ATTAHADI MEDICAL JOURNAL
Journal homepage:
http://attahadi.edu.ly/journal/index.php/amj/index

Effect of Clay Pots Made from Red and White Clay on the Physicochemical Properties of Stored Water and Their Efficacy in Improving Water Alkalinity

Abdulsalam Aebeedat*, Aml Almurabit

Department of Biology, Faculty of Education, Traghan, University of Fezzan, Sebha, Libya

Keywords:
Clay Pots,
Water Alkalinity,
Physicochemical Properties,
Water Quality.

Received *22 May 25*
Accepted *19 July 25*
Published *27 July 25*

ABSTRACT

This study aims to assess the impact of storage in earthenware vessels, fabricated from two distinct clay types (red and white), on the physicochemical properties of distilled water. A specific focus was placed on pH and alkalinity. The experimental procedure involved storing distilled water in both red and white clay vessels, with a glass container serving as a control sample. Measurements were subsequently acquired at predetermined intervals: 2, 6, 12, 24, and 48 hours. The analyses encompassed measurements of electrical conductivity, total dissolved solids, and the concentrations of various ions, including sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, and nitrate. Results demonstrated a notable increase in the pH of water stored in the clay pots when compared to the glass control, thereby indicating their capacity to modulate water alkalinity. Furthermore, measurements revealed alterations in the concentrations of certain ions and other physicochemical characteristics, attributable to the interaction between the water and the different clay types. This research contributes to the scientific documentation of the potential efficacy of clay pots as a sustainable and economical alternative for enhancing drinking water quality, particularly in terms of adjusting the water's basic properties.

Citation info. Aebeedat A, Almurabit A. Effect of Clay Pots Made from Red and White Clay on the Physicochemical Properties of Stored Water and Their Efficacy in Improving Water Alkalinity. Attahadi Med J. 2025;2(3):242-247. https://doi.org/10.69667/amj.25310

INTRODUCTION

Water is considered one of the most essential natural resources indispensable for life on Earth, serving as the lifeblood for living organisms and a central element in the ecological balance of aquatic and terrestrial environments [1]. Water is integral to various aspects of life, from domestic, industrial, and agricultural uses to being the primary chemical component of the human body, constituting 50% to 70% of its weight [2]. Water is vital for the optimal performance of cellular functions, tissues, and organs, and no living organism, regardless of its form or size, can survive without it [3].

Water quality is a crucial factor for public health [4], and numerous studies seek to explore natural methods for improving water characteristics. Historically, various civilizations utilized clay pots as one of the oldest and simplest methods for storing water and food [5]. These vessels provide a suitable environment for maintaining water coolness and purity, which is attributed to their porous nature, allowing for partial water evaporation, thereby aiding in content cooling [6]. More importantly, however, are the potential interactions between minerals present in the clay and the stored water, which may lead to changes in the chemical and physical properties of the water, such as pH, and the concentration of salts and minerals [2].

With rapid population growth and accelerating industrial and agricultural development, obtaining clean and usable water has become an increasing global challenge [7]. Water pollution sources are diverse, whether biological, chemical, physical, or radiological, all of which negatively impact water quality and threaten public health and ecological systems [2]. These challenges have driven humanity to seek various methods for water purification and property improvement, ranging from simple traditional approaches to modern and complex technologies. In this context, despite the widespread use of clay pots, there is an urgent need for a deeper understanding of their actual effect on the physicochemical properties of water

In light of the increasing challenges in obtaining clean and healthy drinking water, primarily due to contaminated sources or alterations in its fundamental properties, which in turn affect its diverse uses and may pose health risks, the search for effective solutions to improve water quality has become vital. Despite the historical prevalence of using clay pots for water storage, the precise impact of these vessels, manufactured from different types of clay (red and white), on the physicochemical properties of water, and their efficacy in modifying pH and alkalinity, remains insufficiently documented scientifically. This lack of

*Corresponding E-mail addresses: abd.ebedat@fezzanu.edu.ly

comprehensive understanding represents a research gap that necessitates a systematic study to evaluate these effects and ascertain the true potential of clay pots as a tool for water quality improvement.

