# APPLICATION OF THE COMPLEXOMETRY METHOD IN DETERMINING CALCIUM ($Ca^{2+}$) CONCENTRATIONS IN SOME WELL WATERS IN GOWA REGENCY, SOUTH SULAWESI

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**Abstract**

**Well water is the primary source of clean water for local communities; however, its quality is significantly influenced by geological conditions, such as the presence of limestone ($CaCO_3$), which can increase water hardness. Excessive calcium levels can cause technical issues, such as limescale on household appliances, as well as potential health problems, such as kidney stones. The method used in this study was complexometric titration with ethylenediaminetetraacetic acid (EDTA) as the titrant and Eriochrome Black T (EBT) as the metal indicator. Analyses were conducted on five samples of dug well water from varying locations and depths. The results of the study showed that the calcium concentrations in the five samples were 38.4 mg/L, 28.8 mg/L, 26.4 mg/L, 40.8 mg/L, and 25.7 mg/L. Based on these results, all samples had calcium concentrations below the maximum threshold set by the WHO (150 mg/L). Variations in calcium concentrations between samples were influenced by location and the interaction of water with rock layers in the soil. Overall, well water at the study site is considered safe for consumption in terms of calcium parameters, although regular quality monitoring is still required.**

**Keywords***:* Calcium, Complexometry, Well Water, EDTA.

## I. INTRODUCTION

Water is a fundamental necessity that is essential to human life and plays a vital role in supporting health, domestic activities, and the social and economic development of communities. The availability of clean, safe water is one of the indicators of a region's well-being (Herawati et al., 2024). In Indonesia, particularly in rural areas and urban fringe regions such as Gowa Regency, well water remains the primary source of clean water utilised by the community for various purposes, ranging from drinking, cooking, bathing, washing, to sanitation needs. This high dependence on well water means that its quality must be given serious attention, particularly from chemical, physical, and biological perspectives (Nurhajawarsi & Haryanti, 2023).

The quality of well water is significantly influenced by geological conditions, soil type, well depth, and human activities in the surrounding area. Geochemically, groundwater can dissolve various minerals found in the soil layers and rocks through which it flows. One of the minerals commonly dissolved in groundwater is calcium-containing (Ca) minerals, particularly those derived from limestone ($CaCO_3$) and dolomite (Aminuddin et al., 2025). This dissolution process leads to an increase in the concentration of calcium ions ($Ca^{2+}$) in well water. The presence of

calcium ions in certain quantities is actually required by the human body; however, excessive levels can cause problems, both from a health perspective and in terms of the technical use of water (Khong et al., 2024). Water containing high levels of calcium and magnesium ions is known as hard water. Water hardness is one of the key chemical parameters in assessing the quality of drinking water. Hard water can cause limescale to form on household appliances, water pipes, and kettles, which in the long term can reduce the efficiency of the equipment and increase maintenance costs (Kumar, 2024). Furthermore, water hardness can also reduce the effectiveness of soap and detergents, as calcium ions react with fatty acids to form insoluble deposits. From a health perspective, the continuous consumption of water with excessively high calcium levels has the potential to cause certain health issues, such as the formation of kidney stones in susceptible individuals (Zhang et al., 2025). Therefore, the analysis of calcium content in well water is of great importance as part of water quality control. Various analytical methods have been developed to determine calcium levels in water, both instrumental and titrimetric. Instrumental methods such as atomic absorption spectroscopy (AAS) and ICP-OES offer high precision, but require expensive equipment that is not always available in educational laboratories or small-scale laboratories. As an alternative, complexometric titration offers a simpler, more economical, and sufficiently accurate solution for the analysis of alkaline earth metal ions such as calcium. The complexometric method is based on the formation of a stable complex between the metal ion and a complexing ligand, the most commonly used being ethylenediaminetetraacetate (EDTA). EDTA is a hexadentate ligand capable of forming strong coordinate bonds with $Ca^{2+}$ ions in a 1:1 stoichiometric ratio. The formation of a stable Ca-EDTA complex forms the basis for the quantitative determination of calcium concentration. The endpoint of the titration can be determined using a metal indicator, such as Eriochrome Black T (EBT), which exhibits a distinct colour change when all calcium ions have been bound by EDTA. The advantages of the complexometric method include a relatively simple procedure, short analysis time, and sufficient precision for water analysis. Furthermore, this method is highly suitable for application in the analysis of well water quality in areas with limited access to advanced laboratory facilities. Thus, the complexometric method is not only academically relevant but also practical for environmental quality monitoring. Based on the above, this study was conducted to determine the calcium (Ca) content in several well waters in Gowa Regency using the complexometric titration method (Budi et al., 2023). It is hoped that this study will provide an overview of the hardness levels of well water in the region and serve as a basis for information for the public and relevant parties in the safe and sustainable management and utilization of well water.

