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An Investigation of Water Hardness in Household Open Wells across Six Districts in Kerala

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ABSTRACT: Water hardness refers to the amount of dissolved calcium and magnesium in water. It is a critical factor in determining the quality of water, especially for drinking and irrigation purposes. This study assessed the levels of calcium and magnesium in drinking water from household open wells in Kerala, India. Altogether 132 well water samples were collected from six districts. The results showed that the concentrations range of calcium and magnesium were 5-95 mg/l and 0-77.5 mg/l, respectively. In majority of sites, the concentration levels were within the BIS guidelines for drinking water quality. However, magnesium content was above the desirable limit in 4% of the samples at Ernakulam and Palakkad districts and it was 9% with respect to Kannur district. 4% of the well water has calcium content above the desirable limit at Malapuram and Palakkad district. But it was understood that it did not have any adverse effects on the health of people who drank the water. The results of this study suggest that the levels of calcium and magnesium in drinking water from household open wells in Kerala are generally safe, but there is some variation between the wells. Further studies are needed to investigate the health implications of these variations.

Keywords: Water hardness, calcium, magnesium, drinking water, household open wells, Kerala.

INTRODUCTION

Freshwater is a vital resource for human life and the environment. It is essential for drinking, sanitation, agriculture, and industry. However, freshwater resources are increasingly threatened by overexploitation, poor management, and ecological degradation (Boominathan *et al*., 2012). In developing countries, water quality is a major issue, as surface water sources have become increasingly polluted with organic, inorganic and biological contaminants. In Kerala, India, open wells are a major source of drinking water. The water quality of these wells can vary depending on a number of factors, including location, geological conditions, surrounding land use and potential sources of contamination. Pollutants such as agricultural runoff, industrial waste, and sewage can all affect the water quality of open wells. It is therefore important to have open wells tested regularly for water quality. This will help to ensure that the water is safe for consumption and that any potential problems can be identified and addressed early on. Regular monitoring and assessment of water quality is essential to protect public health and ensure the sustainability of freshwater resources.

Hard water is a type of water that contains high levels of dissolved minerals, particularly calcium and magnesium. These minerals come from the earth's crust and are carried into aquifers by rainwater as it moves through natural rock formations (Kumar and Prasad 2014). The hardness of water depends on its origin. Water from tube wells tends to have higher calcium content than water from open wells or rivers. This is because tube wells typically tap into deeper aquifers, which are more likely to contain calcium-rich minerals (Kumar and Prasad, 2014). The calcium content of drinking water can also vary seasonally, depending on the rainfall patterns (Kumar and Singh, 2020). In different parts of India, groundwater is known to have a high mineral content due to the presence of limestone and dolomite in the region. The levels of these minerals were generally within the permissible limits set by the World Health Organization (WHO). However, there was some variation in the levels of these minerals, depending on the location of the well (Yadav and Singh 2019).

Hard water, which is high in calcium and magnesium, is not considered a health risk and can contribute positively to overall mineral intake in the human body (Tveit *et al*., 2015). Numerous studies have found that hard water has positive effects on cardiovascular disease and can help to protect against certain types of cancer (Nerbrand *et al*., 2003). Magnesium salts found in hard water act as laxatives, important for the health of bones, teeth, muscle relaxation and nerve function. Calcium is essential for building and maintaining strong bones and teeth (Tveit *et al*., 2015). On the other hand, a lack of calcium or magnesium in drinking water has been associated with lower bone density, a higher incidence of fractures, and disturbed bone development in children. Many people choose to drink water that is high in calcium and magnesium because of their

potential health benefits (Kozisek, 2020). Cooking food in hard water can increase its calcium content, but decrease the calcium content when cooked in soft water (Durlach, 1989). Magnesium in water appears as hydrated ions, which are more easily absorbed than magnesium in food **(**Theophanides *et al*., 1990). The assessment of calcium and magnesium in drinking well water is an important public health measure.

