Cadmium Sorption with Olive Tree (Olea Europaea) Leaves and Factors that Affect Sorption

Teoman Ozkan[1], Sinan Tuna[2]

Abstract

*Although there is a variety of issues concerning the future of humanity, one of the categories that causes the biggest issues is environmental issues. Environmental issues can also be categorized, and one of the biggest concerns is the cleanliness of water sources. Heavy metals such as Cadmium (Cd), Lead (Pb), Arsenic (As), and Mercury (Hg), can have detrimental effects on human health if they enter the human metabolism. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater, and thus, can enter the human body. The real problem is to find a way to extract these heavy metals from water. The focus of this research was solely on a method to remove Cadmium from water. The research also tested what kind of materials could be be used for this. Cadmium Sulfate hydrate solutions (3 $CdSO_4$ * 8 H_2O) were prepared and used olive leaves as a sorbent to remove the cadmium from the water. Initial and final concentrations were measured to see if there was any effect on the cadmium amount. Additionally, the research was repeated to observe the effects of external effects such as temperature, initial concentration, sorbent amount, and pH.*

Keywords: *Absorbance, olive leaves, cadmium, sorption, concentration, solution;*

1. Introduction

One of the main driving forces behind this experiment was the fact that cadmium is an harmful metal for the environment. Turkey is one of the leading producers of olives in the world. Every year, thousands of tons of olive leaves go to waste, since only the olives themselves are consumed. Consequently, we wondered if these leaves could be used as sorbents for such harmful metals like Cadmium. After further research, we decided to conduct the experiment using Cd ions. Our goal was to introduce olive leaves as an alternative sorbent for the purification of the environment from harmful metals.

In this experiment, the absorption of Cadmium ions from solution, using olive leafs as sorbents, was observed. The effects of factors including temperature, pH of solution, stirring time and speed, absorption time, olive leaf dose, and initial cadmium concentration, on the sorption process were measured and analysed. It was hypothesized that all of these factors except for initial cadmium concentration would be directly proportional to the cadmium sorption. However, as the initial cadmium concentration was increased, it was expected for the sorption to decrease, since the leaves could only absorb a finite amount of cadmium ions.

2. Materials and Preparation

2.1 Pre-Treatment of Olive Leaves

- Two bags of olive leaves were collected from Bursa, Turkey.
- The leaves were washed thoroughly and dried for 3 days in an oven at 50°C.
- The leaves were sieved, crushed, and blended into dust until no major change in size occurred during blending.
- The products were washed with distilled water and dried again in the same oven at 50°C.

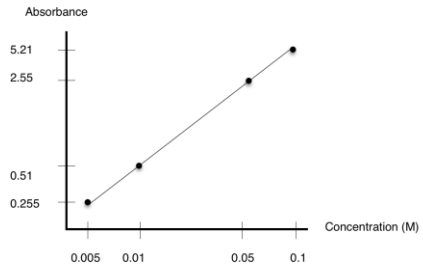
[1] Hisar School, Turkey
[2] Hisar School, Turkey

2.2 Preparation of Cadmium Solutions

- Cadmium solutions of desired concentration was prepared utilizing its sulfate (3 CdSO4·8H2O) in distilled water.
- 10 mL of this solution was diluted to 100 mL to create solutions at desired concentrations.

2.3 UV Spectrophotometer

- Spectrophotometer wavelength was calibrated calibrate between 0 and 800 nm
- Spectroscopy was used throughout the experiment. The absorbance values of cadmium solutions before and after olive leave addition were measured.
- The absorbance values were measured by the spectrophotometer and the absorbance values were translated to cadmium concentration. The two values were compared.
- By selecting a common wavelength for each graph, an Absorbance vs. Concentration graph was prepared for identifying remaining cadmium concentration in later procedures. The graph was linear since absorbance and concentration are directly proportional.

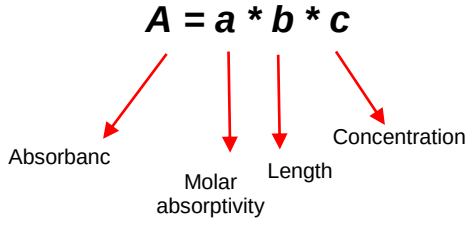


Graph. 1. Absorbance vs. Concentration graph of cadmium solutions

2.4 Measurement of Absorbances

- 2 grams of olive leaves were added to the reference solution.
- It was stirred on a magnetic stirrer and waited for 15 minutes before being inserted into the spectrophotometry machine.

For the analysis of each individual effect, a standard solution of 0.001 M was altered according to the effect and was put in the spectrophotometer. The spectrophotometer gave us data in the shape of a Absorbance vs. Wavelength graph, and concentration was using the reference graph from Beer's Law:



3. Measurements and Discussion

The following effects were tested:

3.1. Effect of Initial Concentration of Cadmium

To investigate the effect of cadmium concentration on sorption process, a reference solution with a concentration of 0.001 M was selected. By taking 10 mL of this solution and diluting it to 100 mL, the concentration was altered to 0.0001 M. 2 grams of olive leaves which were ground and sieved were added. The solution was then stirred at a constant stirring rate. This process was conducted using a magnetic stirrer for 15 minutes. After stirring, the olive leaves were given a time of 10 minutes to absorb the cadmium in the solution. Finally, the solution was placed into the spectrophotometer for absorbance measurement. It was observed that as the initial cadmium concentration increases, the amount of cadmium sorbed also increases. As seen from the graph, as concentration increases, the absorbable amount increases, thus increasing sorption amount. The increase in concentration supports to overcome resistance against mass transfer of cadmium between solid and aqueous phases, thus intensifying the sorption process. However, the removal decreased due to the increase in concentration and the amount of sorbent staying the same.

