



## WATER PURIFICATION CAPSULES: EXPLORING THE POTENTIAL OF BITTIM (*PISTACIA KHINJUK STOCKS*) SHELLS

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### Abstract

Original scientific paper

This study was conducted to investigate the water purification potential of capsules derived from Bittim (*Pistacia khinjuk Stocks*) shells. Analysis of 35 elements was performed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), and changes in element concentrations in water samples processed with Bittim capsules were examined. The results indicate that Bittim capsules have the ability to absorb heavy metals and other pollutants present in water. These findings support the evaluation of Bittim capsules as an eco-friendly and effective water purification material. Our future research needs to examine the applicability and effectiveness of this method in water treatment systems in more detail.

**Keywords:** *Bittim (Pistacia khinjuk Stocks), capsule, element, ICP-MS, water.*

## SU ARITMA KAPSÜLLERİ: BITTIM (*PISTACIA KHINJUK STOCKS*) KABUKLARININ POTANSİYELİ

### Özet

Orijinal bilimsel makale

Bu araştırma, Bittim (*Pistacia khinjuk Stocks*) kabuklarından elde edilen kapsülün su arıtma yeteneğini değerlendirmek amacıyla yapılmıştır. İndüktif Eşleşmiş Plazma Kütle Spektrometresi (ICP-MS) kullanılarak 35 elementin analizi gerçekleştirilmiş ve Bittim kapsülü ile işlenmiş su örneklerinin element derişimindeki değişiklikler incelenmiştir. Sonuçlar, Bittim kapsülünün su içindeki ağır metalleri ve diğer kirleticileri absorbe edebildiğini göstermektedir. Bu bulgular, Bittim kapsülünün çevre dostu ve etkili bir su arıtma malzemesi olarak kullanılmasını desteklemektedir. Gelecekteki araştırmamızda, bu yöntemin su arıtma sistemlerindeki uygulanabilirliğini ve etkinliğini daha detaylı şekilde incelemesi gerekmektedir.

**Anahtar Kelimeler:** *Bittim (Pistacia khinjuk Stocks), element, ICP-MS, kapsül, su.*

### 1 Introduction

The increasing world population and industrial activities are exacerbating environmental degradation. Industrial expansion leads to the depletion of natural resources and an increase in water, air, and soil pollution [1]. Water pollution results from various waste sources and industrial activities, disrupting the natural balance and appearance of aquatic environments [2], [3]. This issue is particularly critical for drinking water sources, making the removal of heavy metals from drinking water essential [4].

Heavy metals such as mercury, lead, copper, zinc, and cadmium pose significant risks to both the environment and human health [5], [6]. These metals can infiltrate plants through drinking water, industrial waste,

and agricultural activities, ultimately harming human health indirectly. Thus, the removal of heavy metals from water and wastewater is of utmost importance [7], [7].

Among wastewater treatment methods, adsorption has gained increasing attention in recent years due to its effectiveness in removing persistent pollutants [8]. The adsorption technique is cost-effective and ensures high-quality purification [9]. Its efficiency in removing low-concentration contaminants from large wastewater volumes and its affordability make adsorption a preferred method [10].

In this study, instead of using activated carbon obtained from agricultural waste, the raw waste itself is recommended for water purification due to its natural and inexpensive properties. This method involves

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analyzing drinking water samples, adding Bittim capsules without mixing to simulate natural environmental conditions, and allowing the process to occur at room temperature to increase its practical applicability in everyday life. This approach enables natural and cost-effective metal removal from water. The study examines the ability of Bittim (*Pistacia khinjuk Stocks*) shells, an agricultural waste material, to remove elements, particularly heavy metals, from water.

## 2 Material and Method

### 2.1 Sample Preparation

Bittim shells, abundant in the Siirt region and typically considered agricultural waste, were collected in September (Figure 1). The shells, intended for use as adsorbents, were thoroughly washed with purified water and dried at 60°C in an oven for one hour. The dried shells were ground into a fine powder (75 mesh) using a ball mill. Without further processing, 5 grams of Bittim shells were weighed, wrapped in filter paper, and formed into capsules. 200 mL of previously analyzed natural water was placed in a beaker, and a Bittim capsule was added to test the adsorption process. The capsule was left to stand at room temperature for eight hours without being stirred. The sample was then collected for elemental analysis.



Figure 1. Bittim (*P. khinjuk Stocks*).