MATERIALS AND METHODS

Description of the Study Area

In the present study samples were collected from 6 districts of Kerala. For the sake of interpretation, the study areas have been divided in to central and northern region of Kerala. From northern region samples were collected from Kannur, Wayanad and Kozhikode districts. The central region consists of Malappuram, Palakkad and Ernakulam (Fig. 1). Random samples were taken from 132 stations during pre-monsoon period (Table 1). Majority of the samplings were done from rural areas.

Random sampling was done from six districts of Kerala. 500 ml of water samples were collected from 132 open wells in clean plastic bottles. Calcium (mg/l) and total hardness (ppm $CaCO_3$/l) were analyzed using water analyzing field kits of Nice Chemicals. Magnesium (mg/l) content was measured by subtracting calcium content from total hardness.

Fig. 1. Location of stations in Kerala.

RESULTS AND DISCUSSION

Results obtained are represented in Figures 2 to 13.

1. Total hardness (mg/l). At Kannur, the total hardness varied from 5to 70 mg/l with an average value of 29.18 (SD=19.02) mg/l. In Wayanad, it varied from 5 to 50 mg/l with an average value of 17.89 (SD=11.40) mg/l. With respect to Kozhikode the total hardness varied from 5 to 32 mg/l with an average value of 28.18 (SD=9.58) mg/l. In Malappuram the total hardness varied from 6 to 120 mg/l with an average value of 21.18 (SD=24.26) mg/ls. At Palakkad, it varied from 5 to 87.5 mg/l with an average value of 17.72 (SD=16.89) mg/l. At Ernakulam, the total hardness varied from 5 to 70 mg/l with an average value of 22.27 (SD=19.30) mg/l (Fig. 2-3).

2. Calcium (mg/l). Figures 4 and 5 represent the distribution of calcium in northern and central Kerala, respectively. At Ernakulam, the calcium varied from 5 to 40 mg/l with an average value of 11.59 (SD=8.36) mg/l (Fig. 8). At Palakkad, the calcium varied from 5 to 20 mg/l with an average value of 8.64(SD=4.68) mg/l (Fig. 9). At Malappuram the calcium content varied from 5 to 95 mg/l with an average value of 17.27 (SD=19.92) mg/l (Fig. 10). With respect to Kozhikode the calcium varied from 5 to 30 mg/l with an average value of 7.05 (SD=5.7) mg/l (Fig. 11). In Wayanad, it varied from 5 to 35 mg/l with an average value of 12.5 (SD=7.83) mg/l (Fig. 12). At Kannur, the calcium varied from 5 to 30 mg/l with an average value of 14.77 (SD=7.48) mg/l (Fig. 13).

3. Magnesium (mg/l). Figures 6 and 7 represent the distribution of magnesium in northern and central Kerala, respectively. At Ernakulam the magnesium content varied from 0 to 45 mg/l with an average value of 10.68 (SD=12.15) mg/l (Fig. 8). At Palakkad, the magnesium content varied from 0 to 77.5 mg/l with an average value of 9.09 (SD=15.86) mg/l (Fig. 9). At Malappuram the magnesium content varied from 0 to 25 mg/l with an average value of 3.9 (SD=5.91) mg/l (Fig. 10). With respect to Kozhikode the magnesium content varied from 0 to 13 mg/l with an average value of 3.09 (SD=3.15) mg/l (Fig. 11). In Wayanad, it varied from 0 to 15 mg/l with an average value of 5.39 (SD=4.97) mg/l (Fig. 12). At Kannur, the magnesium content varied from 0 to 55 mg/l with an average value of 14.40 (SD=14.68) mg/l (Fig. 13).

The results showed that the levels of calcium and magnesium in the majority of sampling site were within the safe limits. The Bureau of Indian Standards (BIS, 2012) recommends a range of 20-75 mg/l for calcium and 10 to 30 mg/l for magnesium in drinking water. The source of calcium in water can from various dissolved sources such as rock, limestone, gypsum, salts and soil. Some areas in Kerala may have higher or lower levels of calcium and magnesium in the drinking water depending on the specific geological features of the region (Hariharan and Mammen 1983). The present study is in agreement with previous studies conducted at different parts of India. The calcium content of drinking water in rural areas of Varanasi district, India varied from 10 to 100 mg/l and the magnesium content varied from 5 to 20 mg/l (Singh *et al.*, 2021). The minimum and maximum concentrations of calcium were 68.0 and 142.0 mg/l and those of magnesium were 15.0 and 35.0 mg/l in Sonbhadra district (Mishra and Singh, 2020).

