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# ADSORPTION IN GREEN CHEMISTRY

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**Abstract**:

Recently, "green chemistry" has become widely circulated in the scientific community, especially in circles related to the environment and pollution. Green chemistry is a sustainable chemistry that uses the safest and most environmentally friendly chemicals. The adsorption method was used to remove the elements cobalt and cadmium and it was found that this technique depends on the time of contact, adsorbent concentration and pH. The results showed the effectiveness and efficiency of date kernel powder in removing the elements of cobalt and cadmium, followed by corn leaf powder and then ferric chloride. The optimal conditions for achieving the highest removal rate were the use of a concentration of 30 ppm and the best time period of 2 hours and at an acid function ranging between (5-6).

**Keywords**: Green chemistry, sustainable chemistry, date kernels, corn leaves and percentage removal.

## Introduction

Undoubtedly, human civilization has tremendous effects on the ecological global system and is often negative. Nowadays, efforts that make significant shifts in all sorts of human activities are urgently needed to slow down climate change, stop pollution and preserve harshly exploited natural resources [1]. The bulk of the burden of such changes is within the chemical industry, which is accountable for producing most of the pollutants and depleting the greatest share of natural resources [2]. Companies working in this field are therefore seeking to adopt new non-polluting, non-depleting manufacturing principles known as green chemistry principles. A specialist area known as "green chemistry" promotes more cautious and intelligent manufacturing methods in sectors of the economy that heavily rely on chemicals[3]. Its goals are to decrease the creation of hazardous wastes, enhance the safety of finished chemical products, and utilize less non-renewable resources in the processes involved in producing chemicals. Green chemistry, sometimes referred to as sustainable chemistry, is a scientific discipline that has been expanding slowly over the past 20 years. [4]. The move towards this novel branch of chemistry was the consequence of a reaction to the many harms that traditional chemistry has done since the nineteenth century. American marine biologist and scientific writer Rachel Carson (1907-1964) wrote her famous book "Silent Spring" in 1962 and explained the severe damage chemicals inflict on local ecosystems. This book was a wake-up call for the public, scientists and decision-makers alike [5]. However, the crystallization of the basic principles of green or sustainable chemistry did not occur until about four decades later, in 1998, when the twelve American chemists Paul Anastas and John Warner formulated the principles of known green chemistry, the culmination of a scientific movement that swept the global chemistry community during the nineties of the last century [6].

The twelve principles represent the main objectives of green chemistry: to make chemicals safer during production, use and disposal and not to create hazardous waste if safe processes are in place. Avoid using limited resources for the benefit of renewable resources. In addition to auditing chemical processes to verify their safety and environmental impact [7]. These principles are primarily aimed at professional chemists and chemical engineers, introducing them to some general concepts such as the preference for reusable raw materials over non-renewable materials (principle 7) and highly specific chemical practices, such as the use of selective catalysts rather than the use of chemical reagents (principle 9) [8]. In general, the most striking thing about the twelve principles is that they address the problem of hazardous chemicals and environmental damage at all levels. It also introduced the concept of "atom economy" in order to reduce waste production at the level of an individual chemical reaction (principle 2) [9].

At the same time, these principles call for the real-time monitoring of industrial chemical reactions to avoid their formation or release of hazardous or polluting substances to the environment (Principle 11)[10].Some scientists winning the Nobel Prize in Chemistry was the culmination of their research in areas of chemistry that were largely seen as green chemistry in 2001 (Knowles, Nouri, Sharpless) and 2005 (Chauvin, Grubs, Schroke) played an important role in promoting the significance of research in green chemistry and contributed to creating greater awareness among scientists. that the future of chemistry must be greener [11].

Adsorption is known as the phenomenon of gathering molecules of a substance, its atoms or ions and it is known as adsorbate on the surface of another material identified as adsorbent, and examples are porous spectra (porous clays) and silica gel (silica gel) [12]. The mechanism of adsorption work also passes through a pair of stages, the first stage occurs the transfer of the adsorbent from the aqueous phase to active sites on the surface of the adsorbent material, but in the second stage a chemical complex is formed [13].

Since liquid and solid are the two states of matter that naturally have distinct surfaces in space, the surface contact fields that result in adsorption are (liquid:liquid) (solid:solid) (solid:liquid) (solid: gas). This is the most popular method for removing pollutants that conventional biological methods are unable to remove. The phenomenon of adsorption is caused by the persistence of unsaturated force fields from incomplete consistency or connections between a sufficient number of calculations on the particles on the surface, as is the case within the liquid or solid phase[14]. Adsorption causes the forces on the surface to become saturated, which in turn causes a decrease in the surface's free energy values ($\Delta G$)[15]. As part of the adsorption process, the molecules that bind to the atoms of the adsorbent surface are constrained, which results in a loss of some of their degrees of freedom. This causes a fall in the value of entropy ($\Delta S$) [16].