This study holds significant importance from several perspectives. Scientifically, it endeavors to bridge an existing knowledge gap by providing a systematic and detailed analysis of the impact of different types of clay pottery (red and white) on the physicochemical properties of water, particularly pH and alkalinity, thereby enriching the scientific literature in this field. In terms of potential practical and health benefits, the anticipated results will contribute to understanding the mechanisms by which clay pots might modify water quality. This could offer a natural and sustainable option for improving drinking water, especially concerning the increase in water alkalinity, which is believed to have health benefits. Furthermore, the study carries an important economic and environmental dimension, as its findings could support the use of clay pots as an effective and economical alternative to complex water purification technologies, particularly in developing or remote areas lacking advanced water treatment infrastructure, thus promoting environmentally friendly practices.

METHODS

This study adopted a descriptive analytical approach to evaluate the effect of clay pots on the physicochemical properties of distilled water. The methodology involved the use of specific materials and adherence to standard procedures to ensure the accuracy and reliability of the results.

Materials Used and Sample Preparation

Clay Pots

Unglazed clay pots, made from red and white clay, were obtained from the local market in Gharyan city. The pots had a height of 20 cm, a maximum diameter of 15 cm, and a capacity of 2 liters.

Pot Preparation:

Before starting the experiment, the clay pots were thoroughly cleaned several times with distilled water and then left to air dry completely. Subsequently, each pot was soaked in distilled water for 24 hours to saturate the clay pores and ensure the stabilization of any soluble materials potentially remaining from the manufacturing process.

Distilled Water

High-purity distilled water was used, obtained from the Dialysis Department at Taraghen Hospital, to ensure the absence of initial impurities that might affect the results.

Experimental Design and Storage Conditions

Three types of vessels were used for water storage: a glass container (as a control sample to manage variables), a white clay pot, and a red clay pot. Each vessel was filled with 1 liter of distilled water. All samples were kept at controlled room temperature (25 ± 2°C) and away from direct sunlight. Samples were taken for analysis at specific time intervals: 2, 6, 12, 24, and 48 hours from the start of storage.

Physicochemical Measurements

The physicochemical properties of distilled water were measured before and after storage at the specified time intervals, using the standard methods outlined in [8] as follows:

***pH*:**

pH values were measured using a HI 2211 pH meter from HANNA Instruments. The device was calibrated using standard solutions of known pH (4 and 7). After calibration, the probe was directly immersed in the sample, and values were recorded after stabilization.

Electrical Conductivity (EC):

Electrical conductivity was measured using a HI 2300 EC meter from HANNA. The probe was immersed, and values were recorded in µS/cm at 25°C.

Total Dissolved Solids (TDS):

Total Dissolved Solids (TDS) were measured by a T.D.S meter Model AR-50-HACH and calculated in mg/l.

Calcium (Ca) and Magnesium (Mg):

Calcium and magnesium ions in water samples were estimated by complexometric titration with EDTA using E.B.T and Murexide indicators.

Sodium (Na) and Potassium (K):

Sodium and potassium were measured using a PFP7 and PFP7/C Flame Photometer from JENWAY, and concentrations were calculated from a pre-prepared standard curve.

Nitrate (NO3-):

Nitrate in water samples was estimated using a PU8625 Series UV/Visible Spectrophotometer from PHILIPS at a wavelength of (λ=220nm).

Chloride (Cl-):

Chloride in water was estimated by titration (Mohr method) using a standard silver nitrate solution (0.05 N).

Bicarbonate (HCO3-):

Bicarbonate was estimated by titration with diluted HCl using methyl orange indicator.

Sulfate (SO4 2-):

The Turbidimetric Method was used to measure sulfate concentration in water samples using barium chloride ($BaCl_2$) reagent, using a PU8625 Series UV/Visible Spectrophotometer from PHILIPS, and absorbance for the sample and standard curve was measured at a wavelength of (λ=540nm).

Statistical Analysis

Microsoft Excel was used for descriptive data analysis and plotting graphical charts illustrating changes in physicochemical indicator values over time (in hours) for each type of vessel.

Results

Table 1 shows a notable increase in the pH values of water stored in clay pots compared to the glass vessel (control sample). Red clay pots exhibited a higher increase in pH values compared to white clay pots across all time intervals. This is further illustrated in (Figure 1), which depicts the changes in pH over time.