In the present work, magnesium content was above the desirable limit in 4% of the samples collected from Ernakulam and Palakkad districts. It was 9% with respect to samples collected from Kannur district. 4% of the well water has calcium content above the desirable limit at Malapuram and Palakkad district. But it was understood that it did not have any adverse effects on the health of people who drank the water. Similar investigations have been reported from earlier studies also. People who drank water with higher levels of calcium and magnesium had a lower risk of hypertension and diabetes mellitus (Suresh *et al*., 2019). People used the water with higher levels of calcium and magnesium had a lower risk of stroke (Babu, 2018). Those who consumed water with higher levels of calcium and magnesium had a lower risk of chronic kidney disease (Thomas *et al*., 2020). These minerals

also have positive impact on cardiovascular diseases (Mathew *et al.*, 2016).

While hard water can have beneficial mineral content, it can also be problematic at home due to issues like staining on clothes, reduced soap lathering, and scale build-up on heating elements and boilers. To address this issue, water softening methods can be used to reduce the levels of calcium and magnesium in drinking water. If the levels of these minerals are too high or too low, it may be necessary to take steps to adjust the water, such as adding or removing minerals. However, more research is needed to confirm these findings and to determine the optimal levels of calcium and magnesium in water for a better human health.

Table 1: Details of the study area.

Sl. No.	District	Stations (Panchayath/ Grama panchayath)	No. of Samples
1	Kannur	Vallithode	22
2	Wayanad	Vythiri	22
3	Kozhikode	Nellipoil, Thiruvampady	22
4	Malappuram	Thanur, Vallillapuzha	22
5	Palakkad	Mankara, Mauur, Keralasserry	22
6	Erankulam	Koovapady, Kanjoor	22

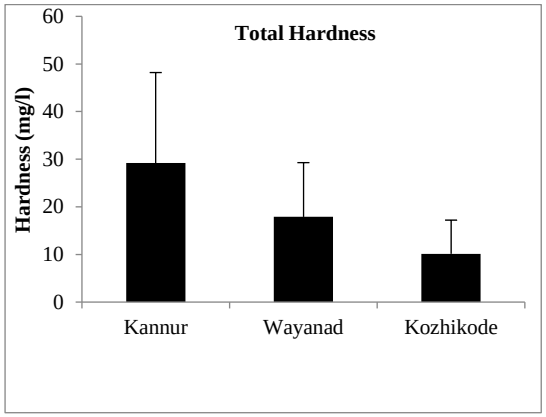

Fig. 2. Distribution of total hardness in northern Kerala.

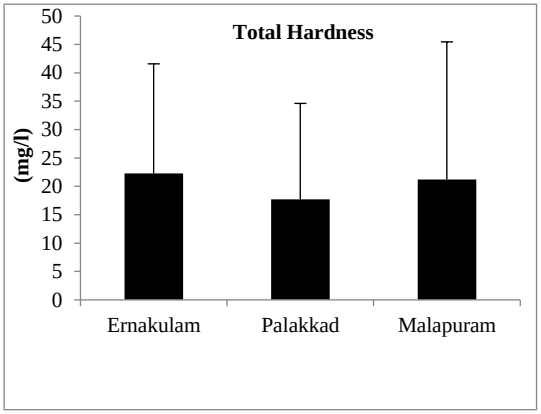

Fig. 3. Distribution of total hardness in central Kerala.