In this research, environmentally friendly and low-cost natural materials such as date kernels and corn leaves were used to remove heavy elements [17]. Heavy elements - In nature, heavy elements are abundant and are released into the environment through geochemical cycles. High concentrations of heavy elements in the aquatic environment pose a threat to living things because these organisms can accumulate and concentrate these elements within their bodies, which can lead to defects in their vital functions. Additionally, these elements can be transferred to humans through food chains, which can result in numerous health problems. [19].

According to definitions, heavy elements are those whose densities are greater than five times that of water (5 mg/cm^ cubic), have detrimental impacts on the environment when utilized excessively, and have an impact on the health of people, animals, and plants [20]. And that while all of these metals have many natural traits in common, their chemical reactions vary, which has an impact on how the metals affect the environment. Certain metals, like cobalt and cadmium, are linked to health risks, while other metals, like copper, iron, and chromium, are only found in workplaces where exposure to the metal occurs over extended periods of time, making them less hazardous than other metals. [21]. Many heavy metals are vital for life, even if they are employed in very small quantities, but they could be toxic if their concentration reaches a high level in the huamnbody, after which they are able to interfere with the growth of cells and the digestive system [22].

Heavy metal poisoning takes place when they get into the human body as a biochemical compound, and when they get into the body in greater quantities higher than the permissible limits over a short span (cumulative poisoning), so it is necessary to remove heavy elements or reduce their concentration to the permissible limits through adsorption either with high-cost chemicals and polluting the environment such as (ferric chloride) or through the use of cheap natural materials such as (date kernels, Corn leaves, tea and coffee bags, pomegranate and orange peels)[23]. Using green chemistry to remove toxic and carcinogenic heavy metals from aqueous and industrial solutions and medical waste, such as (cobalt and cadmium). Recently, the world has begun to move towards sustainable development and waste recycling in various scientific fields.Therefore, we worked to apply adsorption technology to remove heavy metals using powdered date pits and corn leaves to achieve several goals[24].First: To reduce green waste and benefit from it instead of collecting it and spending huge amounts of money to get rid of it.Second: Preserving natural resources for future generations and not depleting them through sustainable development and waste recycling.Third: The research also aims to make a comparison between high-cost chemicals and natural green waste.

## 2-practical part

### 2-1 Materials and Tools

-Pipetes (25ml), Baker (1000ml, 25ml), volumetric flask (25ml)

- Distilled water, Nitric acid, Hydrochloric acid, Ferric chloride (48%), Cobalt metal and cadmium

-date kernel powder and corn leaf powder

**2-2 devices**

Atomic absorption spectrophotometer, sensitive balance, PH meter, Conductivity meter and total dissolved salts (EC&TDS). electric grinder, rocking sieve.

**2-3 Preparation of standard solutions:**

**2-3-1 Preparation of standard cadmium solution:**

dissolve 0.1 grams of cadmium metal in 4 ml of concentrated nitric acid, then add 8 ml of concentrated hydrochloric acid and dilute to 1000 ml with distilled water [25].

**2-3-2 Standard Cobalt Solution:**

Melt 0.1 g of cobalt mineral in 1 ml of nitric acid. And add
1 ml of hydrochloric acid and dilute to 1000 ml with distilled water [26].

**2-3-3 Preparation of standard Ferric chloride solution (chemical standard adsorbent)**

Ferric chloride (coagulant) is prepared as follows:

take (2.1 ml) of ferric chloride concentration 48% and put it in a volumetric bucker (1000 ml) and dilute it with distilled water [27].

**2-3-4 Preparation of Powder of Date Kernel**

Wash the date Kernel with a solution of hydrochloric acid concentration (10%) to get rid of the impurities accumulated around the date Kernel. then wash thoroughly with distilled water. It is dried at a temperature (40 °C). take 200 g from the powdered in Baker and add (500 ml of acid (10%) HCL). The samples were cleared and washed well with water for several times until the traces of the acid are eliminated. The samples were grinded using an electric grinder and sifted by a vibrating sieve. The powder is ready to be used as a natural adsorbent to remove toxic and pathogenic heavy elements [28].

**2-3-5 Preparing Corn Leaf Powder**

Taken corn leaves, clean from dirt, wash with tap water, then wash with distilled water. Then add a hydrochloric acid at a concentration of 0.1M, then wash it several times with distilled waters, dried and grinded. Then sieve with 0.35 sieve. This powder is a natural adsorbent used to remove heavy metals that may be found in normal, industrial or medical water [29].

**2-4 Practical experiences**

**2-4-1 The First Experience**

take the laboratory-prepared sample, which contains the cobalt element, and the other containing cadmium. Tests the (PH, EC, TDS) for the two sample and test the concentration of Cadmium and Cobalt by atomic absorption spectrometer. add different concentrations of the three previously prepared adsorbents and tests (PH, EC, TDS) and test the concentration of cadmium and cobalt with an atomic absorption spectrum device. calculations the removal rate of the element [30] of cobalt and cadmium using the following equation:

Removal ratio % = (final concentration - initial concentration / initial concentration) ×100

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Table (1, 2 and 3) shows the results of this experiment and the Figures (1, 2) also show these results.

