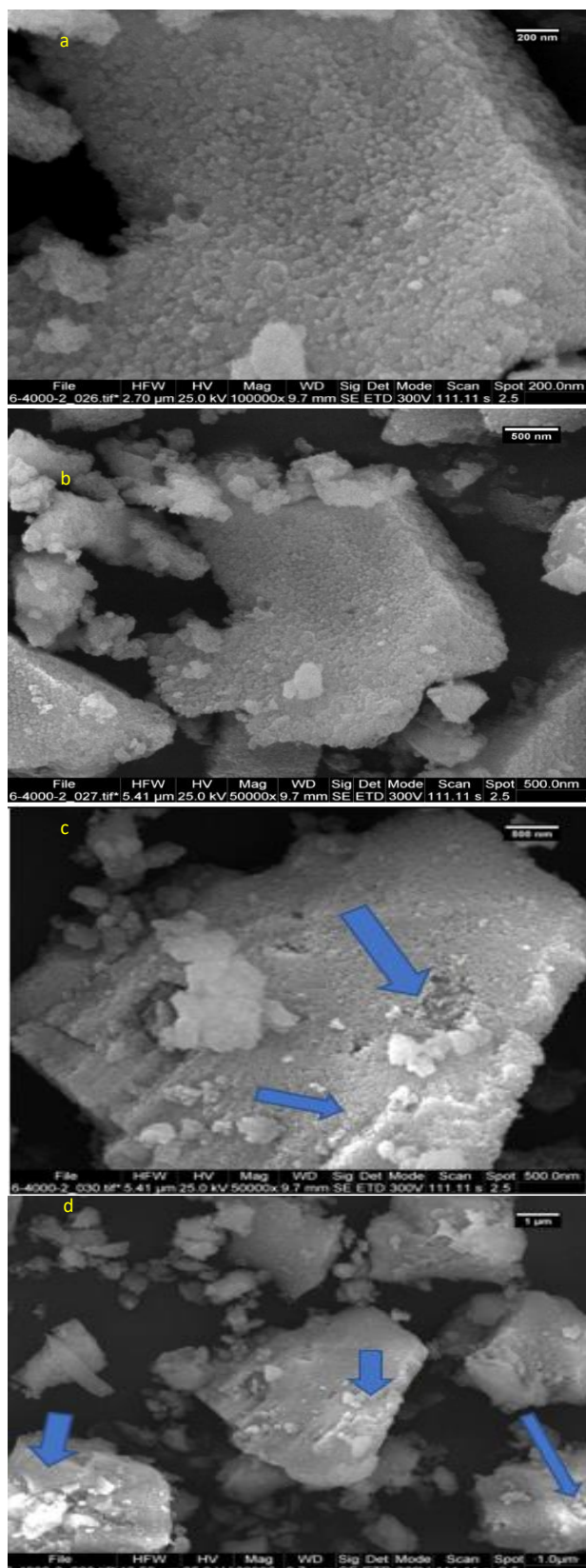


Figure 2. SEM images of (a-b) dolomite before cobalt absorption and (c-d) dolomite after cobalt

