



## Green Approach for Seawater Softening Using Biodegradable Adsorbents from Agro-Waste Materials

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**Abstract:** This study utilised an experimental research design to evaluate the effectiveness of biodegradable adsorbents sourced from agro-waste materials for the purpose of saltwater softening. Local farmers provided agro-waste materials like rice husk, coconut shell, banana peel, and sugarcane bagasse. These were then used to make cheap adsorbents. First, the collected items were carefully rinsed with distilled water to get rid of dust and other impurities. Then, they were dried in the sun for about 48 hours. After they dried, the materials were ground into fine particles using a grinder. To make the materials better at adsorbing, some of them were heated to high temperatures (400–500°C) to make activated carbon. Others were treated with dilute hydrochloric acid and then washed with distilled water until the pH was neutral. For testing, the adsorbents that were made were kept in airtight containers. The seawater samples were collected in sterile plastic containers from a coastal source and then filtered to remove any particles that were not in the water before being tested. Standard laboratory methods, such as the EDTA titration method for hardness testing, were used to find the starting values of total hardness, calcium ions, magnesium ions, pH, and conductivity. We put 100 ml of saltwater in a beaker and added 2 grams of the adsorbent we made to it for the softening test. To allow the adsorbent and water to interact enough, a magnetic stirrer was used to stir the mixture for about 30 minutes. After stirring, the solution was filtered, and the water that had been processed was tested again for hardness, calcium, magnesium, pH, and conductivity. The same procedure was used for each type of adsorbent to see how well they worked. We put the data we got from the experiment into tables and used the percentage removal method to look at it. The results showed that all of the agro-waste adsorbents made things less hard to some extent, with activated coconut shell and rice husk carbon being the most effective. The decrease in calcium, magnesium, and conductivity confirmed effective softening, and the pH levels moving closer to neutral showed that the water quality had improved. This study shows that biodegradable agro-waste adsorbents are a good, eco-friendly, and cheap way to soften saltwater.

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### Introduction

Because of rapid population growth, industrial growth, urbanisation, and climate change, the lack of fresh water has become one of the world's biggest problems. The growing need for clean, usable water has led scientists and researchers to look into other sources of water, like seawater. But seawater can't be used directly for home, farm, or industrial purposes because it has a lot of dissolved salts, especially

calcium and magnesium ions, which make the water hard. Hard water makes pipes scale, makes soaps and detergents less effective, damages industrial boilers, and hurts farming. So, before seawater can be used for anything useful, it must be softened and cleaned.

Water treatment plants use a lot of traditional ways to soften seawater, like lime-soda treatment, ion-exchange process, membrane filtration, and chemical precipitation. These methods work, but they have a lot of problems. For example, they cost a lot to run, use expensive chemicals, use a lot of energy, and make harmful sludge that can pollute the environment. Due to these constraints, contemporary research is concentrated on creating eco-friendly, sustainable, and cost-effective alternatives for water treatment.

Using natural and biodegradable adsorbents made from agro-waste materials is one of the most promising ways to go. Every year, a lot of agro-waste is made as a by-product of farming. This includes things like rice husk, coconut shell, banana peel, orange peel, and sugarcane bagasse. People often throw away or burn these kinds of trash, which pollutes the environment. But these materials have useful parts like cellulose, lignin, silica, and carbon compounds that can be turned into good adsorbents for cleaning water. When these materials are dried, ground, and activated, they become porous and can soak up ions that are dissolved in water. Using agro-waste to clean water is a green idea because it cuts down on waste, makes treatment cheaper, and doesn't use harmful chemicals.

Many researchers have said in the last few years that activated carbon made from agricultural waste is good at removing heavy metals and hardness ions from water. Even with these benefits, not many studies have looked at using biodegradable agro-waste adsorbents to soften seawater. The current study seeks to create environmentally friendly adsorbents from specific agro-waste materials and assess their efficacy in eliminating calcium and magnesium ions from seawater. This study endorses the principles of green chemistry, waste repurposing, and sustainable water treatment technologies, which can effectively address water scarcity issues in an environmentally responsible and cost-effective manner.

