# A Method Development to Enhance Water Alkalinity for Reducing Health Risks Associated with Unsafe Water

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## Abstract

Background: Water is essential for life, sustaining both biological and human activities. It plays a crucial role in the physiological functions of the human body and shapes human civilization. Water's unique properties and its pH, a measure of its acidity or alkalinity, influence its quality and impact on health. The pH of drinking water is particularly important for microbial activity and human health. This study aimed to investigate the effectiveness of increasing water alkalinity, with a focus on improving pH levels in tap water through the use of clay pots. Methods: The study was conducted in Sulaymaniyah city, with tap water sourced from the Dokan Dam. Ceramic clay pots, selected for their availability and affordability, were used to treat the tap water. The experiment measured the pH of untreated tap water and compared it to water stored in clay pots over a 24-hour period for 12 weeks. A paired t-test was used to analyze the difference in pH levels between untreated and treated water across two seasons, autumn and winter. Results: The results showed a significant increase in the pH levels of tap water after treatment with clay pots. In autumn, pH values rose by an average of 2.86, while in winter, the increase averaged 2.66. Statistical analysis confirmed highly significant differences in pH between untreated and treated water for both seasons ($p = 0.000002$), demonstrating the effectiveness of clay pots in raising water alkalinity. Conclusion: The study concluded that clay pots offer a simple and cost-effective method to increase the alkalinity of tap water, improving its quality. This approach can benefit public health, particularly in regions with limited access to advanced water treatment technologies. Further research is needed to explore the long-term effects and broader applications of using clay pots for water treatment.


**Keywords:** Water Quality, PH Levels, Clay Pots, Alkalinity, Public Health

***Significance*** | This study demonstrated a practical method to enhance drinking water quality, potentially reducing health risks associated with unsafe water.

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Editor Md Shamsuddin Sultan Khan, And accepted by the Editorial Board Aug 10, 2024 (received for review Jun 02, 2024)

## Introduction

Water, the essence of life, plays a fundamental role in sustaining both biological and human activities. As Chartres and Varma (2011) emphasized, water creates the conditions necessary for life and ensures its continuity. It forms the backbone of human civilization, shaping cities and cultures throughout history. The human body, composed of approximately 70% water, relies on this resource for every physiological function, with water facilitating processes as critical as brain function, which is itself nearly 90% water (Joseph, 2013; Mitchell, 2010). Water's unique properties, such as its ability to exist in solid, liquid, and gaseous states, make it indispensable to life and the natural world. Chemically, it consists of two hydrogen atoms and one oxygen atom (Grafton & Quentin, 2011), and its behavior at different temperatures, particularly its

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**Please cite this article.**
Aram Dawood Abbas (2024). A Method Development to Enhance Water Alkalinity for Reducing Health Risks Associated with Unsafe Water, Journal of Angiotherapy, 8(8), 1-7, 9849

expansion below 4°C, distinguishes it from most substances (Brini et al., 2017; Saeedy, 2015). In biological systems, water acts as a vital medium, enabling digestion, absorption, and metabolism in humans, animals, and plants (Brini et al., 2017; Saeedy, 2015). It constitutes 50-60% of living cells and is essential for cellular composition and function (Health Canada, 2015; Bermúdez et al., 2004; Utz, 2010; Atya et al., 2012). Biochemical reactions depend on water's presence, either as a catalyst, mediator, or active participant, under various temperatures and interactive conditions (Sterling, 2004; Vennesland & Stotz, 2019; Zhang et al., 2013).

One critical aspect of water quality is its pH, a measure of acidity or alkalinity. The pH scale, ranging from 0 to 14, determines whether water is acidic, neutral, or alkaline. Acidic water has a pH below 7, alkaline water above 7, and neutral water at exactly 7 (Sun et al., 2015; Laine, 2016; WSC, 2007). These values depend on the concentration of hydrogen ($H^+$) and hydroxyl ($OH^-$) ions, with hydrogen-rich water being acidic and hydroxyl-rich water alkaline. When these ions are balanced, water is neutral (EPA, 2007; Altorkmany, 2005). Water's pH affects microbial activity; for instance, aerobic bacteria struggle to function in highly alkaline water, while fungi thrive in more acidic conditions (Oram, 2007; Carr & Neary, 2006).

This study aimed to explore the importance of water quality, particularly pH, on human health and how to elevate water's alkalinity efficiently and affordably. Specifically, it seeks to answer two key questions: first, is adjusting water's pH to make it more alkaline an easy and cost-effective process? Second, does consuming more alkaline water have a positive impact on human health, particularly in boosting immunity? Addressing these questions will provide valuable insights into the relationship between water quality and well-being.

