

Determination of Hardness of Water by EDTA Method

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Abstract: *Water with high concentration of minerals is hard water. Water is essential for life. But water with veryhigh degrees of hardness is harmful to health. 120 samples of ground water samples were collected from one town and two different villages. Hardness of water can be determined by EDTA titrimetric method. Out of all the samples tested 39 (32.5%) samples were moderately hard, 76 (63.33%) samples were hard water and 5 (4.16%) samples were very hard water. Extreeme degrees of hardness are dangerous to health. The present study did not revealed any soft water. There is a false notion that hard water is harmful to health, its not hard water, its very hard water (>180ppm). The minerals that are supplemented to body through water will be beneficial to health in several ways. So public should be educated about degrees of hardness and its effects.*

Keywords: EDTA Method, Clark's Method, Washing Soda, Hardness of Water

I. INTRODUCTION

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.

Water hardness is the traditional measure of the capacity of water to precipitate soap. Hard water requiring a considerable amount of soap to produce leather. Scaling of hot water pipes, boilers and other house hold appliances is due to hard water. Hardness of water is no specific constituent but is a variable and complex mixture of cations and anions. It is caused by dissolved polyvalent metallic ions. In fresh water, the principle hardness causing ions are calcium and magnesium. The other ions like Strontium, Iron, Barium and Manganese also contribute. Hardness is commonly expressed as CaCO₃ in mg/L. The degree of hardness of drinking water has been classified in terms of the equivalent CaCO₃ concentration as follows:





Soft 0-60 mg/L;
 Medium 60-120 mg/L;
 Hard 120-180 mg/L;
 Very hard > 180 mg/L;

Although hardness is caused by cation, it may also be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness. Carbonate hardness refers to the amount of carbonates and bicarbonates in solution that can be removed or precipitated by boiling. This type of hardness is responsible for the deposition of scale in hot water pipes and kettles. When total hardness is numerically greater than that of total alkalinity expressed as CaCO₃, the amount of hardness equivalent to total alkalinity is called ‘carbonate hardness’. The amount of hardness in excess of total alkalinity expressed as CaCO₃ is non carbonate hardness. Non carbonate hardness is caused by the association of the hardness of causing cation with sulphate, chloride or nitrate and is referred to as “permanent hardness” because it cannot be removed by boiling.

Objective

Analyze the Integration of Artificial Intelligence in Education: Examine how Artificial Intelligence (AI), Machine Learning (ML), and Data Analytics can be integrated into a single learning ecosystem to enhance both student and faculty experiences. This includes exploring the use of adaptive learning algorithms that dynamically adjust the learning content and quiz difficulty based on individual student performance. The objective is to understand how AI-based personalization can overcome the limitations of traditional, uniform education systems. Evaluate Learning Personalization and Feedback Mechanisms: Assess how quiz-based progress analysis enables intelligent feedback loops for students. This review aims to determine the effectiveness of using AI models to evaluate quiz outcomes, predict weak learning areas, and recommend targeted content. Additionally, it investigates how continuous data-driven feedback can motivate students and assist faculty in tailoring lesson plans for improved understanding and retention. Explore Faculty Involvement and Decision Support: Study how faculty dashboards, powered by real-time analytics, can assist educators in identifying at-risk students, monitoring academic performance trends, and making informed pedagogical decisions. The review also examines the role of AI-driven insights in improving teacher efficiency and promoting collaborative learning environments within academic institutions. Examine Technological and Systemic Integration: Investigate how the proposed platform can integrate seamlessly with existing educational infrastructures such as Learning Management Systems (LMS), virtual classrooms, and mobile learning applications. The review aims to evaluate the challenges of scalability, data security, and interoperability when deploying AI-driven educational tools across diverse institutions.

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. synthesized “ 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 CaSO_4 and MgSO_4 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 Ca^{2+} and Mg^{2+} . 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 CO_2 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"

III. EDTA METHOD

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 (Ca^{2+}) and magnesium (Mg^{2+}), 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: $\text{Hardness (in ppm or mg/L)} = (\text{Volume of EDTA solution} \times \text{Normality of EDTA solution} \times \text{Equivalent weight of CaCO}_3) / \text{Volume of water sample}$ 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.



Fig1: Temporary Hardness Removing Method

Preparation of Reagents

Buffer solution:

Dissolve 16.9 g NH_4Cl in 143 ml NH_4OH . Add 1.25 g magnesium salt of EDTA to obtain sharp change in colour of indicator and dilute to 250 ml. If magnesium salt of EDTA is not available, dissolve