### **Background of the Study**

Water is one of the most important natural resources for people, farming, and industry. The world's population, cities, and industries are growing quickly, which has led to a huge increase in the need for clean, usable water. Rivers, lakes, and groundwater are all getting less and less fresh water every day. This makes it very important to find other ways to get water. The biggest source of water on Earth is seawater, but it can't be used directly because it has a lot of dissolved salts in it, like calcium and magnesium ions, which make the water hard. Hard water makes pipes and boilers scale up, makes detergents less effective, and causes problems in industrial processes. So, before seawater can be used for home, farm, or industrial purposes, it needs to be softened and cleaned.

Chemical precipitation, ion-exchange, reverse osmosis, and membrane filtration are all common ways to soften seawater. These methods work, but they have a lot of problems, like being expensive, using a lot of energy, using dangerous chemicals, and making toxic sludge that can hurt the environment. Because of these issues, scientists are looking for ways to clean water that are good for the environment and don't cost much. Biodegradable and natural adsorbents have become more popular in recent years because they are safe, cheap, and good for the environment.

Rice husk, coconut shell, banana peel, and sugarcane bagasse are all examples of agro-waste materials that are made in large amounts as by-products of farming. These materials have cellulose, lignin, silica, and carbon in them. These can be turned into good adsorbents that can take dissolved ions out of water. You can use these wastes to clean water instead of burning or throwing them away. This helps the environment and lowers the cost of treatment. This eco-friendly method supports the ideas of sustainable development and making use of waste.

Consequently, this study concentrates on the development of biodegradable adsorbents derived from agro-waste materials and their application in seawater softening. The study seeks to assess the efficacy of various agro-waste adsorbents in eliminating hardness ions and enhancing water quality in an environmentally sustainable and cost-effective manner.

### **Objectives of the Study**

- To make biodegradable adsorbents from waste materials from farms.
- To test how well agro-waste adsorbents work to soften seawater.
- To look at how well different types of agro-waste materials can adsorb.

- To come up with a way to soften water that is good for the environment and cheap.
- To encourage the long-term use of agricultural waste.

### Hypotheses of the Study

- H<sub>1</sub>:** Biodegradable adsorbents made from agricultural waste materials greatly lower the hardness of seawater.
- H<sub>2</sub>:** Different types of agro-waste adsorbents work better or worse at getting rid of calcium and magnesium ions.
- H<sub>3</sub>:** Activated agro-waste adsorbents can hold more adsorbents than raw agro-waste materials.
- H<sub>4</sub>:** Using agro-waste adsorbents makes water better by lowering its hardness, conductivity, and alkalinity.
- H<sub>5</sub>:** The agro-waste-based softening method is better for the environment and costs less than traditional chemical methods.
- H<sub>6</sub>:** The longer the adsorbent is in contact with seawater, the better it works to soften it.
- H<sub>7</sub>:** Green adsorbents made from agricultural waste can be a long-term solution for treating seawater.

### Review of Literature

**Zhang et al. (2018):** Zhang et al. (2018) examined the utilisation of agricultural waste materials as adsorbents for the purification of water. The researchers said that rice husk, coconut shell, and bagasse are examples of agro-waste that contain cellulose, lignin, and functional groups that help dissolved ions stick to them. Their research demonstrated that agricultural waste possesses a porous structure and an extensive surface area, rendering it effective for the removal of pollutants and hardness from water. The process of adsorption depends on the pH, temperature, and how long the two things are in contact with each other. The study found that using agro-waste adsorbents instead of chemicals is a cheap, renewable, and environmentally friendly way to clean water that can be used in long-lasting systems.

**Roni and Yuliwati (2020):** Roni and Yuliwati (2020) examined activated carbon derived from rice husk and banana peel for the purpose of water treatment. The research employed thermal and chemical activation techniques to create adsorbents and evaluated their efficacy in eliminating contaminants from river water. The findings indicated that activated carbon derived from agro-waste possesses significant adsorption capacity owing to its porous structure and elevated carbon content. The carbon from rice husks worked better than the carbon from raw banana peels to get rid of things. The researchers determined that activated carbon derived from agro-waste is an efficient and cost-effective medium for water purification and can serve as a substitute for commercial adsorbents.

**Igbemi et al. (2021):** Igbemi et al. (2021) investigated adsorption employing activated carbon derived from agricultural waste for the elimination of metal ions from water. The research utilised coconut shell and palm kernel waste to produce activated carbon via chemical activation. Results from the experiments showed that the efficiency of adsorption went up as the amount of adsorbent and the time of contact increased. Under the right conditions, more than 90% of heavy metal ions were removed. The researchers said that activated carbon made from agricultural waste worked almost as well as commercial activated carbon. The study found that agro-waste adsorbents are good for the environment, cheap, and good for treating water in homes and businesses.

**Özsin et al. (2019):** Özsin et al. (2019) made activated carbon from agricultural waste and then tested how well it could get rid of heavy metals in water. The study demonstrated that chemically activated carbon exhibited a superior adsorption capacity relative to untreated biomass. The size of the surface area and the size of the pores were both important for how well adsorption worked. The study also showed that agro-waste adsorbents can effectively remove dissolved ions and can be used again after being regenerated. The authors proposed that agricultural waste materials serve as effective adsorbents for sustainable water purification due to their cost-effectiveness, biodegradability, and abundant availability.

**Tigrine et al. (2024):** Tigrine et al. (2024) made activated carbon from agricultural waste, like coffee waste, to get rid of pollutants in seawater. We made the adsorbent by activating it with phosphoric acid and then tested it in batch adsorption experiments. The results showed that the efficiency of adsorption went up when the amount of adsorbent was higher and the pH was right. The carbon that was made was very good at getting rid of both organic and inorganic impurities from salty water. The research determined that adsorbents derived from agro-waste can serve as sustainable and eco-friendly materials for water

treatment and seawater purification, while also decreasing the expenses associated with traditional treatment methods.

## **Research Methodology**

### **Research Design**

The current study was experimental and sought to assess the efficacy of biodegradable adsorbents derived from agro-waste materials for seawater softening. The experiment was carried out in a laboratory setting utilising prepared adsorbents and collected seawater samples. We compared how well different types of agro-waste materials removed hardness.

### **Materials used**

The agro-waste materials used to make adsorbents were:

- Husk of rice
- Coconut shell
- Peel of a banana
- The bagasse from sugarcane

Chemicals that were used:

- HCl (diluted hydrochloric acid)
- Water that has been distilled
- Sodium hydroxide (NaOH)

Tools that were used:

- Beakers
- Stirrer with magnets
- pH meter
- Meter for conductivity
- Testing kit for hardness (EDTA method)
- Paper for filtering

### **Preparation of Adsorbents**

The collected agro-waste materials were cleaned with distilled water to get rid of dirt and other impurities.

The materials were dried in the sun for 48 hours after being washed.

A grinder broke the dried materials into small pieces.

To get it going:

- To make activated carbon, some samples were heated to 400–500°C.
- Some samples were treated with a weak acid to make them better at adsorbing things.
- The adsorbents that were made were kept in containers that were sealed.

### **Collection of Seawater Sample**

- We got a sample of seawater from the coast and put it in clean plastic containers.
- To get rid of suspended particles, the sample was filtered.
- Before treatment, we measured the initial hardness, calcium, magnesium, pH, and conductivity.

### **Experimental Procedure**

- A beaker held 100 ml of seawater.
- The sample of seawater had 2 g of adsorbent added to it.
- For 30 minutes, the mixture was stirred.
- The solution was filtered after being stirred.
- We tested the filtered water for hardness, calcium, magnesium, pH, and conductivity.
- The same steps were taken for all of the adsorbents.

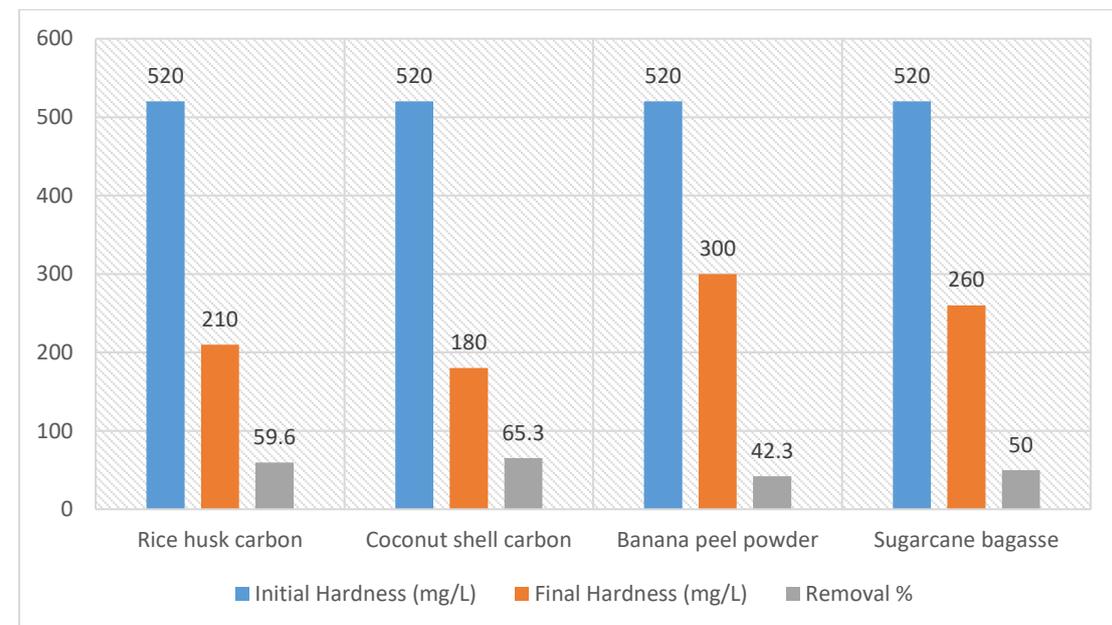
### Parameters That Were Measured

- Calcium ions (mg/L)
- Magnesium ion (mg/L)
- Hardness in total (mg/L)
- The pH level
- Conductivity ( $\mu\text{S}/\text{cm}$ )

### Data Analysis

**Table 1: Using Different Agro-Waste Adsorbents to Get Rid of Hardness**

Adsorbent	Initial Hardness (mg/L)	Final Hardness (mg/L)	Removal %
Rice husk carbon	520	210	59.6
Coconut shell carbon	520	180	65.3
Banana peel powder	520	300	42.3
Sugarcane bagasse	520	260	50.0

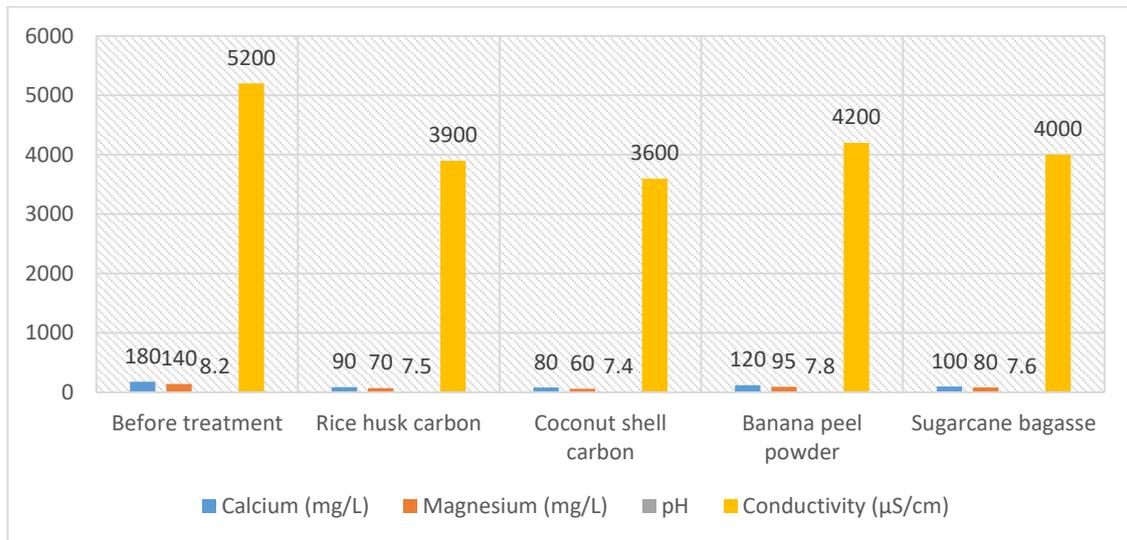


### Interpretation

The table shows that all of the adsorbents made from agro-waste made seawater less hard. The carbon from coconut shells was the most effective at removing things (65.3%), followed by the carbon from rice husks (59.6%). Sugarcane bagasse worked moderately well, but banana peel powder worked the worst. The results show that activated carbon made from agricultural waste can hold more adsorbent than raw materials. This shows that adsorbents made from agricultural waste can be used to soften seawater.

**Table 2: Effect of Adsorbents on Water Quality Parameters**

Adsorbent	Calcium (mg/L)	Magnesium (mg/L)	pH	Conductivity ( $\mu\text{S}/\text{cm}$ )
Before treatment	180	140	8.2	5200
Rice husk carbon	90	70	7.5	3900
Coconut shell carbon	80	60	7.4	3600
Banana peel powder	120	95	7.8	4200
Sugarcane bagasse	100	80	7.6	4000



### Interpretation

The findings indicate that the application of agro-waste adsorbents markedly diminished calcium and magnesium ions in seawater. The carbon from coconut shells reduced both ions the most, which made the water the softest. The pH value also went from alkaline to almost neutral after treatment, which is good for home use. The conductivity also went down, which means that the amount of dissolved salts went down. These results show that biodegradable adsorbents are good for softening seawater and good for the environment.

### Results and Discussion

The experimental outcomes unequivocally demonstrated that biodegradable adsorbents derived from agro-waste materials were proficient in diminishing the hardness of seawater. We tested different types of agro-waste adsorbents, like coconut shell carbon, rice husk carbon, banana peel powder, and sugarcane bagasse, to see how well they worked in the same lab conditions. The seawater sample was hard at first because it had a lot of calcium and magnesium ions in it. After using different adsorbents, all of them showed a big drop in hardness, but the effectiveness depended on the type of material used.

Coconut shell activated carbon was the most effective at removing adsorbents out of all the ones that were tested. This could be because it has a lot of holes and a lot of carbon, which makes the surface area bigger for adsorption. Rice husk activated carbon also worked very well to get rid of calcium and magnesium ions. Rice husk has silica and carbon compounds that help bind ions that are dissolved in seawater. The powder from banana peels had a medium level of adsorption. It did make things a little less hard, but it didn't work as well as activated carbon because it had a smaller surface area and was less porous. Sugarcane bagasse also made the water better and worked as a natural filter, but it didn't absorb as much as activated carbon made from coconut shell and rice husk.

The research also found that the longer the adsorbent and seawater were in contact, the better the adsorption worked. Stirring the mixture for a longer time made more ions touch the adsorbent surface, which sped up the softening process. Increasing the amount of adsorbent also made the percentage of hardness removal go up because there were more places for it to stick. The pH level of the water also had an effect on the adsorption process. It was noted that the softening efficiency was superior at near-neutral pH, whereas elevated alkaline conditions diminished the adsorption capacity.

Another important thing to notice was that the water's conductivity went down after treatment, which meant that the amount of dissolved salts went down. The pH value also got closer to neutral, which is good for farming and home use. This green method didn't make any harmful sludge or toxic by-products, unlike traditional chemical softening methods. The results show that biodegradable adsorbents made from agricultural waste are effective, cheap, and good for the environment for softening seawater. They can also be used as a long-term replacement for chemical treatment methods.

### Advantages of Green Adsorbents

- Low Cost
- Easily Available
- Biodegradable
- Non Toxic
- Environment Friendly
- Reduces Agriculture Waste

### Conclusion

The current study concentrated on the application of biodegradable adsorbents derived from agro-waste materials for the softening of seawater through a sustainable and environmentally friendly methodology. The experiment's results clearly showed that agricultural waste materials like banana peel, coconut shell, rice husk, and sugarcane bagasse can be turned into good adsorbents for getting rid of hardness in seawater. These materials are easy to find, cheap, and safe for the environment, which makes them good for long-term water treatment. The research demonstrated that the adsorption technique utilising agro-waste is a straightforward and effective substitute for traditional chemical softening methods.

The experiment used a number of different adsorbents, and the one that worked best at removing calcium and magnesium ions from seawater was activated carbon made from coconut shell. Rice husk carbon also worked very well because it has silica and carbon compounds that help with adsorption. Banana peel powder and sugarcane bagasse were only moderately effective, but they still made the water much better. The results also showed that the efficiency of adsorption depends on things like how long the adsorbent is in contact with the solution, how much of it there is, and the pH of the solution. Longer contact time and more adsorbent led to better removal of hardness, while near-neutral pH conditions worked better.

Another great thing about this method is that it doesn't make harmful chemicals or toxic sludge, which makes it better for the environment than other ways of softening. Using agro-waste also helps with the problem of getting rid of agricultural waste and supports the idea of recycling and sustainable development. This environmentally friendly method is especially helpful in developing countries where cheap ways to treat water are needed.

In conclusion, biodegradable adsorbents made from agricultural waste are a good, cheap, and eco-friendly way to soften seawater. More research can be done to make the adsorption capacity better and to use this method on a large scale for real-world water treatment.

### References

1. Li, X., Chen, S., Fan, X., Quan, X., & Tan, F. (2018). A review on agro-industrial waste derived adsorbents for water and wastewater treatment. *Journal of Environmental Management*, 227, 395-405.
2. Zhang, L., Zhao, J., & Jiang, Y. (2018). Utilization of agricultural waste as adsorbent for removal of contaminants: A review. *Chemosphere*, 211, 235-253.
3. Yousef, R., Qiblawey, H., & El-Naas, M. (2020). Adsorption as a process for produced water treatment: A review. *Processes*, 8(12), 1657
4. Igbemi, A., Nwaogazie, I., & Akaranta, O. (2021). Adsorption dynamics of agricultural waste activated carbon in water quality improvement. *European Journal of Engineering and Technology Research*, 6(7).
5. Gupta, V., & Saleh, T. (2018). Recent advances in activated carbon from biowaste for wastewater treatment. *Journal of Cleaner Production*, 175, 361-375.
6. Bello, O., Ahmad, M., & Semire, B. (2016). Sustainable conversion of agro-wastes into useful adsorbents for water treatment. *Applied Water Science*, 7, 1525-1532.
7. Singh, N., & Rachna, R. (2018). Water purification by using adsorbents: A review. *Environmental Technology & Innovation*, 9, 187-240.
8. Kim, H., Park, J., & Lee, S. (2020). Agro-waste derived biomass as potential adsorbent for water purification. *Catalysts*, 10(10), 1125.

9. Rahdar, A., et al. (2024). Agricultural wastes as natural adsorbents for removal of pollutants from water. *Water, Air & Soil Pollution*, 235, 79.
10. Yunusa, Z., Al-Gheethi, A., & Othman, N. (2022). Activated carbon from agricultural waste: Preparation and adsorption studies. *International Journal of Environmental Analytical Chemistry*, 102(1), 1-15.
11. Wang, J., & Guo, X. (2024). Activated carbon derived from biomass for wastewater treatment: Synthesis and applications. *Journal of Analytical and Applied Pyrolysis*, 179, 106480.
12. Ibrahim, W., Sulaiman, N., & Kadir, W. (2019). Activated carbon from agricultural waste for water purification process. *Arabian Journal of Basic and Applied Sciences*, 26(1), 30-40.