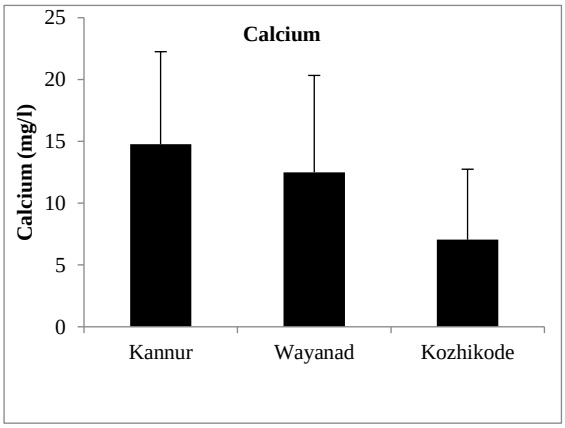

Fig. 4. Distribution of calcium in northern Kerala.

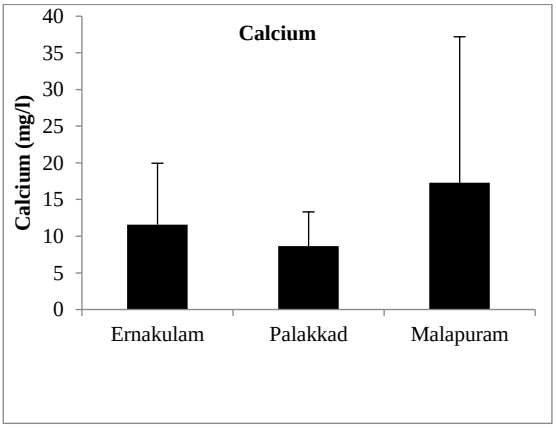

Fig. 5. Distribution of calcium in central Kerala.

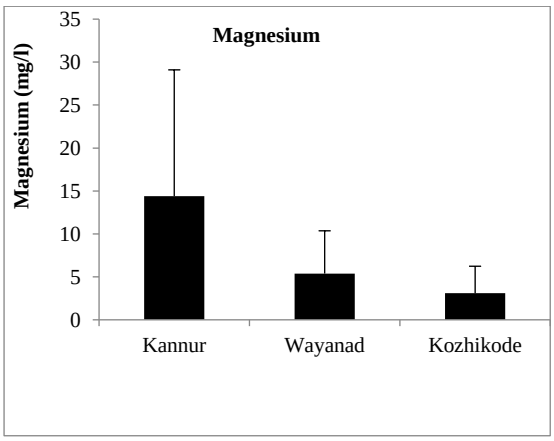

Fig. 6. Distribution of Magnesium in northern Kerala.

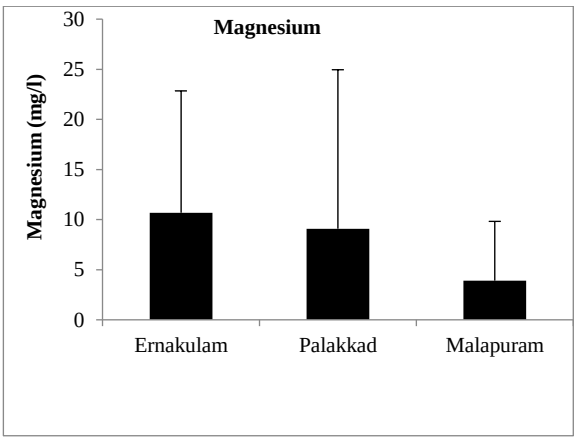

Fig. 7. Distribution of Magnesium in central Kerala.