## 2. Materials and Methods

### *2.1 Study Area and Water Source*

This study was conducted in Sulaymaniyah city, where tap water is supplied from the Dokan Dam. The experiment focused on assessing and increasing the pH of tap water distributed during the autumn and winter seasons. Tap water pH was tested at the distribution point to analyze its quality before any treatment.

### *2.2 Experimental Setup*

To increase the alkalinity of the tap water, we used ceramic pots made of clay, sourced from two different local suppliers in Sulaymaniyah city. Two sizes of pots, small and medium (Figure 1), were utilized to determine the effect of clay pottery on water pH. Clay was selected due to its easy availability, low cost, and its physical properties, such as low permeability and high resistance when solidified (Hansen et al., 2018; Khalil, 2005). The pottery was fired at temperatures ranging between 1000°C and 1400°C, which helps to retain its structural integrity and maintain low permeability due to the small pore sizes (Guggenheim & Martin, 1995; Grave, 2009).

### *2.3 pH Measurement Methods*

*Two common methods for measuring pH are the colorimetry method and the electrometry method. For this study, we chose the more accurate electrometry method, as it is unaffected by water color or turbidity. This method works by measuring the electrical potential difference between solutions with varying proton concentrations (Joseph, 2013; Alkhrabya & Alfarhan, 2003). We utilized the 8685 AZ pH meter model, which has a pH range of 0.0 to 14.0, an accuracy of ±0.2, a resolution of 0.1, and a temperature accuracy of ±0.1.*

### *2.4 Experimental Procedure*

The experiment began by measuring the initial pH value of the tap water before placing it into the clay pots. After this measurement, the water was poured into small and medium-sized ceramic pots, where it was left undisturbed for 24 hours to allow interaction between the water and the clay. Following this 24-hour period, the pH of the water in the pots was measured again. This process was repeated weekly for 12 weeks, with five tests conducted each week for both the untreated tap water and the water treated in the clay pots. The mean of these tests was used for further analysis.

### *2.5 Statistical Analysis*

A paired t-test was conducted to evaluate the difference in pH levels between the tap water and the water treated in clay pots during both the autumn and winter seasons. The analysis was performed using the R platform (R Core Team, 2013) with a 99% confidence interval, assessing the significance of pH changes by considering the mean differences. Statistical analysis was carried out using R software, with the paired t-test being the primary method to determine the significance of the pH variations. This methodology ensured accurate and reliable measurements of pH changes, focusing on understanding the effect of clay pots on increasing water alkalinity over time.

## 3. Results and Discussion

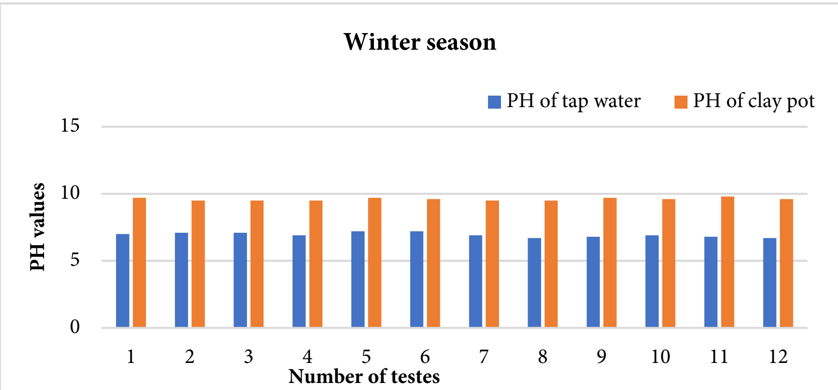
The results of this study reveal significant changes in the pH levels of tap water after being treated in clay pots during both the autumn and winter seasons. During the fall, the initial pH values of tap water ranged from 6.6 to 7.2, as shown in Table 1 and Figure 2. After 24 hours in the clay pots, the pH values increased substantially, with most samples registering between 9.5 and 10.0. The difference in pH between the untreated tap water and the clay-treated water averaged 2.86 for the fall season. This indicates that the clay pots significantly raised the pH levels, making the water more alkaline.

In the winter season, the initial pH of tap water was similar, ranging between 6.7 and 7.2 (Table 1, Figure 2). However, the water in the clay pots reached pH values between 9.5 and 9.8 after 24 hours, with an average pH increase of 2.66. While the increase in pH during