Adsorption properties result from the detection of vibrational modes, for example, lattice vibrations or object vibrations in the molecular group. Minerals have characteristic absorption bands in the mid-infrared range, between 400 and 4000cm$^{-1}$ wavelengths. The dolomite group consists of minerals with an unusual trigonal rod symmetry. The amount of calcium and magnesium is equal in most samples, but sometimes one element may be slightly more than the other. There are also small amounts of iron and manganese. In the FTIR spectrum of dolomite, at the peak points of 718, 2628, and 3445 cm-$^1$, dolomite absorption is characteristic. Fig 3. (a,b) shows the FTIR diagram of cobalt adsorption with modified dolomite and FTIR diagram before cobalt adsorption , respectively. The observed peak in the range of 500 to 1000, the links are out-of-plane and strong. Between 2400 and 3400, carbolic acid type bonds are strong. In the range of 3100 to 3500, the bonds are of the first and second amine type - medium tensile and bending (Fowkes, 1964; Cathelineau & Le., 1994).
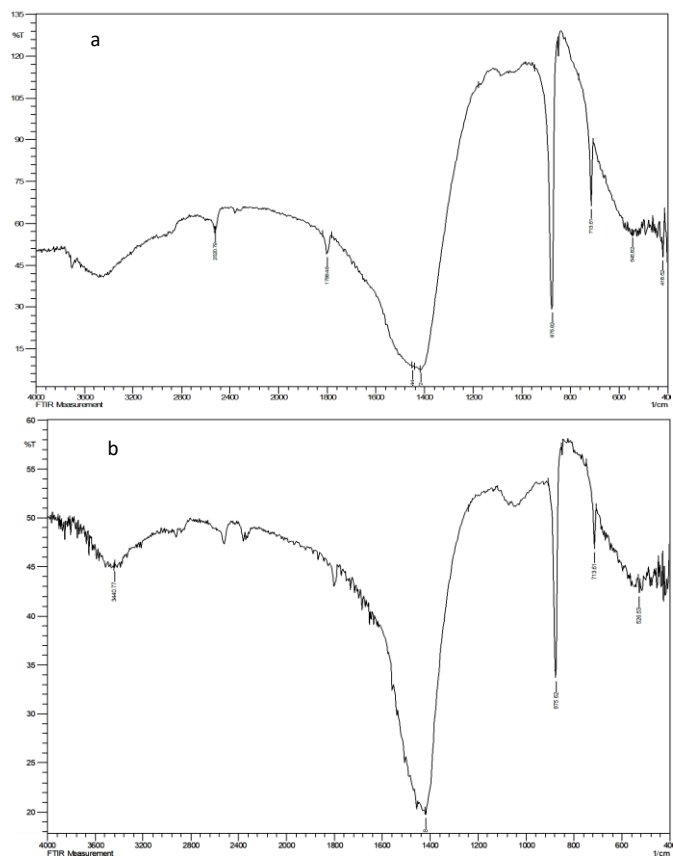


Figure. 3. (a) FTIR diagram of cobalt adsorption with modified dolomite, (b) FTIR diagram before cobalt adsorption

### 3.2. Results of absorption tests by adsorbent

### 3.2.1. Effect of initial concentration of the solution on the removal percentage of cobalt by Modified dolomite

The effect of the initial concentration of the solution on the removal of cobalt from the solution is shown in Fig 4. As shown, increasing the initial concentration of dye solution from 10 to 200 mg/L decreased the removal efficiency from about 99.07 to 93.15%. This result can be described by the fact that the effect of the initial concentration of the dye depends on the direct relationship between the concentration of the dye and the sites on the absorbent surface. In the end, it was found that the maximum absorption was obtained at a concentration of 10 ppm because at high concentrations the active sites of the absorbent are saturated. As a result, for the next test, it was determined that the most appropriate contact time should be the concentration of 10 ppm.

At concentrations of 70 and 100ppm, the color of the solution turned green. The reason for this state is that the free complexes in the cobalt salt that are not absorbed by the adsorbent remain in the solution and give it a green color. It is the same in other metals, and for example, for copper, its free complex turns purple.
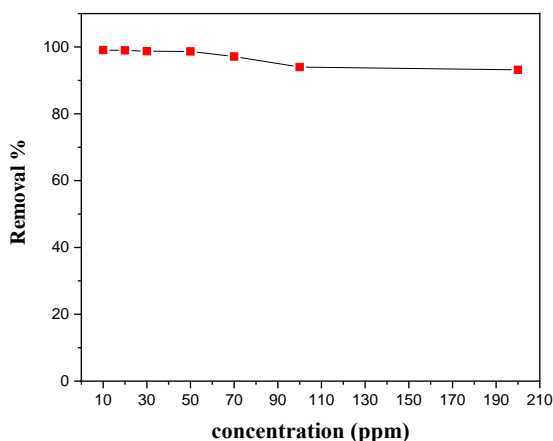


Figure. 4. Effect of concentration on the removal of cobalt Modified dolomite (pH = 6, adsorbent0.5 g , min contact 240 time, 10 mgL-1 cobalt, at 30 °C).

