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Determination and Removal of Hardness of Water.

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Abstract —

Water hardness is a frequent problem that affects the quality and usage of many different water sources. The detection and elimination of hardness in water samples are summarised in this abstract. The main contributors to water hardness are dissolved calcium and magnesium ions. High levels of hardness can have a number of unfavourable impacts, including the buildup of scale in appliances and pipes, decreased soap and detergent effectiveness, and other negative outcomes. The soap test, EDTA titration, atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP-MS), and the gravimetric method are some of the techniques used to determine the hardness of water. The quality and use of many diverse water sources are impacted by the recurrent issue of water hardness. This abstract provides an overview of the methods used to identify and remove hardness from water samples. Calcium and magnesium ions that are dissolved in the water are the main causes of hardness. High levels of hardness can have a variety of detrimental effects, including as the accumulation of scale in plumbing and appliances, a red fuction in the efficacy of soap and detergent, and other undesirable results.

Keywords — **Lime soda, Clark's Method, Washing Soda, Hardness**

I. *INTRODUCTION*

The term "water hardness" describes the amount of dissolved minerals in water, primarily calcium and magnesium ions. It is a typical indicator of water quality that may have important ramifications for numerous home, commercial, and industrial applications. High water hardness levels can cause a variety of issues, including scale buildup in plumbing and home appliances, decreased soap and detergent effectiveness, and perhaps harmful impacts on machinery and industrial processes.To understand water quality and apply suitable treatment strategies, water hardness must be determined.

The quantitative and qualitative analysis of water hardness can be done using a variety of techniques. These techniques range from straightforward visual examinations to complex instrumental methods. The approach chosen will depend on various elements, including the level of accuracy necessary, the resources available, and the particular application.Effective steps to remove or minimise water hardness can be implemented once it has been identified. Depending on the degree of hardness and the desired water quality, different treatment methods are used to handle hard water.

These techniques seek to lessen or completely eliminate the amount of calcium and magnesium ions present in the water, hence lowering its hardness and avoiding related issues.The soap test, EDTA titration, atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP-MS), and the gravimetric method will all be examined in this study to determine the hardness of the water. We will go over the fundamentals, benefits, and drawbacks of each approach, emphasising how they might be applied in various situations.

We will also look into other methods for removing water hardness.Boiling, ion exchange, softening of lime-soda ash, reverse osmosis (RO), and distillation are some of these techniques. We will investigate the mechanisms by which these methods lessen hardness, the effectiveness of their removal of hardness ions, and any other factors that should be taken into account.For the aim of supplying high-quality water for home, commercial, and industrial uses, it is essential to comprehend how water hardness is determined and removed. This information enables the implementation of appropriate treatment procedures, preventing the formation of scale, enhancing the effectiveness of cleaning agents, and increasing the lifespan of water-using equipment. We can improve water efficiency, lower maintenance costs, and support sustainable water management practises by managing water hardness.

II. LITERATURE REVIEW

1]An Author Nor Izzah Abdul Aziz1 , Norzila Othmal, Wahid Ali Hamood Altowayti1 , Zalilah Murni Yunus, Nurina Fitriani , Mohd Fadhil Md Din4 , Firhat Muhammad Fikri proposed the paper titled"Assessment of Water Quality and Quantity of Surface and Subsurface Drainage System in the Command Area."a similar problem with water scarcity affects lower riparian and end-users of Sindhi's Indus Basin irrigation system. In order to address this problem, the quality and quantityThe majority of samples' results showed that the drainage effluent was within the WHO permissible limits for alkalinity, hardness, and TDS for sub-surface and surface drains, respectively, of 3 to 7.2 mg/L and 3 to 9 mg/L, 490 to 990 mg/L and 320 to 1250 mg/L. It can be used for cattle, fisheries, and irrigation while the 3L-Sub drain had somewhat poorer water quality as a result of the saline agricultural land portions. By dilution with fresh water according to approved ratios, the quality of this water can be improved.