## II.METHODOLOGY

### Equipment and Materials

The equipment used in this study consisted of glassware such as measuring flasks, Erlenmeyer flasks, burettes, funnels, beakers, measuring cups, stirring rods, spatulas, volumetric pipettes and dropper pipettes.

The materials used included calcium carbonate ($CaCO_3$), hydrochloric acid

(HCl) p.a., sodium ethylenediaminetetraacetate ($Na_2EDTA$), Erichrom Black Thymol (EBT) indicator, and aquadest.

**Preparation of CaCl Standard Solution**

Weigh 0.2 g of calcium carbonate ($CaCO_3$) and dissolve it in 100 mL of aquadest. Then, add 30 drops of concentrated hydrochloric acid (HCl). Next, transfer the solution to a 250 mL volumetric flask, then add distilled water up to just below the mark and wipe the neck of the flask dry. Then add aquadest drop by drop until the mark is reached.

$$\text{M } CaCO_3 = \frac{a-b}{Mr \,.V}$$

**Preparation of a 0.01 M $CaCl_2$ solution**

Pipette 0.184 mL of a $CaCl_2$ stock solution into a 50 mL volumetric flask. Then add distilled water ($H_2O$) up to the mark. Mix thoroughly.

**Standardisation of Na-EDTA Solution Using a $CaCl_2$ Standard Solution**

Pipette 25 mL of $CaCl_2$ solution into a 250 mL Erlenmeyer flask, then add 3 mL of pH 10 buffer and a spatula tip of Erikrom Black Thymol (EBT) indicator, and mix until the solution turns burgundy. Then titrate slowly with the Na-EDTA solution until the colour changes to blue. Repeat in duplicate.

**Preparation of 100 mL of 0.01 M Na-EDTA Solution**

Weigh 0.03 g of sodium ethylenediaminetetraacetate ($Na_2EDTA$), then place it in a beaker and dissolve it using distilled water. Afterwards, transfer the solution to a 100 mL volumetric flask and dilute to the mark.

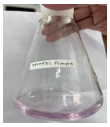
**Analysis calcium of water sample**

A 25 mL water sample was pipetted into a 250 mL Erlenmeyer flask, to which 3 mL of pH 10 buffer and a small amount of Erikrom Black Thymol (EBT) indicator were added; the mixture was then homogenised until it turned burgundy. It was then titrated slowly with a Na-EDTA solution until it turned blue. The procedure was repeated in duplicate.

## III. RESULTS AND DISCUSSION

Complexometry is an analytical method widely used to determine the concentration of metal ions in aqueous solutions. This technique is based on the titration process between metal ions and complexing agents or chelating ligands, and is therefore often referred to as complexometric titration (Winarni et al., 2025). The principle involves converting free metal ions into stable complexes, whilst the equivalence point is determined using a suitable metal indicator. In practice, the most commonly used complexing agent is ethylenediaminetetraacetate (EDTA). The chelating agent in this method is typically disodium EDTA ($Na_2EDTA$) as it has high solubility in water, is non-hygroscopic, and is stable during storage (Yazid et al., 2023). This study was conducted at the Analytical Chemistry Laboratory, Department of Chemistry, Faculty of Science and Technology, UIN Alauddin Makassar in December 2025 using a complexometric titration method aimed at analysing the calcium (Ca) content in five well water samples from the vicinity of Jln. Sultan Alauddin, Samata-Gowa. Well water samples were collected from several residential areas in Gowa Regency, South Sulawesi.

**Table 1** Results of observations on Na-EDTA solutions using a $CaCl_2$ standard solution

| No. | Treatment | Volume of Na-EDTA (mL) | Colour change | |
|---|---|---|---|---|
| | | | Before | After |
| 1 | Simplo | 0.3 |  Burgundy |  Blue |
| 2 | Duplo | 0.5 |  Burgundy |  Blue |

The preparation of the Na-EDTA solution as a titrant utilised a mixture of Na-EDTA and $MgCl_2 \cdot 6H_2O$ to ensure the presence of $Mg^{2+}$ ions in the solution. Na-EDTA served both as the titrant and as a secondary standard solution, the concentration of which was determined via complexometric titration using $CaCl_2$ as the standard. The standardisation step involves adding an ammonium buffer ($NH_4OH$–$NH_4Cl$) to the Erlenmeyer flask to maintain the stability of the ions at a pH suitable for complex formation. The correct pH conditions result in optimal complexation reactions, ensuring the titration process is accurate. The addition of the Eriochrome Black T (EBT) indicator serves to mark the end point of the titration, as the indicator changes colour to burgundy when the complex is fully formed.