### 3.2.2. Effect of contact time on the removal percentage of cobalt by Modified dolomite

The effect of contact time on cobalt removal from aqueous solution by modified dolomite adsorbent is shown in Fig 5. As shown, the absorption had a large upward trend at the beginning, and after sometime this upward slope decreased and reached its peak at 240 min and was saturated at a level of approximately 99.21%. This result can be described by the fact that in the initial stage, the number of available active sites is large and the adsorption of dye molecules is carried out easily and without any repulsion. After 240 minutes, a dynamic balance between absorption and desorption is achieved.

Therefore, the adsorption equilibrium time was considered to be 240 minutes.
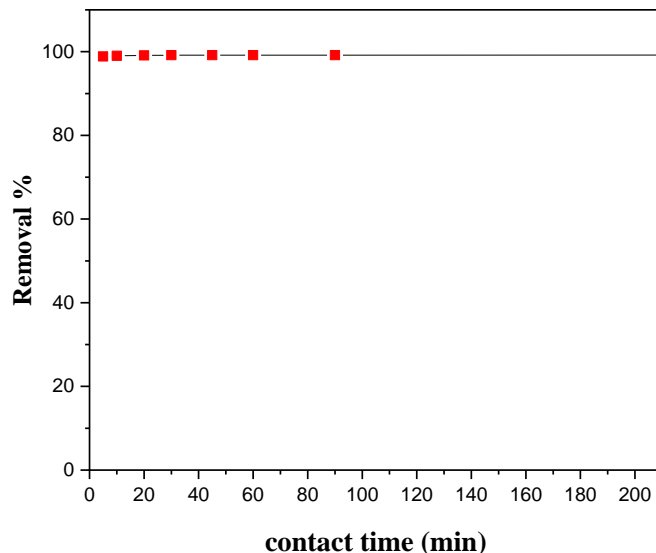


Figure. 5. Effect of contact time on the removal of cobalt dye by Modified dolomite (pH = 6, adsorbent0.5 g, 10 mgL$^{-1}$ cobalt, at 30 °C).

### 3.2.3. Effect of temperature on the removal percentage of cobalt by the Modified dolomite

The effect of temperature on the removal of cobalt from solution by the modified dolomite adsorbent is shown in Fig 6. As shown in the graph, the removal efficiency decreased as the temperature increased from 303.15 to 323.15 K. This is because the absorption process is exothermic.
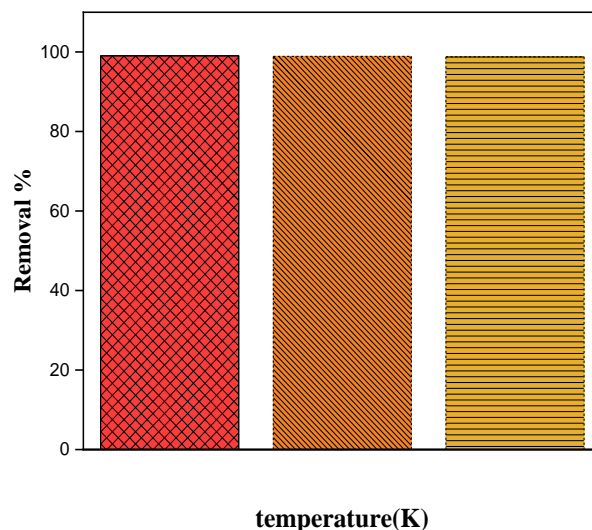


**Fig. 6.** Effect of temperature on the removal of cobalt by Modified dolomite. (pH = 6, min contact time240, 0.5 g adsorbent, 10 mgL$^{-1}$ cobalt)

### 3.3. Adsorption isotherm

The Fig 7 shows the Langmuir and Freundlich isotherm of heavy metal cobalt by modified dolomite. Table 2 shows the values of each model. According to the graph and table, it is concluded that the higher correlation coefficient of the Langmuir isotherm (0.9843) shows that this isotherm is more consistent than the Freundlich isotherm, so the adsorption process is single-layer and homogeneous. The maximum capacity ($q_m$) of modified dolomite adsorbent was also obtained based on the Langmuir isotherm of 10 mg.g$^{-1}$.