**Table 1.** Results of pH examinations before and after pottery clay pots of tap water for Sulaymaniyah city in the fall and winter seasons/2021-2022

| Autumn | Mean pH of tap water | Mean pH of clay pot | Winter | Mean pH of tap water | Mean pH of clay pot |
|---|---|---|---|---|---|
| week 1 | 6.7 | 9.5 | week 1 | 7.0 | 9.7 |
| week 2 | 6.8 | 9.6 | week 2 | 7.1 | 9.5 |
| week3 | 6.9 | 9.8 | week3 | 7.1 | 9.5 |
| week4 | 6.7 | 10.0 | week4 | 6.9 | 9.5 |
| week5 | 7.0 | 9.7 | week5 | 7.2 | 9.7 |
| week6 | 6.8 | 9.5 | week6 | 7.2 | 9.6 |
| week7 | 6.6 | 9.6 | week7 | 6.9 | 9.5 |
| week8 | 6.9 | 9.5 | week8 | 6.7 | 9.5 |
| week9 | 6.9 | 9.5 | week9 | 6.8 | 9.7 |
| week10 | 6.8 | 9.5 | week10 | 6.9 | 9.6 |
| week11 | 7.1 | 9.8 | week11 | 6.8 | 9.8 |
| week12 | 7.2 | 9.7 | week12 | 6.7 | 9.6 |

**Figure 1.** clay pots used in the process of increasing the pH values.



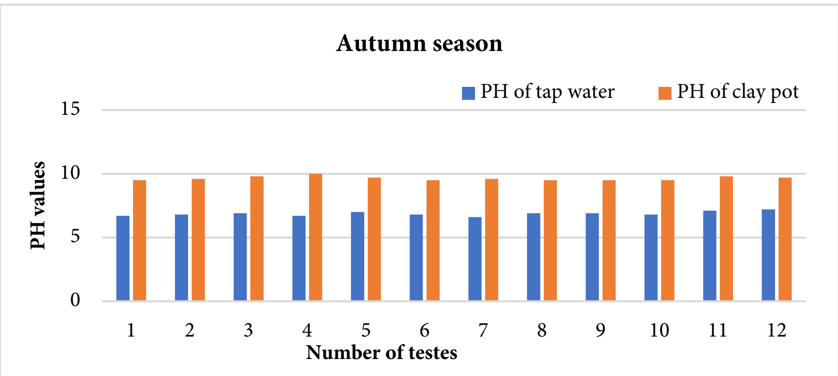




**Figure 2.** The amount of differences between pH of tap water and clay water for both seasons (Winter and Autumn).

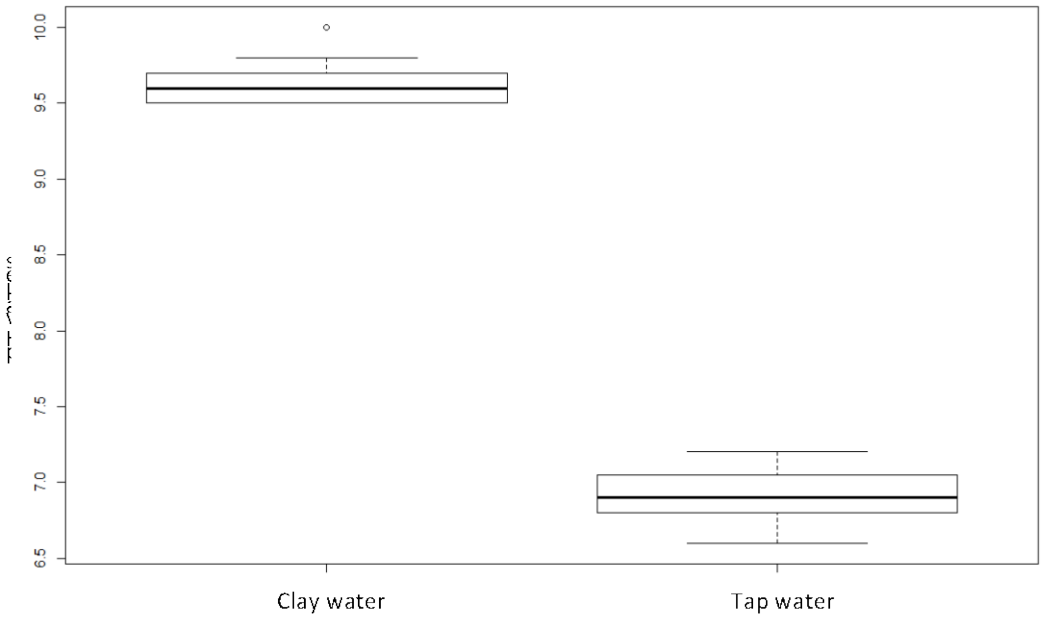



**Figure 3.** The box plot shows the mean pH differences between tap water and clay water for both seasons.

winter was slightly lower than in autumn, the difference between tap water and clay-treated water remained substantial.

Statistical analysis confirmed these results. A paired t-test showed highly significant differences between the pH values of tap water and water treated in clay pots after 24 hours for both seasons ($t = 61.6$, $df = 23$, $p = 0.000002$). The mean difference in pH across both seasons was 2.71 (Table 1, Figure 3). These findings suggest that the use of clay pots can consistently and significantly increase the alkalinity of tap water, regardless of seasonal variations.

