UTILSATION OF RESINO HYDROSOFTNER FOR REDUCING HARDNESS OF WATER

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Abstract - *Water hardness, primarily caused by dissolved calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions, poses significant challenges in both domestic and industrial water usage. Excessive hardness leads to scaling in pipelines, boilers, and household appliances, thereby reducing operational efficiency and increasing maintenance costs. In this study, a Resino Hydrosoftener, an advanced ion exchange-based water softening system, has been utilized for the reduction of total hardness in groundwater samples collected from rural regions near Nagpur. The Regino Hydrosoftener operates on a strong acid cation exchange resin, wherein calcium and magnesium ions are replaced with sodium (Na^{+}) ions during the softening cycle. Experimental procedures involved passing hard water through the hydrosoftener unit and analysing hardness levels pre- and post-treatment using the standard EDTA titrimetric method, as per APHA 2340-C. The study demonstrated a significant reduction in total hardness from initial values of 320–450 mg/L (as $CaCO_3$) to below 75 mg/L after treatment, falling well within the BIS (IS 10500:2012) permissible limits for potable water. The performance efficiency, resin regeneration frequency, and water flow rates were also monitored and analysed. This paper highlights the applicability and efficiency of Regino Hydrosoftener in rural water treatment setups, especially for sustainable and low-maintenance water purification in resource-constrained environments.*

Keywords: *Water Hardness, Ion Exchange, Regino Hydrosoftener, Calcium, Magnesium, EDTA Titration, Rural Water Treatment, BIS Standards*

1.INTRODUCTION

Water is one of the most essential natural resources required for sustaining life. However, the **quality of water**, especially in terms of its chemical composition, plays a vital role in determining its suitability for domestic, agricultural, and industrial purposes. One of the major issues affecting water quality in both rural and urban regions is **water hardness**, which is primarily due to the presence of **divalent metal ions**, mainly **calcium (Ca^{2+})** and **magnesium (Mg^{2+})**. These ions react with soaps, reduce lather formation, and cause scaling in plumbing systems, boilers, and industrial machinery. Hard water is not only inefficient for daily use but also results in increased maintenance costs, energy consumption, and reduced appliance lifespan.

In rural areas near Nagpur and other regions across India, groundwater is the principal source of drinking and domestic water. However, in many cases, this groundwater exhibits high levels of hardness, often exceeding the permissible limits prescribed by Bureau of Indian Standards (BIS: IS 10500:2012) for potable water. This necessitates the implementation of effective water softening technologies that are both affordable and sustainable in decentralized settings.

The present study focuses on the utilization of the Resinohydrosoftener, a compact and efficient ion exchange-based water softening unit. The Resinohydrosoftener employs cation exchange resin technology, wherein calcium and magnesium ions are removed by exchanging them with sodium ions, thus significantly reducing the total hardness of the water. This process is both chemically effective and operationally simple, making it suitable for use in rural and small-scale applications.

This research aims to evaluate the performance of the Resinohydrosoftener through a series of controlled experiments. The objective is to determine its efficiency in hardness removal, regeneration cycles, flow rate compatibility, and overall applicability in a rural context. The findings of this study are expected to support the adoption of such technologies for improving rural water quality and public health outcomes.

This paper addresses the design and implementation of resiono hydrosoftner which is beneficially used for reducing the hardness of water

Table No. 1 Hardness Classification

Village name	Observation on water sample		
	PH	Hardness (ppm)	Chloride (ppm)
Amra	8.77	86	26.98
Hingna	6.22	326.08	23.44
Digdoh	6.11	304.34	25.2
Wanadongri	7.8	270	26.90
Amgaon	7.9	260	23.22

Water hardness is typically classified based on the concentration of calcium and magnesium ions, expressed in milligrams per litre (mg/L) as calcium carbonate ($CaCO_3$). According to standard classification, water is considered:

- Soft: 0–75 mg/L
- Moderately hard: 76–150 mg/L
- Hard: 151–300 mg/L
- Very hard: >300 mg/L

In the Nagpur district and surrounding rural areas, groundwater serves as the primary source of drinking and domestic water. Recent surveys and water quality assessments conducted by local water authorities and academic studies indicate that a significant portion of the groundwater in this region falls under the "hard" to "very hard" category. In many villages, total hardness levels have been reported in the range of 320 to 450 mg/L as $CaCO_3$, far exceeding the desirable limit of 200 mg/L set by Bureau of Indian Standards (BIS: IS 10500:2012).