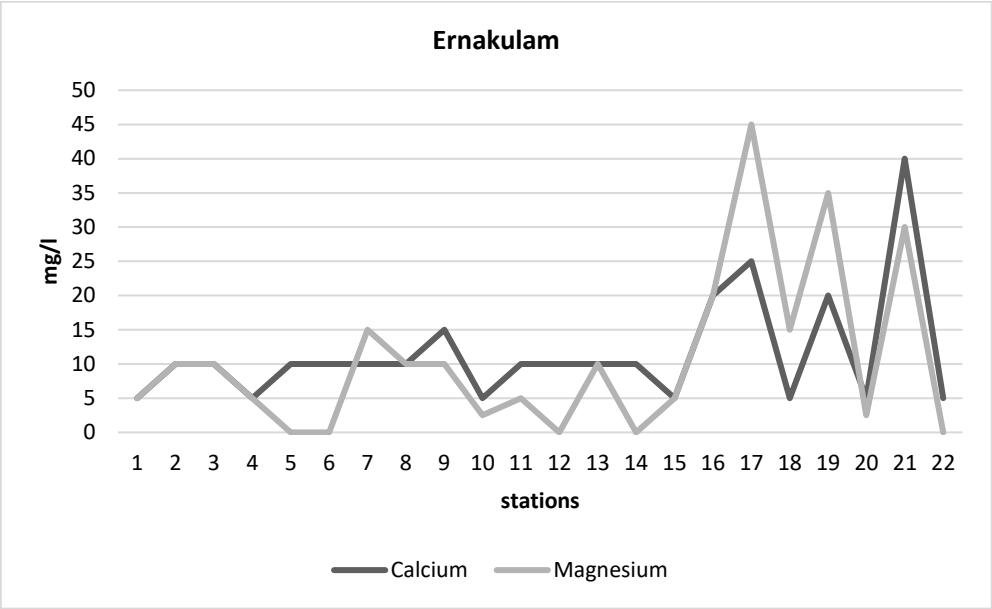

Fig. 8. Distribution of calcium and magnesium at Ernakulam district.

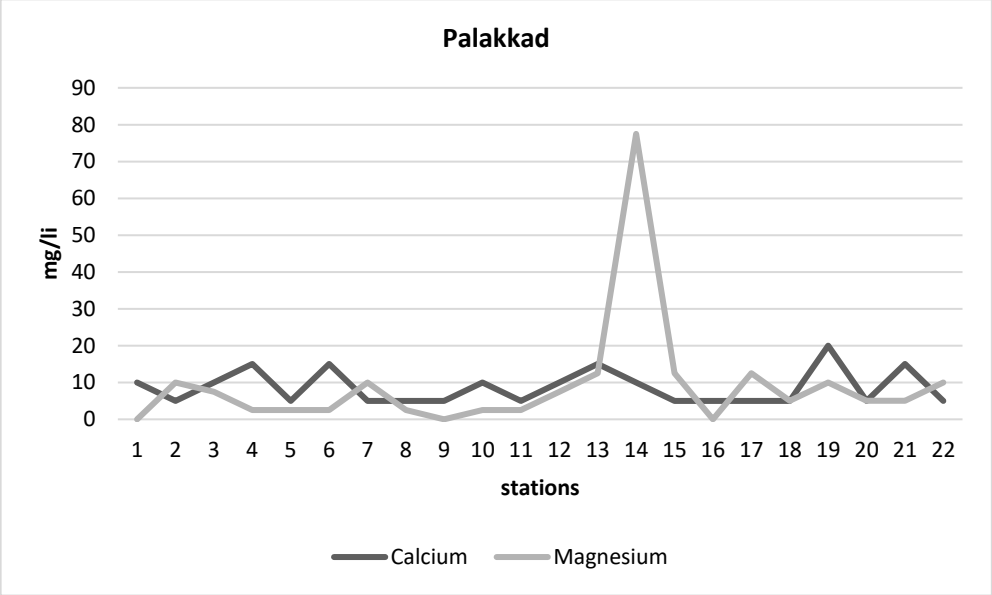

Fig. 9. Distribution of calcium and magnesium at Palakkad district.