Table 1: pH Values of Water Stored in Different Vessels Over Multiple Time Intervals

Time (Hours)	Glass Vessel	White Clay Pot	Red Clay Pot
2	6.8	7.1	7.3
6	6.8	7.3	7.5
12	6.8	7.4	7.7
24	6.8	7.5	7.8
48	6.8	7.5	7.9

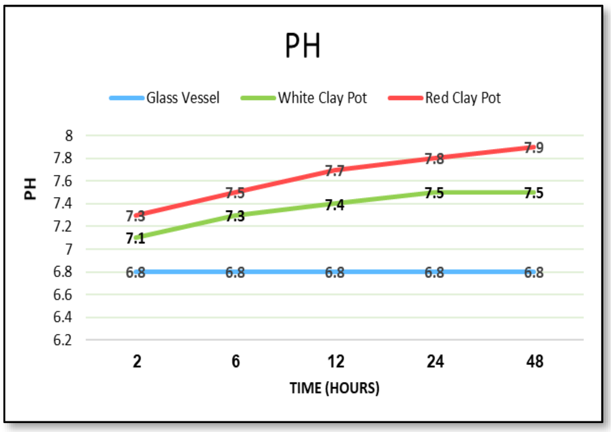

Figure 1: Changes in pH of Distilled Water Stored in Different Vessels Over Time

Figure demonstrates that the pH in the glass vessel remained stable at 6.8 throughout the experiment. In contrast, a gradual increase in pH was observed for both white and red clay samples, with the pH in the white clay pot reaching 7.5 after 48 hours, while it reached 7.9 in the red clay pot for the same period.

A wide range of other physicochemical properties were also measured, including Electrical Conductivity (EC), Total Dissolved Solids (TDS), and the concentrations of both cations and anions. These results are summarized in Table 2.

Table 2: Physicochemical Properties of Water Stored in White and Red Clay Pots Over Multiple Time Intervals

Clay Type	Time (Hours)	PH	conductivity (µS/cm)	TDS (ppm)	Cations (ppm)				Anions (ppm)			
					Na^+	K^+	Ca^{+2}	Mg^{+2}	Cl^{-1}	SO_4^{-2}	HCO_3^{-1}	NO_3^-
White Clay	2	7.1	647	412	250	17	20	24	263.4	19	19.5	-
	6	7.3	657	420	250	16	24	28.8	223.7	18.7	73.2	-
	12	7.4	611	389	260	20	24	26.4	283.3	20	103.7	-
	24	7.5	606	385	250	26	36	38.4	273.4	20.6	109.8	-
	48	7.5	662	422	260	39	28	19.2	288.3	22.6	122	-
Red Clay	2	7.3	684	440	250	16	20	21.6	238.6	23	122	-
	6	7.5	725	464	250	17	20	28.8	248.5	24	134.2	-
	12	7.7	735	470	260	19	32	28.8	248.3	25	122	-
	24	7.8	780	499	270	18	32	38.4	278.3	22	122	-
	48	7.9	730	460	260	25	40	43.2	298.2	21.7	152.5	-

Note: (-) indicates not detected.

Figure 2 demonstrates a clear increase in both Electrical Conductivity (EC) and Total Dissolved Solids (TDS) in water stored in both types of clay pots throughout the study period. It was observed that EC and TDS values in the red clay pot were generally higher compared to the white clay pot.

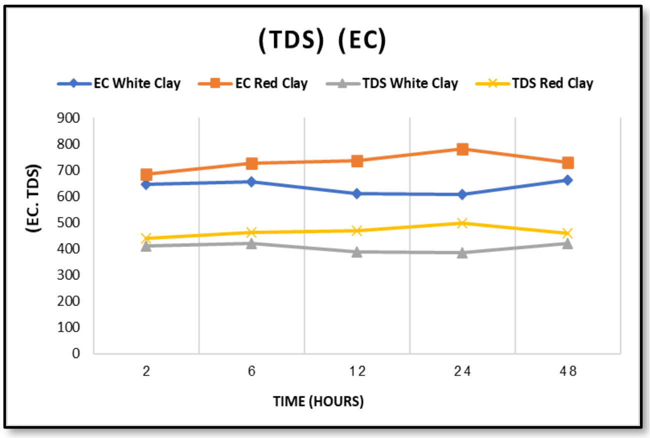

Figure 2: Changes in Electrical Conductivity (EC) and Total Dissolved Solids (TDS) of Water Stored in Clay Pots Over Time

Figure 3 presents changes in sodium and potassium ion concentrations. Generally, sodium concentrations remained relatively stable in both white and red clay, while potassium concentrations in both clay types showed a notable increase over timm.