### 2.1. Adsorption kinetics

In order to investigate the absorption kinetics, the obtained data were adapted by pseudo-first-order and pseudo-second-order kinetic models, and the constants and correlation coefficients of each were obtained. Fig 8. (a,b) shows pseudo-first-order and pseudo-second-order kinetics for thermally modified dolomite adsorbent. The parameter values of each model are also given in the Table 3.

a) Pseudo-first-order model

According to the diagram, there is no good correlation coefficient ($R^2$=0.9251) and the absorption capacity of the model ($q_e$ model = 0.0018) is very different from the experimental capacity ($q_e$ exp), so this model is not the optimal absorption process.

b) Pseudo-second-order state

It has a very good correlation coefficient ($q_e$ model = 0ʹ9922) and also the equilibrium absorption capacity of the model is in better agreement with the experimental equilibrium absorption capacity ($q_e$ exp). Therefore, the absorption process follows pseudo-second-order kinetics.
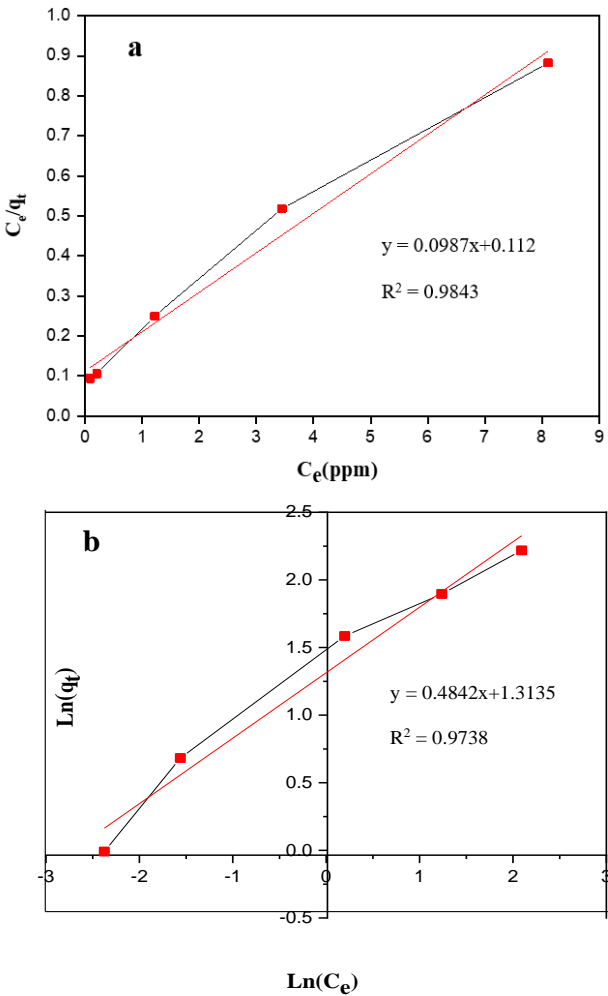


Figure. 7. (a) Langmuir linear diagram of MB adsorption on Modified dolomite, (b) Freundlich linear diagram of Modified dolomite

Table 2.Values of Langmuir and Freundlich isotherm constants of cobalt on Modified dolomite

| model | $q_m$ (mgg$^{-1}$) | $K_L$ (Lmg$^{-1}$) | $R_L$ | $R^2$ |
|---|---|---|---|---|
| Langmuir | 10 | 0.881 | 0.010 | 0.9843 |
| | $k_f$ (mgg$^{-1}$) | 1/n | n | $R^2$ |
| Freundlich | 198.64 | 1.9808 | 0.528 | 0.9738 |