[2]ABDU, M.S., MUSTAPHA, A., ASKA, A. S., ABDU, S. U and MADARA, M. S. synethisized " Determination and Removal of Hardness of water in Water samples from Bultumari ward in Gashua and Hausari ward in Nguru, Yobe State of Nigeria."Because of the presence of dissolved salts like Ca(HCO3)2 and Mg(HCO3)2, which cause temporary hardness while CaSO4 and MgSO4 cause permanent hardness, hard water is the type that does not immediately lather with soap. In order to establish the hardness, ground water samples were taken from the Bultumari and Hausari wards and subjected to qualitative examination.Both temporary and permanent hardness were present in the water samples taken from the study regions. The amount of calcium sulphate in water and the amount of soap solution consumed are inversely proportional. As a result, the study areas' hard water is to blame for the high amount of soap that people use in their daily domestic tasks.Before beginning to cook or do laundry, water in the study areas should be softened for improved health and safety as well as soap economy.

[3]The paper was proposed by P.Ramya*, A.Jagadeesh Babu1, E.Tirupathi Reddy2 and L.Venkateswara Rao Only 4.16% of the samples in the current study had severe levels of hardness, which may not be detrimental to people. Although most people dislike using hard water, magnesium and calcium may have some protective effects on cardiovascular mortality. However, the evidence is still up for debate and does not establish causation. Additionally, drinking water is the body's main source of calcium and magnesium intake. The majority of people have the incorrect belief that hard water is unhealthy for your health; in reality, very hard water has extremely high levels of hardness. Therefore, it would be preferable if we raised public awareness.

[4]Rafia Sarfraz, Mehwish Taneez , Sabahat Sardar, Lubna Danish and Abdul Hameed study used the ethylene diamine tetra acetic acid (EDTA) technique to determine the hardness levels of 17 distinct water samples.

[5]Adelekan, B. A. and Abegunde K.D. Among these, samples of pool water from Seoul's outdoor swimming area (140 ppm) revealed significant levels of the ions Ca2+ and Mg2+. The carbonation process with a closed pressure reactor for a 5 min reaction time reduced the hardness of the various water samples by 40-85%.The 21 g/L of CO2 carbonation for 5 minutes at room temperature reduced the hardness of the natural water samples taken from various parts of South Korea by 70 to 85%. The findings showed that the carbonation process in a closed pressure reactor may easily and effectively manage the hardness of various types of water."Evaluation of biological treatment for decreasing water hardness"

***METHODOLOGY*Hardness Major Method**

- **EDTA**

The determination of water hardness using EDTA (ethylene diamine tetraacetic acid) is a widely used method in analytical chemistry. EDTA forms a stable complex with metal ions, particularly calcium (Ca2+) and magnesium (Mg2+), which are the main contributors to water hardness. The major method for determining water hardness using EDTA is known as complexometric titration.

Here's a step-by-step procedure for the EDTA complexometric titration method to determine water hardness:

Sample Preparation: Collect a representative sample of the water to be tested in a clean and dry container. If the water contains any suspended particles, filter it before proceeding.

Titration Setup: Fill a clean burette with a standardized EDTA solution. The EDTA solution is prepared by dissolving a known weight of EDTA in water and then standardizing it against a primary standard solution of calcium or magnesium.

Indicator Selection: Choose a suitable metal ion indicator that forms a colored complex with the metal ions being titrated. Eriochrome black T (EBT) or calmagite are commonly used indicators. EBT changes color from wine-red to blue when the metal ions are complexed with EDTA.

Titration Procedure: Take a measured volume of the water sample (e.g., 50 mL) in a titration flask. Add a few drops of the selected metal ion indicator to the sample solution. The indicator will typically be red or pink in the absence of metal ions.

Titration Initiation: Begin the titration by slowly adding the EDTA solution from the burette into the flask while swirling the flask gently. The EDTA will react with the calcium and magnesium ions in the sample, forming stable complexes.