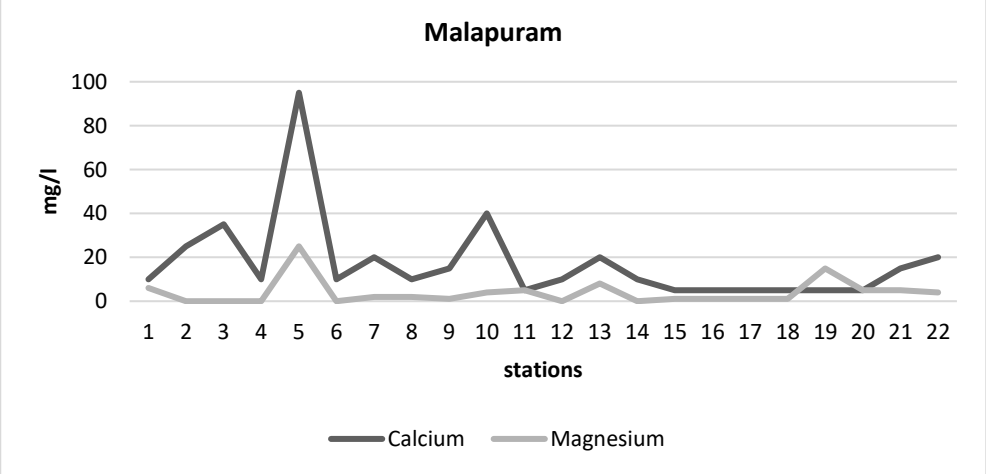

Fig. 10. Distribution of calcium and magnesium at Malapuram district.

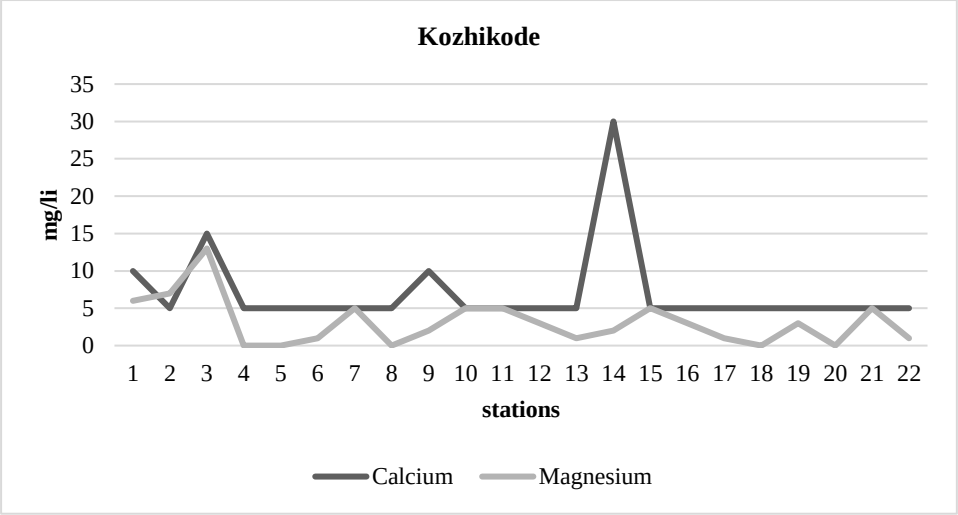

Fig. 11. Distribution of calcium and magnesium at Kozhikode district.

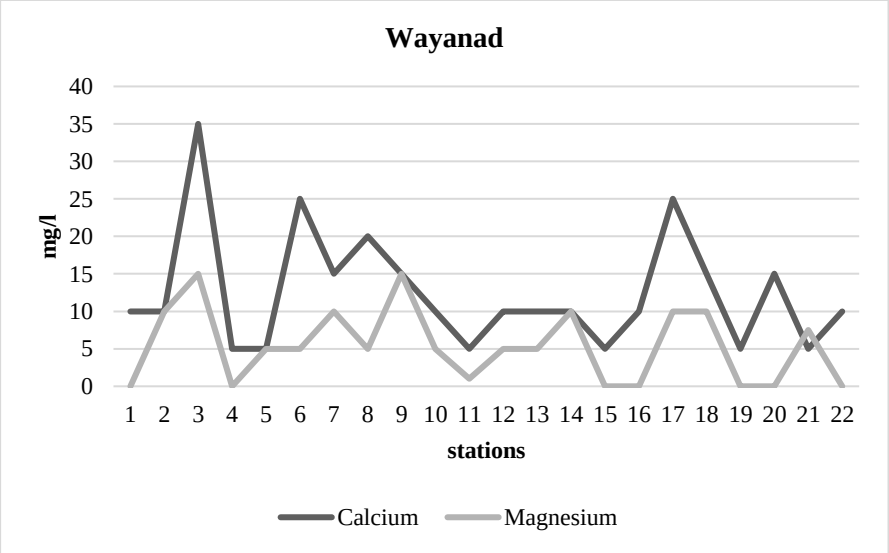

Fig. 12. Distribution of calcium and magnesium at Wayanad district.