### 2-4-2 The Second Experience

take a sample of laboratory-prepared solutions container heavy elements (cobalt and cadmium) and perform the following tests (PH, EC, TDS) and then measure the concentration of cobalt and cadmium with an atomic absorption spectrometer. put 30 mg/liter of adsorbent materials. change the time (30minutes, 1hour, 2hours, 2.30hours). then perform the following tests after adding the coagulant (PH, EC, TDS) and then measure the concentration of cadmium and cobalt by the atomic absorption spectrum device. calculate the percentage of removal of heavy elements in laboratory-prepared soutions. Tables (4,5,6) show the results and Figures (3,4).

### 2-4-3 The Third Experience

take a sample of laboratory-prepared solutions contain the heavy elements of cobalt and cadmium and tests (PH, EC, TDS) and measure the concentration of cobalt and cadmium with an atomic absorption spectrometer. adding 30 milligrams / liter of adsorbent materials and change the acidic function to know which media gives the best removal by applying the following equation:

Removal ratio % = (final concentration - initial concentration / initial concentration) ×100

Tables (7,8,9) show the results and removal ratios as well as figures (5,6) also show the results of the experiment.

## 3-Results and Discussion

### 3-1 Change of concentration

The result and Discussion for first experiment: In the first experiment, the concentrations of the three adsorbents were changed and it was found that the adsorbent (date kernel powder) gave the best removal of heavy metals (Cd, Co) at a concentration of 30mg/L .Tables (1,2,3) show this.

Figures (1,2) show that date kernel powder gave the highest removal compared to corn leaf powder and the chemical (ferric chloride) because date kernel contain a high percentage of protein, oils and fibers and have a density estimated at 0.920[31]

Table (1): Result of (Cd, Co, PH, EC, TDS) when change the Con. Of $FeCl_3$

| analysis | Con. Before adding Coagulant | 25 ppm Ferric chloride | Removal % | 30 ppm Ferric chloride | Removal % | 35 ppm Ferric chloride | Removal % | 40 ppm Ferric chloride | Removal% |
|---|---|---|---|---|---|---|---|---|---|
| Cd | 2.056 | 1.6 | 0.22 | 1 | 0.5 | 1.4 | 0.31 | 1.3 | 0.36 |
| Co | 1.6 | 0.9 | 0.43 | 0.6 | 0.63 | 0.8 | 0.5 | 0.7 | 0.56 |
| PH | 8.5 | 7.3 | 0.14 | 7.5 | 0.11 | 8.2 | 0.03 | 7.6 | 0.1 |
| EC | 985 | 985 | 0.00 | 926 | 0.05 | 919 | 0.06 | 928 | 0.05 |
| TDS | 465 | 465 | 0.00 | 465 | 0.00 | 460 | 0.01 | 464 | 0.002 |

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Table (2): Result of (Cd, Co, PH, EC and TDS) when change the Con. Of (date kernel).

| Removal % | 40 ppm date kernel powder | Removal % | 35 ppm date kernel powder | Removal % | 30 ppm date kernel powder | Removal % | 25 ppm date kernel powder | Con.Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.65 | 0.7 | 0.7 | 0.6 | 0.75 | 0.5 | 0.61 | 0.8 | 2.056 | Cd |
| 0.68 | 0.5 | 0.63 | 0.6 | 0.81 | 0.3 | 0.63 | 0.6 | 1.6 | Co |
| 0.36 | 5.4 | 0.31 | 5.8 | 0.36 | 5.4 | 0.43 | 4.8 | 8.5 | PH |
| 0.06 | 922 | 0.02 | 966 | 0.03 | 954 | 0.02 | 967 | 985 | EC |
| 0.12 | 410 | 0.09 | 422 | 0.12 | 411 | 0.09 | 422 | 465 | TDS |

Table (3): result of (Cd, Co, PH, EC and TDS) when change the con. Of corn leaves powder.

| Removal % | 40 ppm corn leaf powder | Removal % | 35 ppm corn leaf powder | Removal % | 30 ppm corn leaf powder | Removal % | 25 ppm corn leaf powder | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.58 | 0.85 | 0.61 | 0.8 | 0.65 | 0.7 | 0.5 | 1 | 2.056 | Cd |
| 0.62 | 0.6 | 0.56 | 0.7 | 0.68 | 0.5 | 0.5 | 0.8 | 1.6 | Co |
| 0.4 | 5.14 | 0.38 | 5.2 | 0.38 | 5.2 | 0.41 | 5 | 8.5 | PH |
| 0.07 | 912 | 0.009 | 976 | 0.004 | 981 | 0.052 | 933 | 985 | EC |
| 0.09 | 422 | 0.098 | 419 | 0.11 | 410 | 0.13 | 400 | 465 | TDS |