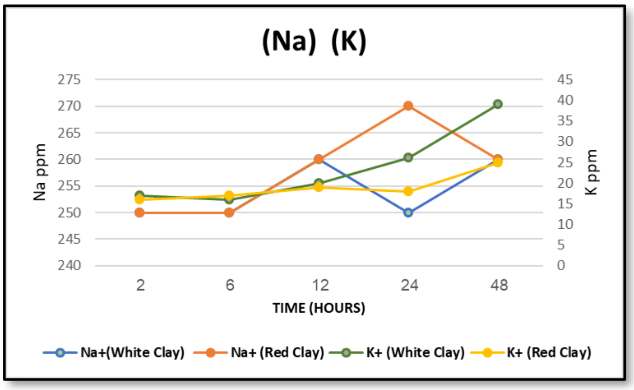

Figure 3: Changes in (Na+, K+) Ion Concentrations in Water Stored in Clay Pots Over Time

Figure 4 illustrates the changes in calcium and magnesium ion concentrations. A gradual increase in the concentration of both calcium and magnesium ions was observed in water stored in both clay types, especially red clay, with increasing storage time.

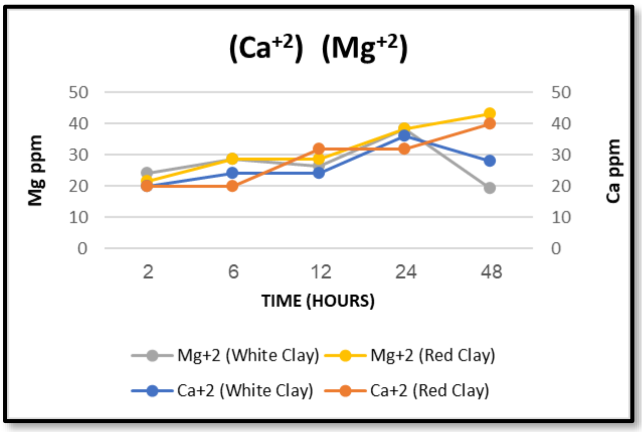

Figure 4: Changes in Calcium (Ca+2) and Magnesium (Mg+2) Ion Concentrations in Water Stored in Clay Pots Over Time

Figure 5 illustrates changes in chloride and sulfate ion concentrations. While chloride concentrations showed some fluctuation in white clay, a slight increase in sulfate concentrations was observed over time.

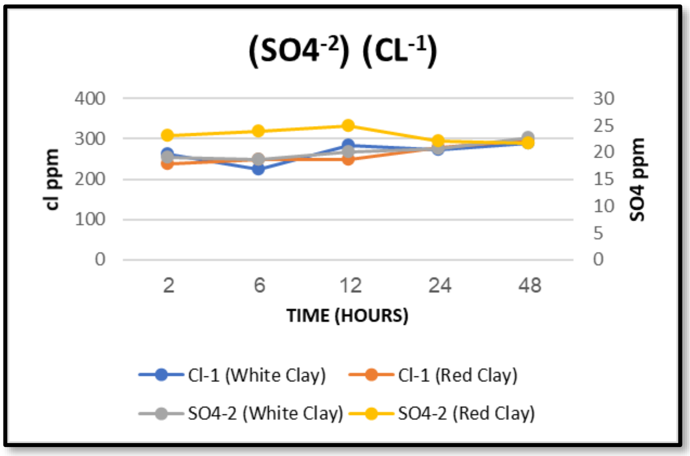

Figure 5: Changes in Chloride (Cl-1) and Sulphate (SO4-2) Ion Concentrations in Water Stored in Clay Pots Over Time

Finally, Figure 6 presents changes in bicarbonate concentrations. A clear increase in bicarbonate ion concentration was evident in water stored in both white and red clay, with significantly higher values in red clay compared to white clay. Nitrate ions were not detected in any of the samples (Table 2).