Endpoint Determination: As the EDTA solution approaches the equivalence point, the color of the indicator will change. In the case of EBT, it will change from red to blue. The endpoint is reached when the color change is permanent, indicating that all the metal ions in the sample have reacted with EDTA.

Calculation: Note the volume of EDTA solution required to reach the endpoint. The hardness of the water sample can be calculated using the following formula:

Hardness (in ppm or mg/L) = (Volume of EDTA solution × Normality of EDTA solution × Equivalent weight of $CaCO_3$) / Volume of water sample

The equivalent weight of $CaCO_3$ is the molecular weight of calcium carbonate divided by the number of moles of calcium or magnesium that reacts with one mole of EDTA (this depends on the stoichiometry of the reaction).

Repeat and Average: Perform multiple titrations using different water samples or replicate trials to ensure the accuracy of the results. Calculate the average hardness value from the replicate determinations.

It's worth noting that this is a simplified description of the method, and actual laboratory protocols may involve additional steps, specific equipment, and precise calculations. Always refer to an authoritative source or consult a laboratory manual for detailed instructions and safety guidelines when performing complexometric titration using EDTA.

1)Temporary Hardness Removing Method

Clarks method

Boiling: Temporary hardness of water can be removed by boiling water. During boiling, bicarbonates are processed to form hydroxides and calcium bicarbonates and then they are converted to form carbonates. Temporary hardness can be eliminated by filtering these precipitates.

Clark's method: Thomas Clark is known in chemistry for introducing a method for softening hard water known as Clark's method. His method involves softening calcareous water by removing carbonic acid from them. His method consists of adding milk of lime to hard water until the formation of precipitation of calcium and magnesium carbonates.

Removing water hardness by Clark's method

Minerals, salts, metals, cations, anions and other dissolved solids in water can be removed to reduce water hardness. One of the common methods of water softening is Clark's method by which the temporary hardness of water can be removed by using cold lime.

Clark's method helps in the preparation of water in a direct cooling tower makeup. This method can be used as a first-stage treatment before ion exchange for boiler makeup or recycling of RO reject water. Lime or a combination of lime and soda ash is added to treat the water (carbonate ions). They generate insoluble compounds when they come in contact with the hardness and natural alkalinity of the water. Sedimentation or calcification can be further removed from the water by precipitating them. Many companies use this method to treat water with moderate to high levels of hardness and alkalinity of about 150-500 ppm.

Fig 1

Boiling

Temporary hardness of water can also be removed by simply boiling the hard water, as by boiling bicarbonates are converted to insoluble carbonates which can be simply removed by filtration. But for permanent hardness of water boiling does not help as sulphate salts do not decompose on heating

2)Perament Hardness Removing

Ion exchange method-

Step-1

The hardness of water is due to the presence of a number of ions such as chloride ions, sulfate ions, and bicarbonates ions of calcium or magnesium metal these ions are present in the water when it passes through any rock, Hard water is not capable of producing lather on reacting with soap solution because different ion reacts with soap and form precipitate which is insoluble in nature and thus get settled at the bottom of soap solution.

Step-2

Therefore, the ion exchange method is used to remove the hardness of water, different ions which is responsible for causing the hardness of water are substituted with less damaging ion, ion exchange is of two types namely inorganic ion exchange or organic ion exchange.

For example, in order to remove the hardness of ion by inorganic ion exchange hard water is poured into the tank which has hydrated sodium aluminium silicate as an exchanger which reacts with the calcium ion of hard water to form calcium zeolite.