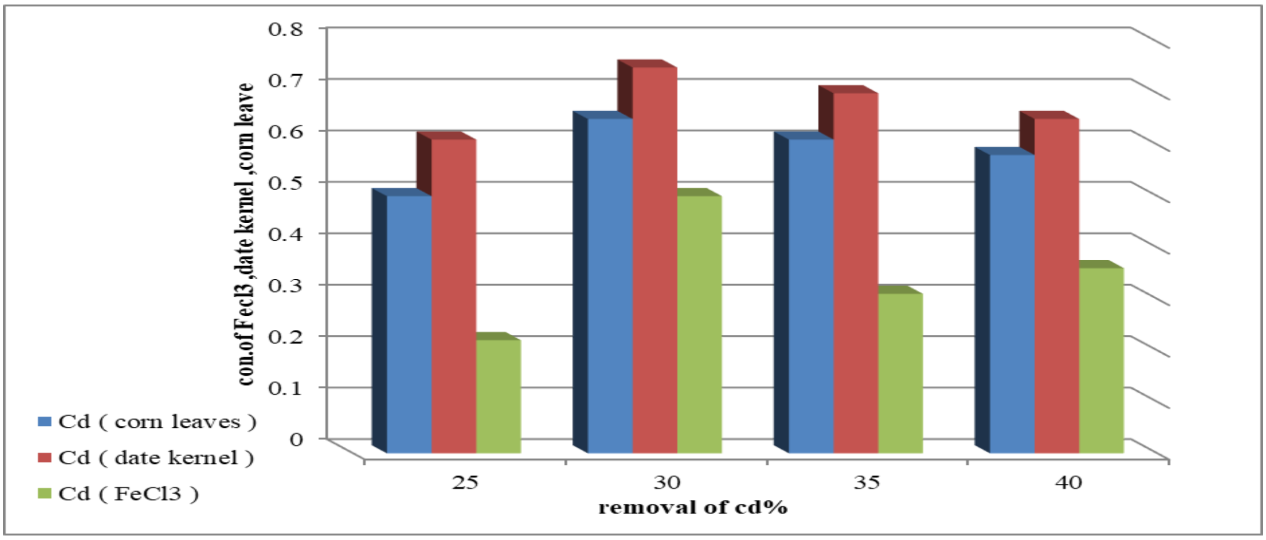


**Figure (1): relationship between Con. (date kernel, corn leaves and $FeCl_3$) with % Removal of (Cd)**

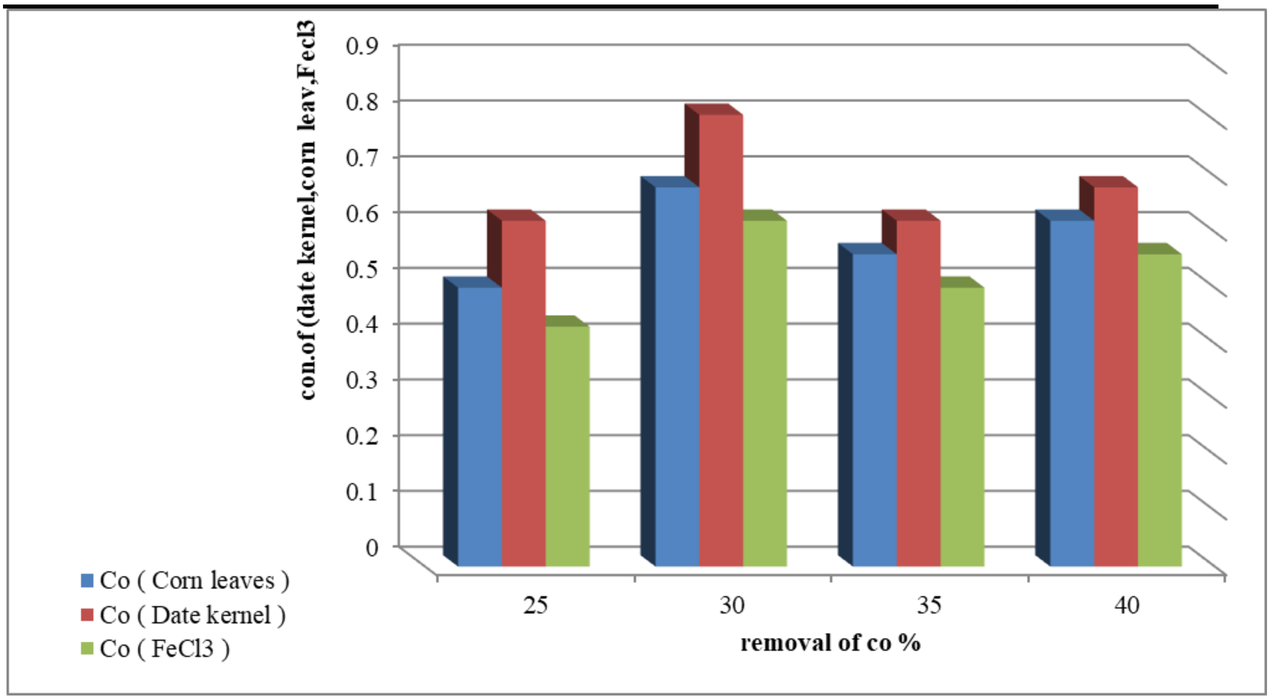


**Figure (2): Relationship between Con. (date kernel, corn leaves and $FeCl_3$) with % Removal of (Co).**

### 3-2 Change of Time

The result and Discussion for the second experiment: In the second experiment, the time was changed for the three adsorbent materials, and it was found that the adsorbent (date kernel powder) gave the best removal of heavy metals (Cd, Co) in a time of 2 hours .Tables (4,5,6) show this .Figures (3,4) show that date kernel powder gave the highest removal compared to corn leaf powder and the chemical (ferric chloride) [32] because date kernel contain a high percentage of protein, oils and fibers and have a density estimated at 0.920.

Table (4): Result of (Cd, Co, PH, EC and TDS) when change the Time (hour) Of $FeCl_3$

| Removal % | 2.5 hours | Removal % | 2 hours | Removal % | 1 hour | Removal % | 0.5 hour | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.12 | 1.4 | 0.37 | 1 | 0.25 | 1.2 | 0.6 | 1.6 | 1.6 | Cd |
| 0.20 | 1.11 | 0.35 | 0.9 | 0.07 | 1.3 | 0.05 | 1.33 | 1.402 | Co |
| 0.26 | 5.3 | 0.27 | 5.2 | 0.27 | 5.2 | 0.3 | 5 | 7.2 | PH |