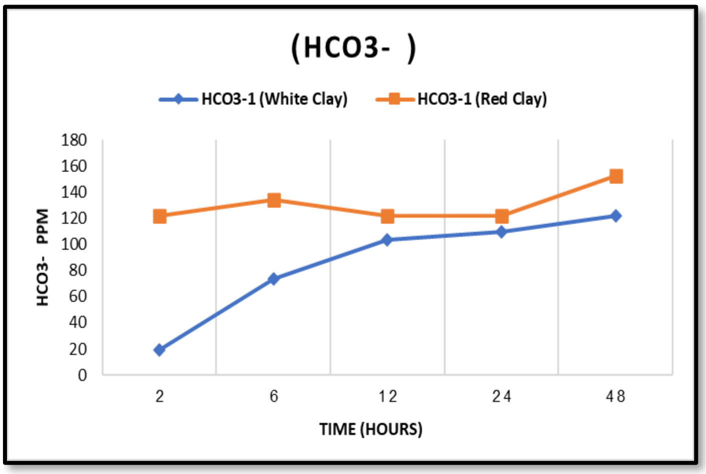

Figure 6: Changes in (HCO3-) Ion Concentrations in Water Stored in Clay Pots Over Time

DISCUSSION

The findings from this study confirm that clay pots, regardless of whether they are crafted from red or white clay, exert a discernible influence on the physicochemical properties of stored water, specifically on its pH and alkalinity.

Effect of Storage in Clay Pots on pH: The results clearly indicate that clay pots led to a significant increase in the water's pH when compared to the glass control vessel, which consistently maintained a pH value of 6.8 throughout the experimental period (Figure 1). This observed rise in pH signifies a shift of the water towards alkalinity. Notably, red clay pots demonstrated superior efficacy in elevating pH values compared to those made from white clay. This increase in pH can be attributed to the leaching of basic ions and soluble minerals from the porous structure of the clay into the water, a well-established process known to influence the chemical characteristics of water upon contact with porous materials [9]. These minerals, particularly calcium and magnesium carbonates, react with water to generate hydroxide (OH-) ions, consequently increasing water alkalinity. Calcium carbonate, in particular, is recognized as a significant source of alkalinity, reacting to neutralize acids and elevate pH [10]. The differential increase in pH observed between red and white clay suggests variations in their respective mineral and chemical compositions. Specifically, red clay may contain a higher proportion of iron oxides and more reactive basic minerals , which contribute more substantially to pH elevation due to their unique chemical makeup and interaction with water [11,12].

Electrical Conductivity (EC) and Total Dissolved Solids (TDS): The pronounced increase in both electrical conductivity (EC) and total dissolved solids (TDS) values in water stored in clay pots (Figure 2) substantiates the occurrence of mineral and salt leaching from the clay material into the water [13,14]. The higher EC and TDS values observed in red clay compared to white clay suggest that red clay may either possess elevated concentrations of soluble ionic compounds or exhibit greater porosity and reactivity with water. This leads to a more pronounced release of ions, thereby increasing both conductivity and total dissolved solids [11]. This observed increase is congruent with the notable rise in pH, as the liberation of basic ions contributes to both phenomena [10,13,14,15].

Changes in Ion Concentrations and Their Impact on Water Alkalinity:

Cations (Na+, K+, Ca+2, Mg+2): The discernible increase in the concentrations of sodium, potassium (Figure 3), calcium, and magnesium ions (Figure 4) in water stored in clay pots supports the hypothesis that these minerals leach from the clay structure [15]. Calcium and magnesium ions, in particular, play a pivotal role in determining water alkalinity and hardness. Their presence in water enhances its capacity to neutralize acids, consequently increasing its alkalinity [10].