This elevated hardness is largely due to the geological composition of the region, which includes limestone, dolomite, and other mineral-rich strata that contribute to the leaching of calcium and magnesium into aquifers. Such high hardness levels not only affect water usability for domestic chores but also lead to scaling in pipes, storage tanks, and electrical appliances. Therefore, the classification of water hardness in this region becomes a critical parameter for selecting appropriate water softening technologies like the Resinohydrosoftener

2. CASE STUDIES

2.1 Parseoni Village, Nagpur

In the semi-rural area of Parseoni, located in Nagpur district, groundwater was found to have high total hardness averaging 410 mg/L (as $CaCO_3$). A Resinohydrosoftener unit with 500 LPH capacity was installed at the village borewell. Post-treatment results showed a consistent reduction in hardness to below 70 mg/L, improving water usability and preventing scale formation in household systems. The resin required regeneration every 7–8 days, and the maintenance was manageable even with minimal technical support. The community reported higher satisfaction with water quality after implementation.

2.2 Meerut Rural Belt (Uttar Pradesh)

In a cluster of villages near Meerut, groundwater drawn from tube wells showed extreme hardness, often exceeding 500 mg/L. The cause was traced to the local geology rich in calcium-bearing minerals. A Resinohydrosoftener was installed in one of the community centres to test its effectiveness. Within the first week, treated water showed a drastic reduction in hardness levels to 65 mg/L. The treated water allowed improved cleaning efficiency, and users experienced less soap consumption and no scale deposits on taps and utensils. The softener system was praised for its low operational cost and easy regeneration process using sodium chloride.

2.3 Coimbatore Suburban

In the outskirts of Coimbatore, where textile industries coexist with residential colonies, water hardness levels were observed at around 360–420 mg/L due to borewell dependency. A pilot-scale Resinohydrosoftener was introduced in a school premises to evaluate performance under consistent daily usage. The system successfully maintained treated water hardness under 75 mg/L for over two weeks without regeneration. The resin showed excellent life-cycle performance, and even teachers noted reduced wear and tear on laboratory glassware and water heating systems. The success led to recommendations for installing similar systems in other nearby institutions

Treated and untreated water

3.METHODOLOGY

3.1 Selection of Study Area

The study focused on rural and semi-urban regions known for high groundwater hardness, including villages in Nagpur (Maharashtra), Meerut (Uttar Pradesh), and Coimbatore (Tamil Nadu). These areas were selected based on previous water quality reports, community complaints regarding scaling and soap inefficiency, and accessibility for onsite experimentation.

3.2 Sample Collection

Groundwater samples were collected from borewells used for domestic consumption in each selected location. Samples were taken in 1-liter pre-cleaned polyethylene bottles, following standard water sampling techniques to avoid contamination or alteration of hardness. Bottles were labeled and transported immediately to the testing site

3.3 Initial water Quality Analysis

Before treatment, each water sample was subjected to the following laboratory analyses:

- Total Hardness was determined using the EDTA Titrimetric Method (APHA Standard Method 2340-C), with results expressed in mg/L as $CaCO_3$.
- Calcium and Magnesium Hardness were determined separately using standard titration techniques.
- Other parameters such as pH, TDS (Total Dissolved Solids), and electrical conductivity were measured using portable digital meters to understand the overall water chemistry.

3.4 Installation of Resinohydrosoftener Unit

A Resinohydrosoftener unit with a capacity of 500 Liters Per Hour (LPH) was installed at each test site. The unit is based on ion exchange technology, which uses a strong acid cation exchange resin in sodium form. During the softening process, calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in hard water are exchanged with sodium (Na^{+}) ions present in the resin bed.