| 0.06 | 1346 | 0.019 | 1286 | 0.031 | 1201 | 0.018 | 1151 | 816 | EC |
| 0.02 | 671 | 0.09 | 460 | 0.116 | 598 | 0.09 | 575 | 405 | TDS |

Table (5): Result of (Cd, Co, PH, EC and TDS) when change the Time(hour) of date kernel

| Removal % | 2.5 hours | Removal % | 2 hours | Removal % | 1 hour | Removal % | 0.5 hour | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.37 | 1 | 0.6 | 0.6 | 0.5 | 0.8 | 0.31 | 1.1 | 1.6 | Cd |
| 0.42 | 0.8 | 0.57 | 0.6 | 0.21 | 1.1 | 0.35 | 0.9 | 1.402 | Co |
| 0.26 | 5.3 | 0.29 | 5.11 | 0.30 | 5.0 | 0.31 | 4.9 | 7.2 | PH |
| 0.074 | 1210 | 0.009 | 1222 | 0.004 | 1111 | 0.05 | 1010 | 816 | EC |
| 0.92 | 622 | 0.098 | 480 | 0.11 | 566 | 0.13 | 500 | 405 | TDS |

Table (6): Result of (Cd, Co, PH, EC and TDS) when change the Time(hour) of corn leaves powder

| Removal % | 2.5 hours | Removal % | 2 hours | Removal % | 1 hour | Removal % | 0.5 hour | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.23 | 1.22 | 0.5 | 0.8 | 0.37 | 1 | 0.18 | 1.3 | 1.6 | Cd |
| 0.4 | 1 | 0.35 | 0.9 | 0.14 | 1.2 | 0.07 | 1.3 | 1.402 | Co |
| 0.3 | 5 | 0.3 | 5 | 0.31 | 4.9 | 0.36 | 4.6 | 7.2 | PH |
| 0.05 | 1112 | 0.06 | 1210 | 0.05 | 1000 | 0.03 | 999 | 816 | EC |
| 0.03 | 600 | 0.07 | 466 | 0.05 | 540 | 0.02 | 489 | 405 | TDS |