1. 179 g disodium salt of EDTA (AR grade) and 780 mg $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ or 644 mg $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ in 50 ml distilled water. Add this to above solution of NH_4Cl in NH_4OH and dilute to 250 ml.
2. Inhibitor: Dissolve 4.5 gm hydroxyl amine hydrochloride in 100 ml 95% ethyl alcohol or isopropyl alcohol.
3. Eriochrome black T (EBT) indicator: Mix 0.5 gm dye with 100 gm NaCl to prepare dry powder.
4. Muroxide Indicator: Prepare a ground mixture of 200 mg of murexide with 100 gm of solid NaCl.
5. NaOH (2N): Dissolve 80 gm NaOH and dilute to 1000 ml.
6. Standard EDTA Solution 0.01M: Dissolve 3.723 gm EDTA disodium salt and dilute to 1000 ml. Standardized against standard calcium solution, 1ml = 1mg CaCO_3
7. Standard Calcium Solution: Weigh accurately 1gm CaCO_3 and transfer to 250 ml conical flask. Then add 1:1 HCl till CaCO_3 dissolve completely. Add 200 ml dist. water and boil for 20 to 30 min. then cool and add methyl red indicator. Add NH_4OH 3N drop wise till intermediate orange colour develops. Dilute to 1000 ml to obtain 1ml = 1mg CaCO_3 .

Procedure

(a) Total hardness

- i. Take 25 or 50 ml or well mixed sample in a conical flask



- ii. Then add 1 to 2 ml buffer solution followed by 1 ml inhibitor
- iii. Add a pinch of Eriochrome black T and titrate with standard EDTA (0.01M) till wine red colour changes to blue, then note down the volume of EDTA required (A) .
- iv. Run a reagent blank. Note the volume of EDTA (B).
- v. Calculate volume of EDTA required by sample, $C = A - B$ (from volume of EDTA required in steps (iii & iv).

(b) Calcium hardness

- i. Take 25 or 50 ml sample in a conical flask
- ii. Add 1 ml NaOH to raise pH to 12.0 and add a pinch of monoxide indicator.
- iii. Titrate immediately with EDTA till pink colour changes to purple. Note the volume of EDTA used (A1).
- iv. Run a reagent blank. Note the ml of EDTA required (B1) and keep it aside to compare end points of sample titrations.
- v. Calculate the volume of EDTA required by sample, $C1 = A1 - B1$.

IV. MATERIAL & METHODS

One Hundred and twenty samples (120) of ground water were collected from one town and two different villages while attending Mega Animal Health Camp organized by College of Veterinary Science, Proddatur, YSR KADAPA district, Andhrapradesh, India. All the water samples were collected aseptically in to sterilized screw capped glass bottles and brought to the laboratory. Hardness of all the water samples was tested by using EDTA-tritrimetric method by taking 50ml of water sample into a conical flask along with 100ml of ammonia buffer solution and 100-200-mg of Eriochrome black- T indicator followed by titration with EDTA solution present in a burette. End point is noted down by changing of the water solution color from wine red to blue and expressed as CaCO₃ equivalent in mg/l (Standard Methods, 1998). Amount of Hardness in water is calculated by using the formula.

V. RESULT & DISCUSSION

The present study had revealed that out of three places, the two villages had shown high level of hardness compared to the town. In Proddatur town, out of 40 water samples collected, almost all the samples were moderately hard (42.5%) and hard water samples (52.5%). Only few samples were very hard water (5%) (Table). The results of Villages were different from the results of town. Forty each number of samples were collected from two villages.

In Sannapalli village, more number of samples had shown hardness between 150-300mg/l of CaCO₃ (67.5%) i.e. hard water. Some of the samples had shown moderate hardness (30%) and very few of them have shown extreme hardness (2.5%) (Table). Similar type of results were found in the study of samples of Chinnakuravaluru village also. The results were hard water - 70%, moderately hard water - 25% and very hard water - 5%. Finally no soft water sample was found in all the 120 samples (Table).

Altogether out of 120 samples, most of the samples are hard water (63.33%). There are only 5 samples (4.16%) which are found to be very hard water. According to Kozisek, (2003) both the extreme degrees of hardness are dangerous to human health i.e. very hard and very soft water. The present study did not reveal presence of any soft water, but it had reported very hard water in about 4.16% of the samples which is negligible. Water intake of cattle and milk production were unaffected by water containing up to 290 ppm of hardness (NRC, 1974). So the water in the above three places may not decrease the water intake and milk production of cattle in the above said areas.

Hard drinking water is generally not harmful to one's health, (WHO, 2003) but can pose serious problems in industrial settings. Most of the people especially housewives dislike hard water because it does not lather well or does not taste good, but they may not be knowing that it may prolong their lives, and more especially their husbands (Time, Medicine, 2011). Hardness as mg/l CaCO₃ = ml of EDTA solution used x 1000 / Volume of water samples taken



VI. 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.

The present study had revealed extreme degrees of hardness in only 4.16% of the samples which may not be harmful to the people. Although most of the people dislikes to use hard water, magnesium and calcium are having some protective effect on cardiovascular mortality, the evidence being debated and does not prove causality and also the drinking water is the source of calcium and magnesium intake which are essential for the body. Most of the people are in false opinion that hard water is harmful to health, it's not hard water, and it's very hard water (extreme degrees of hardness). So it would be better if we bring awareness among the public.

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