### 2.2 Microwave Digestion

To prepare samples for ICP-MS analysis, approximately 1000 mg of each sample was carefully weighed and transferred into Teflon vessels. Concentrated 65% nitric acid (Merck, Darmstadt, Germany) was added to each sample, and a blank Teflon vessel containing 10 mL of 65% nitric acid was prepared for control purposes. The prepared vessels were processed in a CEM MARS6 ONE TOUCH microwave digestion System (Matthews, NC, USA). The samples were heated to a maximum of 210°C within 25 minutes and held at this temperature for 15 minutes, completing the digestion process in a total of 40 minutes. Once cooled to ambient temperature, the Teflon vessels were washed with ultrapure water and transferred to 50 mL volumetric flasks for dilution and ICP-MS analysis.

### 2.2 ICP-MS Method

Calibration standards (Table 1) were prepared using commercially available multi-element standards diluted with Suprapur nitric acid (1%, Millipore Sigma, Burlington, MA, USA) and ultrapure water. Samples were analyzed using a NexION 2000 B ICP-MS spectrometer (PerkinElmer, Waltham, MA, USA) equipped with a quartz nebulizer, a cyclonic spray chamber, and an integrated autosampler. A washing solution containing Suprapur nitric acid (1%) and ultrapure water was prepared for cleaning, and yttrium (89Y) was used as the internal standard. Samples were injected into a cyclonic spray chamber via a peristaltic pump, with argon gas as the carrier. Helium gas was used to reduce interference. Instrument settings, data acquisition, and analysis were managed using Syngistix software version 2.2 (PerkinElmer, Waltham, MA, USA).

Table 1. Calibration standards.

Analitler	Std1 (ppb)	Std2 (ppb)	Std3 (ppb)	Std4 (ppb)	Std5 (ppb)	Std6 (ppb)	Internal standard
Li, B, Al, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Ga, As, Şe, Rb, Sr, Nb, Mo, Ru, Pd, Ag, Cd, Sn, Ba, Hf, Ta, W, Au, Pb, U	0,5	1	5	25	50	100	89Y
Na, Mg, K, Ca, Fe	25	50	2,50	1250	2500	5000	

Table 2. ICP-MS operating conditions.

Parameter	Description/Value
Nebulizer	MEINHARD plus Classic Type C
Spray Chamber	Glass cyclonic (baffled), 4 °C
One-Piece Torch	w/2.5 mm Quartz Injector
Injector	2.0 mm inner diameter
Nebulizer Flow	Optimized for <2% oxides
RF (Radio Frequency) Power	1600 W
Cone	Ni
Multiplier	3
Dwell Time	50 ms
Aerosol Dilution	Set to ×2.5
Sample Delivery Rate	350 µL/min
Rinse Time	45 seconds
Nebulizer Gas Flow Rate	0.93 L/min
Deflector Voltage	~12 V
Analog Stage Voltage	~1750 V
Pulse Stage Voltage	1100 V
Discriminator Threshold	26
Sample Tubing (Orange-Yellow)	Extended PVC pump tubing 0.51 mm/0.89 mm
Internal Standard Tubing (Orange-Red)	Extended PVC pump tubing 0.19 mm/0.91 mm
Peristaltic Pump Speed	35 rpm
Alternating Current (AC) Rod Offset	~4

## 3 Results and Discussions

This study analyzed 35 elements using ICP-MS to determine the potential of Bittim shells for water purification. The element concentrations in untreated water samples (Table 3) and those treated with Bittim capsules (Table 4) were compared.

The evaluation of the efficacy of Bittim capsules as an adsorbent material in water treatment processes has revealed a significant reduction in the concentrations of a wide range of elements present in natural water samples. According to the experimental findings, high removal performance was observed for alkali and alkaline earth metals. Specifically, the Potassium (K) concentration decreased from 24,907.581 ppb to 6,988.354 ppb, representing a 71.94% reduction, while Magnesium (Mg), Sodium (Na), and Calcium (Ca) achieved removal efficiencies of 65.60%, 51.32%, and 46.55%, respectively. Furthermore, the detection of a notable 86.09% decrease in Strontium (Sr) content served as a primary indicator supporting the high potential of Bittim-based capsules in regulating the mineral composition of water.

Heavy metal and trace element analyses have demonstrated that the adsorption capacity of Bittim capsules covers a remarkably broad spectrum of specific pollutants. According to the results, the concentrations of environmentally critical elements such as Copper (Cu) decreased from 56.472 ppb to 38.824 ppb, Barium (Ba) from 68.029 ppb to 55.929 ppb, and Rubidium (Rb) from 22.867 ppb to 7.628 ppb. Similarly, reductions were recorded in Lead (Pb) levels from 108.547 ppb to 100.650 ppb, and in Cadmium (Cd) levels from 6.263 ppb to 5.963 ppb. These data scientifically substantiate that capsules derived from Bittim shells can serve as an eco-friendly, sustainable, and highly effective adsorbent alternative in processes for water purification and the removal of undesirable elements.