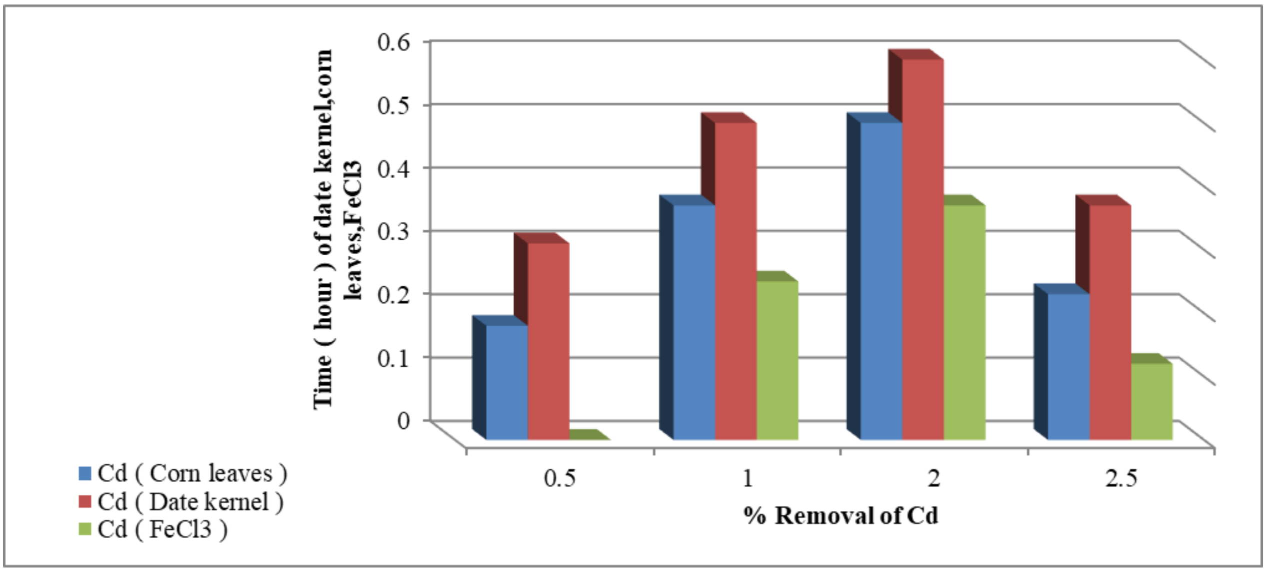

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Figure (3): Relationship between time of (date kernel, corn leaves and $FeCl_3$) with % Removal of (Cd).

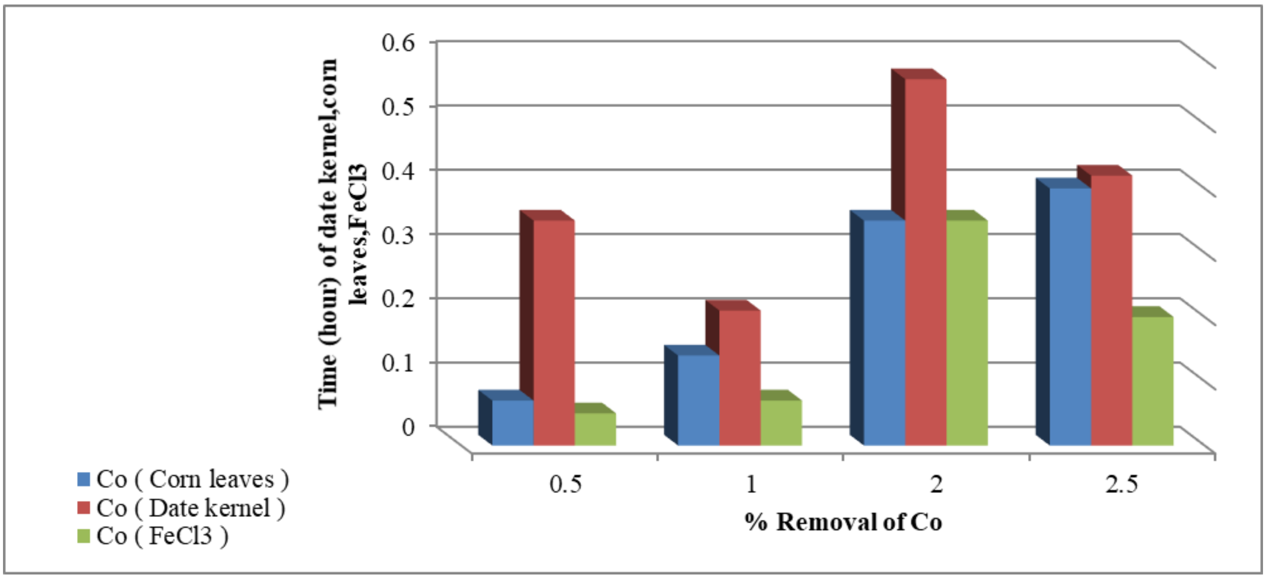


Figure (4) relationship between time of (date kernel, corn leaves and $FeCl_3$) with % Removal of (Co).

**3-3 Change of PH**

The result and Discussion for the third experiment: In the third experiment, the pH of the three adsorbent materials was changed and it was found that the adsorbent (date kernel powder) gave the best removal of heavy metals (Cd, Co) at a pH from 5.2 to 6 .Tables (7,8,9) show this . Figures (5,6) show that date kernel powder gave the highest removal compared to corn leaf powder and the chemical (ferric chloride) because date kernel contain a high percentage of protein, oils and fibers and have a density estimated at 0.920.

Table (7): Result of (Cd and Co) when change the PH of $FeCl_3$

| Removal % | PH 8 | Removal % | PH 7 | Removal % | PH 5 | Removal % | PH 4 | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.176 | 1.4 | 0.058 | 1.6 | 0.23 | 1.3 | 0.058 | 1.6 | 1.7 | Cd |
| 0.06 | 1.88 | 0.1 | 1.8 | 0.6 | 0.8 | 0.55 | 0.9 | 2 | Co |

Table (8) Result of (Cd and Co) when change the PH of date kernel

| Removal % | PH 8 | Removal % | PH 7 | Removal % | PH 5 | Removal % | PH 4 | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.23 | 1.3 | 0.81 | 1 | 0.88 | 0.2 | 0.23 | 1.3 | 1.7 | Cd |
| 0.28 | 1.44 | 0.66 | 1.5 | 0.85 | 0.3 | 0.75 | 0.5 | 2 | Co |