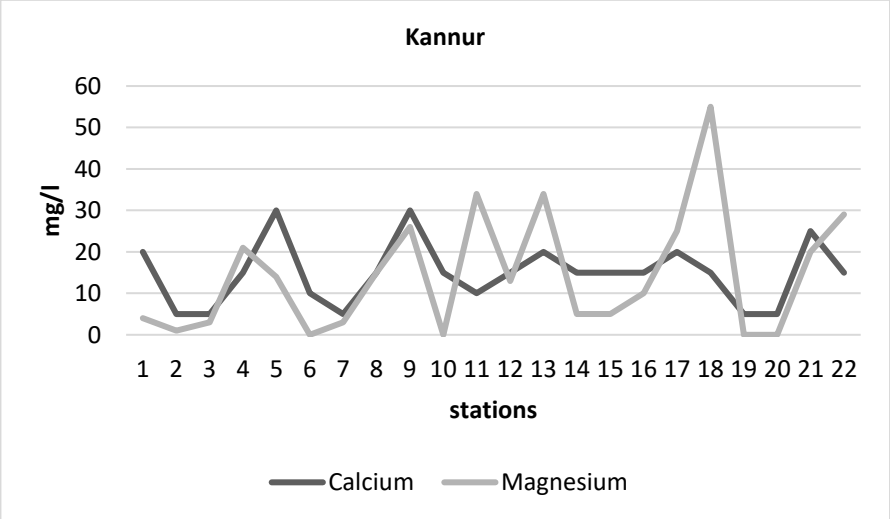

Fig. 13. Distribution of calcium and magnesium at Kannur district.

CONCLUSIONS

Calcium and magnesium are two essential minerals that are naturally found in water and their levels in drinking water can have a significant impact on human health outcomes. The present assessed the calcium and magnesium content of 132 household open wells in the state of Kerala, India. The overall levels of calcium and magnesium in the drinking water samples were found to be within the permissible limits set by the BIS. Even though there were some samples that exceeded the BIS limits for calcium and magnesium, it does not have any adverse effect on people who consumed the water. The study recognizes the significance of understanding the mineral composition of drinking water, as imbalances in calcium and magnesium concentrations can have potential health implications. It is known that calcium and magnesium in drinking water may have beneficial effects on cardiovascular health, diabetes mellitus, stroke, and chronic kidney disease. The findings of the present study contribute to the existing body of knowledge on water quality and offer valuable insights for public health officials, policymakers, and individuals concerned about the safety and health aspects of drinking water sourced from open wells. The development of new technologies like the use of remote sensing will allow more efficient and cost-effective monitoring of water quality. As new technologies emerge, we will be able to better understand the health benefits of these minerals and ensure that our water supplies are safe and healthy. Further research would involve conducting epidemiological studies to assess if there are any correlations between the mineral levels and specific health outcomes. Conducting longitudinal studies over an extended period could provide valuable insights into the changes in calcium and magnesium levels in well water. Future research could explore potential associations between mineral levels and the presence of other harmful substances in the well water. This broader analysis would provide a more comprehensive understanding of the water quality and potential risks associated with drinking water from open wells.

FUTURE SCOPE

Further research would involve conducting epidemiological studies to assess if there are any correlations between the mineral levels and specific health outcomes. Conducting longitudinal studies over an extended period could provide valuable insights into the changes in calcium and magnesium levels in well water. Future research could explore potential associations between mineral levels and the presence of other harmful substances in the well water. This broader analysis would provide a more comprehensive understanding of the water quality and potential risks associated with drinking water from open wells.

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Conflict of interest. There is absolutely no conflict of interest by the author to declare.

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