Table 2 Results of Calcium (Ca) Concentration Analysis in Well Water

| No. | Sample code | Calsium concentration in Well Water Samples (mg/L) |
|---|---|---|
| 1 | A | 38.4 |
| 2 | B | 28.8 |
| 3 | C | 26.4 |
| 4 | D | 40.8 |
| 5 | E | 25.7 |

Analysis of calcium (Ca) parameters is crucial because the presence of calcium ions in water can contribute to water hardness and have both economic and health implications. Water hardness can lead to the formation of limescale deposits in water heaters and pipework, as well as reducing the effectiveness of soap. Furthermore, the presence of calcium in water that enters the bloodstream can also pose a potential health risk. Excess calcium can accumulate in the nails, skin, and other body tissues even though these organs do not require it. This condition can ultimately lead to various problems, such as premature ageing, fatigue, depression, and several other disorders associated with high calcium levels in the body. Based on measurement results, it is evident that the calcium content varies in each dug well. These variations in calcium levels are influenced by the differing locations and depths of the wells. If a well is situated near certain rock formations, such as limestone, the calcium content in the water tends to be higher. This is due to the interaction of the water with the limestone layers it passes through; as calcium is highly soluble in water, its concentration in the well water increases. According to the BIS/WHO drinking water quality classification, the ideal descriptive calcium level is around 75 mg/L, whilst the maximum acceptable limit is 200 mg/L. In this study, some samples

showed calcium levels below 75 mg/L, meaning the water falls into the low to moderate hardness category, whilst others reached or exceeded 75 mg/L, indicating an increase in water hardness that can lead to limescale formation on equipment and reduce the effectiveness of detergents. From a health perspective, calcium levels exceeding the descriptive threshold are not directly harmful according to the WHO, but if very high, they may contribute to problems such as kidney stones in sensitive individuals if consumed over the long term.

## IV. CONCLUSION

The results of the study indicate that all well water samples taken on Jalan Sultan Alauddin, Samata-Gowa, contain calcium, with concentrations of 38.4 mg/L, 28.8 mg/L, 26.4 mg/L, 40.8 mg/L and 25.7 mg/L respectively.

The calcium content in these water samples is considered safe for consumption, as it remains below the World Health Organisation's (WHO) standard limit for drinking water quality, which is 150 mg/L.

## References


Aminuddin, Madiutomo, N., Cahyadi, T. A., Firmansyah, I., Nurohman, H., & Siswanto, N. D. (2025). Groundwater Quality And Health Risk Assessment In Trenggalek Karst Springs And Underground Rivers As A Drinking Water Source. *Geosciences*, 15(10), 381.

Budi, I., Hidayat, A., & Suyanto, A. (2023). Determination Of Hardness And Major Cations (Ca, Mg) In Domestic Water Using Complexometric Titration And Correlation With Physicochemical Parameters. *Journal of Environmental Chemistry and Ecotoxicology*, 15(2), 67–74.

Herawati, S., Syahrir, M., Yusuf, S. N. S., & Balebu, D. W. (2024). Assessing Groundwater Quality In Rural Communities: A Detailed Study Of Physical, Chemical, And Microbial Contaminant. *International Journal of Medical Toxicology and Legal Medicine*, 27(1), 180–188.

Khong, L. X., Ahmad Nizar, N. H., Ismail, S., Saad, N. A., Kamaruddin, M. A., & Zabidi, H. (2024). Assessing The Groundwater Quality And Hydrogeochemical Characteristics Of Karst Aquifers In Kinta Valley, Perak. Applied Mechanics and Materials, 920, 219–225.

Kumar, R. (2024). Potential Health Impacts Of Hard Water: A Review Of Literature. International Journal For Research In Applied Science And Engineering Technology, 12(6), 606–622.

Nurhajawarsi, N., & Haryanti, T. (2023). Analisis Kualitas Air Sumur Sekitar Kawasan Industri Bantaeng (KIBA). *Sebatik*, 27(1), 43–51.

World health Organization. (2009). Calsium and magnesiun in Drinking water. WHO library, pp:84-88.

Zhang, J., Luo, H., Wu, H., Qian, Y., Tang, Z., Wang, J., Li, Z., Zheng, H., & Tang, F. (2025). The Association Between Domestic Water Hardness And Kidney Stone Disease: A Prospective Cohort Study From The UK Biobank. *International Journal of Surgery*, 111(2), 1957–196.