Table (9): Result of (Cd and Co) when change the PH of corn leaves powder.

| Removal % | PH 8 | Removal % | PH 7 | Removal % | PH 5 | Removal % | PH 4 | Con. Before adding Coagulant | analysis |
|---|---|---|---|---|---|---|---|---|---|
| 0.23 | 1.3 | 0.29 | 1.2 | 0.52 | 0.8 | 0.41 | 1 | 1.7 | **Cd** |
| 0.2 | 1.6 | 0.1 | 1.8 | 0.7 | 0.6 | 0.55 | 0.9 | 2 | **Co** |

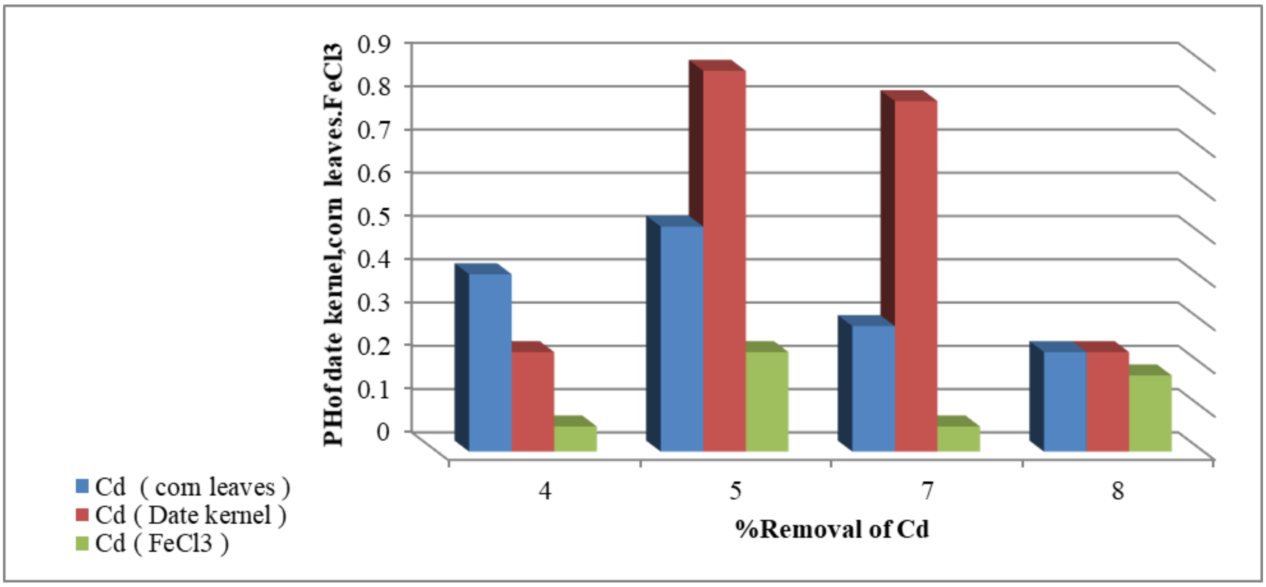


Figure (5) relationship between PH (date kernel, corn leaves and $FeCl_3$) with % Removal of (Cd).