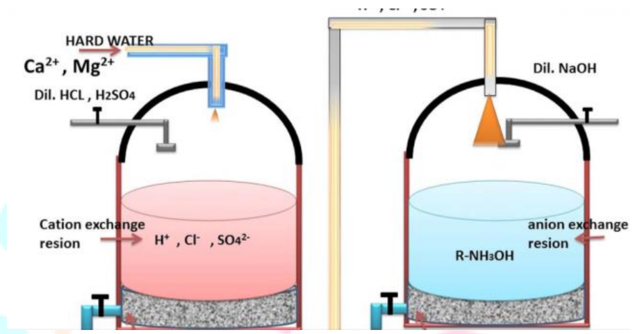

FIG 2

Washing Soda method for treating hardness of water :

Washing soda method is used to remove hardness of water by treating it with hard water which is the one which does not give immediate lather with soap due to the presence of dissolved salts like Ca(HCO3)2 and Mg(HCO3)2 which cause temporary hardness while CaSO4 and MgSO4 cause permanent hardness. In this process, qualitative analysis was carried out on the ground water. The results disclosed the presence of Ca2+, Mg2+, SO42- and HCO3-which indicated the presence of both temporary and permanent hardness in the samples. First of all we will boil the water to remove the temporary hardness of water Furthermore, addition of washing soda (Na2CO3) to the boiled and cooled water by doing this process we will find that permanent hardness of the water will be removed. boiling and addition of washing soda were the suitable methods used in removing the hardness. This is because boiling is a very simple process while washing soda is cheap and available.

2HCO3- boilingCO32- + H2O + CO2

Lime Softening :

Lime softening, which is also used for temporary hardness removal, can partially remove permanent hardness as well. By adding lime (calcium hydroxide) to water, the lime reacts with the calcium and magnesium ions, forming insoluble precipitates that can be removed through sedimentation or filtration. Lime softening is often used as a pre-treatment step in combination with other methods to achieve more complete hardness removal.

Fig3

III. RESULT

- **Water hardness before Hardness Removing**

Water	Water Sample	Burette Reading	Test
Purified water	20ml	1.1	55
Tap water	20ml	2.5	125
Hard water	20ml	4	200
Lab Crated water	20ml	8	400

Hardness Removal Method

- **Temporary Removing**

1) Lime Soda

Water	Water Sample	Burette Reading	Test
Hard water	20ml	1.3	65
Lab created water	20ml	2.3	115

2) Boiling

Water	Water Sample	Burette Reading	Test
Tap water	100ml	14	40

- **Permanent Hardness Removing**

Water	Water Sample	Burette Reading	Test
Hard Water	20ml	1.5	75
Lab created	20ml	2.5	125

3) Washing Soda

Water	Water Sample	Burette Reading	Test
Tap boiling water	50	5	100

Formula

Total hardness = Volume of EDTA solution consumed X1000 / Volume of the hard water taken

These are the water samples that we have taken from polluted river, tap water and one of the hard water we have prepared it in a lab by adding calcium chloride and magnesium chloride in it.

IV.FUTURE SCOPE

The future of hard water removal will contain improvements in techniques, methods, and tactics to deal with the problems brought on by hard water. Here are a few suggested directions for improvement:

Advanced Water Softening Technologies: Water softening technologies including ion exchange, reverse osmosis, and lime softening can be improved through research and development. This entails improving their effectiveness, lowering the amount of energy used, streamlining the regeneration procedures, and creating new materials with increased selectivity and capacity.

Alternative Water Treatment Techniques: Investigating different approaches to treating hard water can lead to new opportunities. In the laboratory, cutting-edge methods including electrochemical treatment, magnetic water conditioning, and catalytic processes have showed promise and may provide more long-lasting and affordable solutions for hard water removal.

Applications of Nanotechnology: Nanotechnology has the potential to

V.CONCLUSION

The harnessing of water resources plays a vital role in various aspects of human life and the development of societies. Water is a precious and essential resource that supports ecosystems, sustains human life, and drives economic activities across the globe.Throughout this report, we have explored different aspects of water harnessing, including water supply systems, hydroelectric power generation, irrigation, and water management strategies. We have examined the benefits, challenges, and potential solutions associated with each of these areas.water supply systems are crucial for ensuring access to clean and safe drinking water for communities. The development of reliable infrastructure and efficient water treatment methods is essential to meet the growing demand for water in urban and rural areas.

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