Anions (Cl-1, SO4-2, HCO3-1): The distinct increase in bicarbonate (HCO3-) ion concentration in water stored in both clay types, especially red clay (Figure 6), serves as the most critical indicator of improved water alkalinity. Bicarbonates are fundamental alkaline ions that function as a primary buffer in water, directly and effectively contributing to both raising and stabilizing pH [10]. It is highly probable that these ions were formed as a result of the interaction between water and naturally occurring carbonates within the clay, such as calcium and magnesium carbonates [16]. While chloride and sulfate ions (Figure 5) exhibited some fluctuations, their influence on water alkalinity is of lesser significance compared to bicarbonates, which are key alkaline ions [10]. Furthermore, the non-detection of nitrate ions (Table 2) is a positive indicator of the water's purity and absence of contamination by nitrogen-containing organic compounds [17].

Comparison Between Red and White Clay: The significant differences in results between red and white clay, particularly concerning pH, EC, TDS values, and bicarbonate concentrations, underscore that the chemical and mineral composition of the clay is a crucial determinant of its impact on water properties. It is widely believed that red clay, often characterized by a higher content of iron oxides and other minerals, exhibits greater reactivity with water. This leads to a more pronounced release of ions, consequently increasing water alkalinity and conductivity to a greater extent than white clay [11]. In conclusion, this study lends strong support to the proposition that clay pots function beyond mere storage vessels; they actively modify the chemical composition of water through the leaching of minerals and ions, thereby enhancing water alkalinity. These alterations may confer potential health benefits, as alkaline water is widely considered advantageous for the human body [18].

CONCLUSIONS

Based on the results obtained in this study, it can be concluded that storing water in clay pots leads to a significant increase in the water's pH, thereby indicating an improvement in water alkalinity. Furthermore, red clay pots were found to be more effective in increasing pH compared to white clay pots. This observed rise in pH is consistently accompanied by notable changes in electrical conductivity, total dissolved solids concentration, and various ion concentrations, particularly a significant increase in bicarbonate ions. These changes confirm the occurrence of active interactions between the water and the minerals present within the clay. Overall, this study clearly demonstrates that clay pots function beyond mere storage vessels; they possess a distinct ability to modify the physicochemical properties of water, potentially offering health benefits through the enhancement of water alkalinity.

Recommendations

Based on the findings of this study, several recommendations are proposed for future research and practical application. It is recommended to conduct deeper future studies to precisely determine the mineral composition of both red and white clay and to thoroughly investigate their specific effects on ion release into water. Additionally, further research should be performed to evaluate the long-term health effects associated with drinking water stored in clay pots, focusing particularly on the potential benefits of alkaline water. It is also advisable to investigate the impact of other influencing factors, such as storage temperature, the original quality of non-distilled water, and the size of the vessels, on physicochemical changes. Moreover, analyses should be conducted to determine if any organic compounds might leach from the clay into the water and to assess their subsequent effect on water quality. Finally, there is a clear need to establish specific standards for the quality of clay pots intended for drinking water storage to ensure both safety and optimal efficiency.

REFERENCES

1. Al-Ghafli, H. A. K. (1992). *A Study on Algae in Razzaza Lake*. [Master's thesis], College of Science for Girls, University of Baghdad.
2. Al-Ghandour, M. M. (2016). Study on the Formation of a Ceramic Filter from Egyptian Clays for Water Purification. *Journal of Research in Specific Education, Mansoura University*, (43).
3. USGS. (2019). *The Water in You: Water and the Human Body*. U.S. Geological Survey. Retrieved from: https://www.usgs.gov/special-topics/water-science-school/science/water-you-water-and-human-body
4. World Health Organization. (n.d.). *Water, sanitation and hygiene (WASH)*. World Health Organization. Retrieved from: https://www.who.int/health-topics/water-sanitation-and-hygiene-wash

5. Forestrails. (2025). *The Timeless Tradition of Using Clay Vessels In 5 Cultures.* Retrieved from: https://forestrails.com/the-timeless-tradition-of-using-clay-vessels/
6. Namaste Mudkart. (2025). *The Science Behind Cooling Water in a Mud Water Pot.* Retrieved from: https://mudkart.com/blogs/news/the-science-behind-cooling-water-in-a-mud-water-pot
7. Baggio, G., Smakhtin, V., & Qadir, M. (2021). *Water Scarcity: Coming Soon.* United Nations University. Retrieved from: https://unu.edu/article/water-scarcity-coming-soon
8. American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF). (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.).
9. American Water Works Association. (2002). *Permeation & Leaching.* U.S. