Eliminating the Water Hardness

Through the feedback of the residents of our college, we have identified that water hardness is a significant issue which is a main cause of numerous problems, mentioned earlier.

Water hardness is primarily caused by dissolved minerals such as calcium, magnesium, chloride, and other impurities.

The lab reports indicate that the tap water in our hostels contains high chlorine levels, along with moderate amounts of magnesium and calcium.

Several processes can be used to address this issue. While some are practical and effective, many are inefficient in terms of cost, space, and time.

After thoroughly researching and evaluating different methods and their limitations, we have chosen to implement the following processes:

Adsorption

Adsorption is the process where particles, ions, or molecules from a liquid stick to the surface of a solid material (adsorbent).

- **Material Used:** Activated Carbon
- **Function:** Activated Carbon removes chlorine, organic compounds, and some heavy metals
- **Working:** Activated Carbon acts as adsorbent. It traps impurities, heavy metals, or organic compounds on their surface
- **Limitation:** It does not directly remove calcium and magnesium

Chelation

Chelation is a chemical process where a special molecule (chelating agent) binds to metal ions, preventing them from causing scale buildup.

- **Material Used:** Citric Acid
- **Function:** Chelating agents bind with calcium and magnesium ions, preventing them from forming scale
- **Working:** Chelating agents form stable complexes with calcium (Ca^{2+}), magnesium (Mg^{2+}), and other metal ions. These prevent hardness minerals from reacting with soap or forming scale

- **Limitation:** Chelation does not remove hardness minerals but keeps them dissolved in water

Prototype

Implementing the above mentioned processes, we have come up with an idea to build a water filter for shower and tap.

Ideally, our prototype will be able to soften the hard water by removing the dissolved impurities.

Materials

- Activated Carbon
- Powedered Citric Acid
- Mesh Bag / Cotton
- A container

Assembly

- **Prepare the Container:** Use a sturdy, water-resistant container with an inlet and outlet
- **Layer the Filter Materials:**
    - Place a mesh bag or cotton at the bottom for pre-filtration
    - Add a layer of activated carbon
    - Sprinkle powdered Citric Acid
    - Cover with another mesh bag or cotton to keep materials in place.
- **Seal & Install:** Secure the container, attach it to the shower or tap, and check for leaks.
- **Maintenance:** Replace or clean the filter media periodically for optimal performance.

Working

- **Water Entry:** Tap or shower water flows into the container.
- **Pre-Filtration:** The mesh bag or cotton removes dirt and sediment.
- **Impurity & Hardness Reduction:**
    - Activated carbon absorbs chlorine and organic impurities.
    - Citric acid chelates calcium and magnesium, reducing water hardness.
- **Final Filtration:** The top mesh bag or cotton ensures clean, debris-free water.
- **Clean Water Output:** Softened and purified water flows out, improving its quality for use.

Limitations

- **Frequent Replacement Needed:** Citric acid and activated carbon degrade over time and need regular replacement for effective filtration.
- **Not Effective for Heavy Contaminants:** The filter does not remove heavy metals (like lead or arsenic) or microbial contaminants (bacteria/viruses).

Existing Products

Yes, there are already products existing to soften the water. But they come with many limtations.

- **High Cost:** Most commercial water softeners, especially ion-exchange and reverse osmosis (RO) systems, are expensive to purchase and maintain.
- **Bulky & Space-Consuming:** Traditional softeners require large tanks and dedicated installation space, making them unsuitable for small apartments or temporary setups.
- **Frequent Maintenance:** Ion-exchange systems need regular salt refills for regeneration.
- **Excessive Water & Salt Usage:** Ion-exchange softeners waste water during regeneration and increase sodium levels in treated water, which might not be ideal for drinking.
- **Not Always Cost-Effective for Small-Scale Use:** Most existing systems are designed for whole-house filtration, making them overkill for showers or taps.

Comparision

Feature	Our Prototype	Existing Products
Cost	Low and Affordable	High and Expensive
Size	Compact and Portable	Bulky
Hardness Removal	Moderate	High
Chlorine Removal	Yes	Not all Models
Water Waste	Minimal	High
Maintenance	Easy and Low-Cost	Frequent Salt Refills and Filter Changes
Purpose	Ideal for Showers and Taps	Better for whole-house filtration

Conclusion

While existing water softeners are effective, they come with significant drawbacks. Our prototype offers a cost-effective, compact, and efficient alternative, designed specifically for showers and taps. While it does not completely eliminate hardness like ion-exchange systems, it significantly improves water quality, making it gentler on the skin, hair, and household appliances.

This innovation serves as a practical, budget-friendly solution for everyday water softening, making clean and softer water more accessible to households without investing in expensive systems.

What's next?

After building the prototype, we will test its output to evaluate its effectiveness in softening water. If it does not meet our expectations, we will modify and optimize the design by incorporating additional materials to enhance performance.