Heavy metal poisoning occurs when toxic levels accumulate in the body [11]. Even at low concentrations, heavy metals can accumulate in living organisms, posing serious health threats [12]. These metals typically enter humans through the food chain, and some, such as lead, are highly toxic and carcinogenic [13]. Lead can damage the liver and kidneys and may be fatal [14]. Arsenic-containing fish consumption can harm the bladder, lungs, and kidneys [15]. Cadmium exposure can lead to growth retardation, acute hypocalcemia, and kidney damage [16]. Excess zinc intake can cause various adverse effects, including fatalities [17], [18]. In this context, the Bittim capsule demonstrates significant efficacy against these toxic elements. Analytical results indicate substantial reduction levels, specifically for Pb (from 108.547 to 100.650 ppb), Cu (from 56.472 to 38.824 ppb), and Zn (from 2225.195 to 2204.380 ppb). Comparable decreases in other critical elements, such as cadmium and selenium, underscore the potential of Bittim as a natural, cost-effective adsorbent for mitigating the health risks associated with heavy metal accumulation.

The fact that Bittim shells are a natural and inexpensive material with the ability to alter the mineral content of water and absorb pollutants makes them a potentially eco-friendly and effective water purification method. Therefore, the use of Bittim shells in water treatment systems and their potential role in purifying drinking water sources are considered promising.

Various studies have demonstrated that natural materials can serve as effective alternatives for water purification. For instance, hazelnut shells have been

found to be effective in removing dyes [9], while corn cobs and barley husks have been shown to effectively remove textile dyes [19]. Additionally, adsorbents derived from agricultural byproducts have been reported to be efficient in dye removal [20], [21], [22].

The presented findings suggest that Bittim shells could be considered an alternative solution in water purification and highlight the importance of further investigation of this method in future research.

**Table 3.** Analysis results of natural water elements.

Li 7	B 11	Na 23	Mg 24	Al 27
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
39,197	684,254	73949,977	30067,710	3371,872
K 39	Ca 43	Ti 48	V 51	Cr 52
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
24907,581	131429,156	92,332	8,610	24,213
Mn 55	Fe 57	Co 59	Ni 60	Cu 63
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
74,318	1346,864	5,323	86,407	56,472
Zn 66	Ga 69	As 75	Se 82	Rb 85
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
2225,195	16,281	6,897	101,031	22,867
Sr 88	Nb 93	Mo 98	Ru 102	Pd 106
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
1956,548	5,755	10,861	2,708	6,826
Ag 107	Cd 111	Sn 118	Ba 138	Hf 180
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
7,473	6,263	8,419	68,029	5,909
Ta 181	W 184	Au 197	Pb 208	U 238
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
8,701	10,160	11,364	108,547	28,500

**Table 4.** Element analysis results of water treated with Bittim adsorbent.

Li 7	B 11	Na 23	Mg 24	Al 27
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
34,667	639,633	35974,627	10340,232	3294,484
K 39	Ca 43	Ti 48	V 51	Cr 52
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
6988,354	70242,528	70,554	7,742	23,291
Mn 55	Fe 57	Co 59	Ni 60	Cu 63
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse	Yukse	Yukse	Yukse	Yukse
(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
42,291	1223,959	5,145	83,432	38,824

**Table 4 Continued.** Element analysis results of water treated with Bittım adsorbent.

Zn 66	Ga 69	As 75	Se 82	Rb 85
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)
2204,380	14,102	7,051	89,124	7,628
Sr 88	Nb 93	Mo 98	Ru 102	Pd 106
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)
272,201	5,684	8,208	2,694	6,742
Ag 107	Cd 111	Sn 118	Ba 138	Hf 180
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)
7,337	5,963	8,447	55,929	5,860
Ta 181	W 184	Au 197	Pb 208	U 238
Helium	Helium	Helium	Helium	Helium
KED	KED	KED	KED	KED
Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)	Yukse (ppb)
8,673	9,850	10,942	100,650	27,744

#### 4 Conclusion

This study evaluated the water purification potential of Bittım capsules using ICP-MS analysis. The addition of Bittım capsules to water resulted in a significant reduction in the concentrations of various heavy metals and elements. These findings indicate that capsules derived from Bittım shells can serve as an eco-friendly and effective water purification method. This study makes a significant contribution to the reuse of natural resources and the development of sustainable water treatment solutions.

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#### Declaration

Ethics committee approval is not required.

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