Preparation of the hardness test

The system was connected to the raw water outlet (e.g., borewell or overhead tank supply), and hard water was passed through the softener under gravity or with the help of a booster pump.

3.5 Softening process Operation

Water was allowed to flow through the Resinohydrosoftener at a consistent rate. The resin inside the column adsorbed Ca^{2+} and Mg^{2+} ions, effectively reducing water hardness. A contact time of 5–10 minutes was maintained, ensuring adequate ion exchange. Treated water was collected after flow stabilization and stored in labeled containers for analysis

3.6 Post-Treatment Analysis

The output (treated) water was tested using the same EDTA titrimetric method to determine residual total hardness. Additional parameters like pH and TDS were also rechecked to ensure no adverse changes occurred during treatment

4.DETAILED DESIGN

4.1 Design capacity

The Resinohydrosoftener is designed with a flow rate capacity of 500 liters per hour (LPH), suitable for treating 1500–2000 liters of water per day. It operates efficiently under low pressure (1–2 kg/cm^2), making it ideal for rural areas where water is supplied through gravity or small pumps. The capacity is optimized for small households or community-level usage, ensuring effective hardness removal with low maintenance

4.2 Resin Column Construction

The resin column is made of FRP or HDPE, ensuring durability and chemical resistance. It is 1200 mm high and 250 mm in diameter, containing layers of gravel and sand to support the resin and allow smooth water flow. The column holds the cation exchange resin, with inlet and outlet valves for easy operation and regeneration. makes it compact, low-maintenance, and suitable for rural use.

4.3 Supporting Media

The supporting media inside the resin column includes a gravel layer (5–10 mm) at the bottom for proper drainage and flow distribution, and a sand layer (0.5–1 mm) above it to prevent resin loss during operation. Together, they ensure uniform water flow, protect the resin bed, and improve the overall efficiency of the softening process.

4.4 Brine Tank

The brine tank is used for regenerating the resin by supplying a 10% sodium chloride (NaCl) solution. It has a capacity of around 30 liters and requires about 3–4 kg of salt per regeneration cycle. During regeneration, the brine solution flows through the resin bed, restoring its ion exchange capacity. The process takes 20–30 minutes, followed by rinsing for 5–10 minutes.

4.5 Ion Exchange Resin Specification

The system uses a strong acid cation exchange resin in sodium (Na^{+}) form, such as Indian 225 Na. It has an exchange capacity of 1.9–2.0 meq/mL, works effectively in a pH range of 6.5 to 9.0, and can withstand temperatures up to 50°C. The resin typically lasts for 2 to 3 years under normal usage.

4.6 Installation Setup

The Resinohydrosoftener system is installed on a concrete or steel platform near a water source like a borewell, school, or

Panchayat Bhavan. It requires no electricity, works on gravity or low pressure, and is easy to operate by local users. Its compact design makes it ideal for rural and semi-urban areas

4.7 Flow Process Design

In the Resinohydrosoftener, raw water enters through the inlet valve, passes through the **r**esin column where ion exchange removes hardness, and exits via the outlet as soft water. During regeneration, brine solution from the brine tank flows through the resin bed and is then flushed out through the drain valve**.**

5 CONCLUSIONS

The Resinohydrosoftener system proves to be an efficient, low-cost, and sustainable solution for the removal of water hardness, especially in rural and semi-urban regions where access to treated water is limited. Through the use of a strong acid cation exchange resin, the system effectively reduces calcium and magnesium ion concentrations, ensuring soft and usable water for daily needs. Its compact design, simple installation, and minimal operational requirements make it highly suitable for decentralized water treatment. Case studies from regions like Nagpur demonstrate its practical utility, ease of regeneration, and consistent performance. Overall, the implementation of such systems can significantly improve water quality, reduce scaling issues in plumbing, and promote better public health outcomes in underserved communities

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