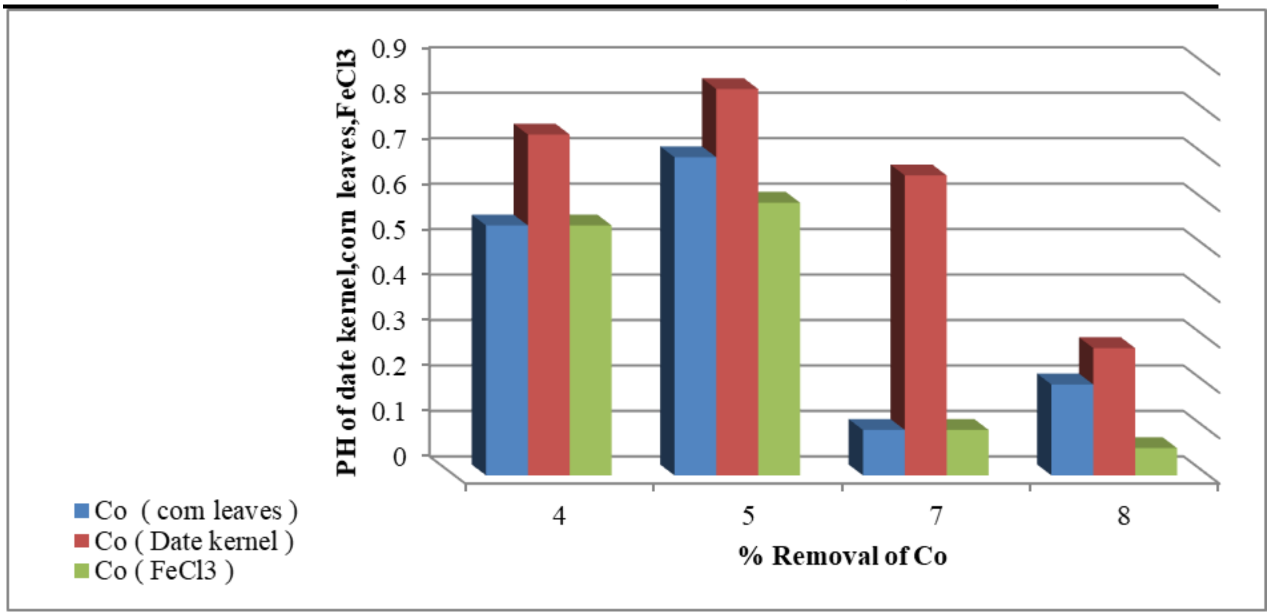


Figure (6): Relationship between PH (date kernel, corn leaves and $FeCl_3$) with % Removal of (Co).

## 4-Conclusion and Recommendation

### 4-1-Conclusions:

In line with this research, when we used three adsorbents, one chemical, which is ferric chloride, and two naturals, which are date kernels and corn peels, and studying the effect of concentration, time, and pH, to determine the amount of their adsorption of heavy materials (cobalt and cadmium that we used in the experiment) from water when using concentrations of 25 ppm. 30 and 35 ppm for adsorbed materials. We noticed that the best concentration is 30 ppm. When using ferric chloride, only 1 ppm of cadmium and 0.6 ppm of cobalt remain in the water. As for dates, at a concentration of 30 ppm, 0.5 ppm of cadmium remains in the water and 0.3 of cobalt remains in the water. Water. As for corn husks, at a concentration of 30 ppm, only 0.7 of cadmium and 0.5 of cobalt remain in their aqueous solutions. Therefore, we find that natural materials absorbed a greater amount of the chemical, and also at a concentration of 30 ppm, the highest concentration at which adsorption occurred. Regarding the time, we used it at 30 minutes and at 1 hour, 2 hours, and 2.5 hours. We found the best adsorption was at 2 hours. As for ferric chloride, when used for 2 hours with an aqueous cadmium solution, only 1 ppm remained, while for cobalt, only 0.9 ppm remained. The date pits remained after two hours. It remains 0.6 for both cadmium and cobalt, while the atomic shells after two hours with cadmium remain only 0.8, while for cobalt only 0.9 remains in their aqueous solutions. When using these conditions, which were two hours with a concentration of 30 ppm, to see the effect of pH, we found that acidic conditions are better than basic ones, especially at a pH of 5.3 to 6. As for ferric chloride, when used with an acidic pH, only 0.23 of the cadmium remains. There is 0.6 of the remaining cobalt in the date pits. After using it with the acidic pH, we noticed that there was only 0.88 of the cadmium remaining and 0.85 of the cobalt remaining. As for the corn shell powder with the acidic pH, only 0.52 of the cadmium remained in the aqueous solution, while the cobalt only had 0.7 remaining. According to these results, we can say that the adsorption of heavy elements is better at a concentration of 30ppm, a time of two hours, and in an acidic environment. Note that the natural materials absorbed a larger number of heavy elements, while the chemical absorbed less than the natural material.

**4-2- Recommendations**

1-It is recommended that laboratories use natural materials (date pits, etc.) instead of using chemicals

2-Using materials from renewable and natural sources extracted from safe plants instead of relying on chemicals that contain a small percentage of toxicity will provide better work because, through the experiments conducted, it is clear that renewable and natural sources give a better removal rate than what chemicals give.

3- On the other hand, natural materials are economical and have a better detoxification rate, unlike the materials currently used in factories and laboratories.

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**الخلاصة:**

خلال الأونة الأخيرة اصبحت "الكيمياء الخضراء" تتداول بكثرة في الوسط العلمي وخاصة في الأوساط التي لها علاقة بالبيئة والتلوث. وتعرف الكيمياء الخضراء بالكيمياء المستدامة التي تستخدم المواد الكيميائية الأكثر أمانًا والصديقة للبيئة. تم تجربة استخدام مواد طبيعية وهي النفايات الزراعية مثل نوى التمر واوراق الذرة في ازالة العناصر الثقيلة السامة والخطرة الثقيلة وهي مثل (الكوبلت والكادميوم) من المحاليل المائية. ومقارنتها بالمادة الكيميائية الشائع استخدامها في ازالة العناصر (كلوريد الحديديك). اظهرت النتائج فعالية وكفاءة مسحوق نوى التمر في ازالة عنصري الكوبلت والكادميوم ثم يلية مسحوق اوراق الذرة ثم كلوريد الحديديك. كانت الظروف المثلى في تحقيق اعلى نسبة ازالة هي استخدام تركيز 30 جزء في المليون وأفضل فترة زمنية 2ساعة وعند دالة حامضية تتراوح بين (5-6).

الكلمات المفتاحية: الكيمياء الخضراء، الكيمياء المستدامة، نوى التمر، اوراق الذرة، نسبة الإزالة.