Ensuring access to safe drinking water is a fundamental necessity for public health globally. Unsafe drinking water is a major contributor to diseases like cholera, dysentery, and diarrhea, the latter being responsible for a significant percentage of child mortality under the age of five (Liu et al., 2012; Atya et al., 2012). In this context, increasing the alkalinity of drinking water is vital because alkaline water has been associated with health benefits such as improved digestion and enhanced detoxification by the kidneys and liver (WASH, 2016).

The significant pH increase observed in this study is consistent with previous research on clay's ability to alter water properties. Clay's low permeability and small pores allow it to retain water while slowly releasing minerals, such as calcium and magnesium, that raise pH levels (Hansen et al., 2018; Khalil, 2005). Additionally, clay's physical characteristics—such as its moisture retention capacity and the way it hardens under low moisture conditions—may enhance its effect on water alkalinity (Guggenheim & Martin, 1995; Grave, 2009).

The study's findings align with research conducted by Mihu-pintilie et al. (2014) on the seasonal variation of pH in Cuejdei Lake, Romania, which also found higher pH values in autumn and lower ones in winter. The slight seasonal difference in pH increase observed in our study, with a higher average pH increase in autumn (2.86) compared to winter (2.66), could be attributed to seasonal temperature variations. Cooler winter temperatures may slow the release of minerals from clay, reducing its effect on pH (Mihu-pintilie et al., 2014). This seasonal variation, while notable, did not significantly impact the overall efficacy of clay pots in raising water pH levels.

Further supporting our findings, Nienie et al. (2017) reported lower pH values during the wet season compared to the dry season in Kenya, highlighting the impact of environmental conditions on water chemistry. However, the overall differences in pH between autumn and winter in our study were minimal, suggesting that clay pots provide a reliable method of increasing water alkalinity year-round.

The effectiveness of clay pots in raising pH, as demonstrated in this study, holds significant potential for public health improvements in regions like Kurdistan, where local governments have historically focused more on water quantity than quality. The lack of attention to pH levels in drinking water, especially in regions that depend on tap water from sources like the Dokan Dam, underscores the need for simple, cost-effective solutions to improve water quality (ALzawi, 2004). Our findings suggest that clay pots, which are readily available and affordable, could offer a practical solution for increasing the pH of drinking water without the need for expensive electromechanical technologies.

The health benefits of drinking water with a balanced pH should not be underestimated. Alkaline water has been shown to aid in detoxifying the body, promoting better digestion, and even helping to regulate body temperature through improved hydration (WET Foundation, 2010). Given the high incidence of waterborne diseases globally, and especially in developing regions, adopting a simple method to increase water alkalinity could significantly reduce the public health burden (World Life Expectancy, 2015).

However, while the results of this study are promising, they also highlight the need for further research. Additional investigations into other factors affecting water quality—such as dissolved oxygen, water basin depth, and distance from the source to the consumer—are necessary to develop a more comprehensive understanding of how to optimize water quality (Maslanka, 2009; Mîndrescu et al., 2010). Future studies could also explore the long-term effects of clay pot use on water chemistry, as well as the potential influence of different types of clay or varying pot sizes on pH levels.

Given that this study is among the first of its kind in the Kurdistan Region, more local research is needed to assess the generalizability of these findings. While our results align with international studies on water pH and seasonal variations, local environmental factors may play a role in the specific dynamics of water chemistry in this region. Therefore, we recommend further studies to explore the broader implications of using clay pots to improve water quality across different regions of Iraq and beyond.

**4. Conclusion**

In conclusion, this study demonstrates that the use of clay pots is an effective and affordable method for increasing the alkalinity of tap water. The significant rise in pH values after 24 hours of water being stored in clay pots suggests that this method could be easily adopted by households in regions like Sulaymaniyah to improve their drinking water quality. With further investigation and refinement, this approach could serve as a model for enhancing water pH in other regions, particularly in areas with limited access to advanced water treatment technologies.

By promoting the use of clay pots as a natural, cost-effective solution for improving water alkalinity, this study contributes to the broader goal of improving public health through better access to safe and healthy drinking water. Moreover, our findings provide a foundation for future research aimed at exploring the full potential of natural materials in water treatment, while also encouraging local governments and communities.

### Author contributions

A.D.A. developed the initial draft of the review, supervised the work, and served as the corresponding author.

### Acknowledgment

The authors were grateful to Geography department at College of Humanities Sci. Education Syid Sadiq, University of Sulaimani. They were also thanked to Dr. Emad Kaky for the review and comments on the first draft of the paper.

### Competing financial interests

The authors have no conflict of interest.

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