Table 3.Kinetic parameters of MB adsorption on Fe3O4-ACAP

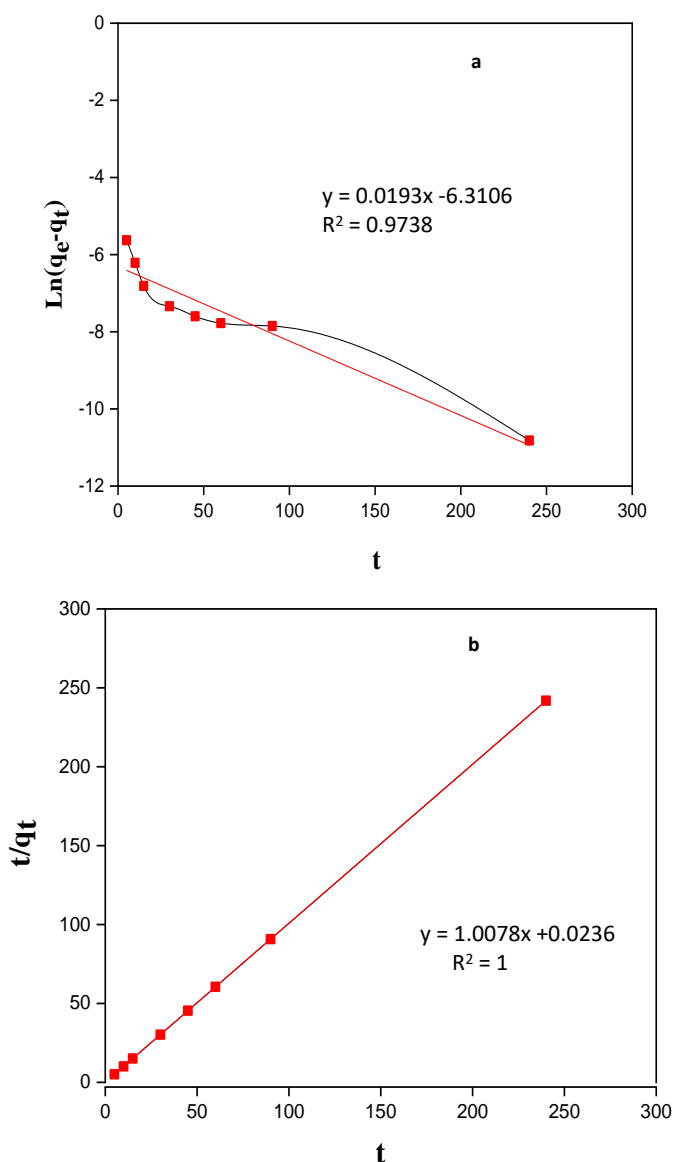| model | $q_{exp}$ (mgg$^{-1}$) | $q_{cal}$ (mgg$^{-1}$) | $K_1$ (min$^{-1}$) | $R^2$ |
|---|---|---|---|---|
| Pseudo-first-order | 10 | 0.0018 | 0.0193 | 0.9251 |
| | | | $K_2$ (g.mg$^{-1}$min$^{-1}$) | $R^2$ |
| Pseudo-second-order | 10 | 0.9922 | 43.04 | 1 |

Figure.8. (a) pseudo-first-order and (b). pseudo-second-order kinetics for thermally modified dolomite adsorbent

## 3. Potential future routes to improve dolomite performance

The combination of modified dolomite with various nanoparticles can significantly increase the adsorption capacity and removal efficiency of pollutants. Below we will examine how this combination works and its effect on the performance of the adsorbent:

### 3.1. Combination with iron nanoparticles

Iron nanoparticles can be added to modified dolomite due to their magnetic properties and high adsorption capacity. This combination can lead to: increasing the active surface area (iron nanoparticles provide more surface area for adsorption), significantly improving the removal efficiency of pollutants such as cobalt (Sadeghian et al., 2020).