Initial Cd Concentration (10^-4 M)	Cd Concentration (10^-4 M)
10.00	5.83
1000.00	961.52
100.00	86.73
1.00	0.23
0.100	0.019

Fig. 1. - Data table showing remaining cadmium concentration with respect to initial concentration.

3.2. Sorbent Dose (Olive Leave Amount)

The same reference solution of 0.001 M concentration was used in this procedure. This time, however, instead of diluting the solution to a lower concentration, a higher amount of olive leaves were added. Instead of 2 grams of olive leaves, 4 grams of olive leaves were added to the solution. The solution was stirred with a magnetic mixer for 15 minutes and was waited for 10 minutes after mixing. Finally, the solution was placed into the spectrophotometer for absorbance measurement. As sorbent dose increased, it was observed that the sorption of cadmium increased. This was due to increase of available sorption sites. The more the sorbent dose, the more the sorbent sorbs the cadmium in the solution. As a result, the amount of cadmium purified in the solution also increased. Combined with the rapid stirring for a period of time, the sorption procedure was efficient.

Olive Leaf Mass (g)	Cd Concentration (10^-4 M)
2.00	5.83
4.00	3.70
3.00	5.02
1.00	8.59

Fig. 2. - Data table showing remaining cadmium concentration with respect to sorbent dose.

3.3. Mixing Time & Mixing Speed

The same reference solution of 0.001 M concentration was used in this procedure. 2 grams of olive leaves were added. This time, the solution was stirred with a magnetic mixer for 30 minutes instead of 15 minutes and was waited for 10 minutes after mixing. Finally, the solution was placed into the spectrophotometer for absorbance measurement. Mixing is a process which increases the rate of a process. When you pure sugar into tea, you mix it so it can dissolve faster. The same thing is applied the observed process. The solution is stirred on a magnetic mixer so the sorption process can accelerate. The longer the stirring

process, the more efficient the sorption process becomes, resulting in more cadmium being removed from the solution.

Mixing Speed (Units of magnetic stirrer)	Cd Concentration (10^-4 M)	Mixing Time (min)	Cd Concentration (10^-4 M)
6	5.83	15.00	5.83
9	2.34	30.00	4.61
7	3.91	10.00	6.26
5	7.12	5.00	7.11
3	8.43	1.00	8.36

Fig. 3 - Data tables showing remaining cadmium concentration with respect to mixing speed and mixing time.

3.4. Olive Leaf Absorption Time

The same reference solution of 0.001 M concentration was used in this procedure. 2 grams of olive leaves were added to the solution. The solution was stirred with a magnetic mixer for 15 minutes but was waited for 20 minutes after mixing instead. Finally, the solution was placed into the spectrophotometer for absorbance measurement. Think of a chemical reaction that takes a very long time to go to completion, such as rusting of metal in open air at standard conditions. The longer the reaction is continued for, more products and results are attained. If the olive leaves are given a significant amount of time to remove cadmium from the solution, the amount of cadmium removed will also increase. This will go on until the olive leaves have reached their absorptive capacity.

Olive Leaf Absorption Time (min)	Cd Concentration (10^-4 M)
60	5.83
360	1.74
120	3.18
30	7.04
10	8.28

Fig. 4. - Data table showing remaining cadmium concentration with respect to absorption time.

3.5. Solution Temperature

The same reference solution of 0.001 M concentration was used in this procedure. 2 grams of olive leaves were added to the solution. Before mixing, the solution was heated to 35°C and then was stirred with a magnetic mixer for 15 minutes. It was waited for 10 minutes after mixing instead. Finally, the solution was placed into the spectrophotometer for absorbance measurement. As temperature increases, the sorption of cadmium also increases. This also shows that this process is an endothermic one. Also, as temperature increases, the kinetic energy of the particles in the solution increase. Not only do the particles gain more mobility, more of them gain sufficient energy to interact with active sorbent sites. Additionally, increase in temperature may cause the olive leaves to swell, increasing their capacity and enabling larger cadmium particles to be absorbed.

Solution Temperature (°C)	Cd Concentration (10^-4 M)
25	5.83
50	5.05
35	5.42
15	5.90
5	6.07

Fig. 5. - Data table showing remaining cadmium concentration with respect to solution temperature.

3.6. Solution pH

The same reference solution of 0.001 M concentration was used in this procedure. Before the addition of olive leaves, the solution's pH was changed until it reached 10 by adding drops of NaOH. 2 grams of olive leaves were added to the solution. The solution was stirred with a magnetic mixer for 15 minutes and was waited for 10 minutes after mixing instead. Finally, the solution was placed into the spectrophotometer for absorbance measurement. It was observed that as pH increased, the concentration of cadmium ions in the solution decreased. It was concluded that an increase in pH increases the sorption of cadmium.

pH of Solution	Cd Concentration (10^-4 M)
3	5.83
12.5	0.77
10	1.89
7	3.58
1.5	8.31

Fig. 6. - Data table showing remaining cadmium concentration with respect to pH.

4. Conclusions

The main goal of this experiment was to analyze the effects of various factors on the sorption process. So the experiment was divided into seven different procedures where different dependent variables were used. In all procedures, the volume of cadmium solution treated was 100 mL. Regarding the results of this experiment, it can be concluded that olive leaves can be used as a sorbent. t can also concluded that the amount of cadmium sorbed was found to vary with initial cadmium concentration, sorbent dose, stirring time and speed, absorption time, pH and temperature. As sorbent dose, stirring time and speed, absorption time, pH and temperature increase, the cadmium absorption increases respectively. When initial Cd concentration is increased, the percent absorption decreases, meaning that a relatively similar amount of Cd is absorbed, although concentration is significantly different. For further experimentation, it could be hypothesized that these absorption trends are similar to that of different metals and sorbents.

References

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