### 3.2. Combination with silver nanoparticles

Silver nanoparticles can be added to dolomite due to their antibacterial properties and ability to absorb pollutants. This combination can: increase the disinfection properties and silver can help reduce the microbial load of water (Rai et al., 2009). Silver nanoparticles may also increase the adsorption capacity of dolomite and thus improve the removal efficiency of pollutants (Khan et al., 2021).

### 3.3. Combination with carbon nanoparticles

Carbon nanoparticles, such as carbon nanotubes, have a high active surface area and excellent mechanical properties. Combining them with modified dolomite can enhance and improve the physical properties because carbon nanotubes can increase the structural strength of dolomite, thereby extending its service life (Liu et al., 2019). In general, the combination of modified dolomite with these nanoparticles can increase the adsorption capacity (by adding nanoparticles, the active surface of the adsorbent increases and the capacity to absorb pollutants increases), improve the efficiency under different conditions (these compounds may improve the efficiency of the adsorbent at different temperatures and pH), and reduce the time required to remove pollutants (by increasing the contact surface, the time required to remove pollutants decreases). Combining modified dolomite with various nanoparticles not only increases the adsorption capacity and the efficiency of pollutant removal, but can also bring additional benefits such as reducing the time of treatment processes and improving the quality of treated water. This innovative approach can be considered as a future direction in water treatment research.

The use of hybrid materials that include dolomite and other natural or synthetic adsorbents can significantly increase the adsorption efficiency. Zeolite, fly ash or activated carbon can be combined with dolomite (Kumar et al., 2020). These compounds can increase the adsorption capacity because combining dolomite with natural adsorbents can help increase the active surface area and porosity. Also, combining dolomite with natural adsorbents can improve the chemical properties of the adsorbent, such as increasing stability against different environmental conditions and reducing the need for additional chemicals for water treatment. Another advantage of combining dolomite with hybrid materials is reduced operating costs and greater stability. Hybrid materials usually have greater stability against environmental conditions, which can increase their useful life, and by increasing the adsorption efficiency, the need for repeated use of the adsorbent is reduced, resulting in lower operating costs.

## 4. Conclusion

In this study, thermally modified dolomite was prepared from raw dolomite as an adsorbent and was used as an efficient adsorbent for the removal of cobalt from aqueous solutions contaminated with this metal using the adsorption method. Modified dolomite is cost-effective for many reasons. As a natural mineral, dolomite is readily available and its extraction and processing costs are lower than other adsorbents such as nanoparticles or complex chemicals. The use of modified dolomite does not require complex equipment and high operating costs. Also, the process of separating the adsorbent after use is simpler, which can reduce additional costs. Dolomite is a natural material that has fewer negative impacts on the environment compared to synthetic adsorbents and can be introduced as a sustainable option for water pollution management. These characteristics make the use of modified dolomite not only economical but also an effective solution for removing cobalt from water sources. Studies have shown that modified dolomite can effectively remove cobalt from water. This high efficiency is due to the increased porosity and active surface area of dolomite after thermal and chemical processes, which increases its adsorption capacity. In optimal conditions, pH= 6, color concentration 10, Contact time of 240 minutes, adsorbent dosage and temperature of 30°C, the maximum percentage of cobalt removal reached 99.21%. The maximum adsorption capacity of the adsorbent by Langmuir isotherm was 10 mg/g. By analyzing the adsorption kinetics, it was shown that the adsorption kinetics follows the pseudo-quadratic model. According to the obtained results, thermally modified dolomite powder can be used as an effective adsorbent to remove cobalt from aqueous solutions. Also, it is important to optimize various parameters such as contact time, amount of adsorbent, and initial concentration of cobalt to achieve maximum removal efficiency. In contrast, other adsorbents such as activated carbon and magnetic nanoparticles often show higher adsorption capacities, sometimes exceeding 100 mg/g, however, these materials can be more expensive and complex to produce. In summary, while thermally modified dolomite may not have the highest sorption capacity compared to some advanced adsorbents, its affordability, environmental compatibility, and ease of use make it a competitive option for cobalt removal from aqueous solutions.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Data Availability

Data will be made available on request

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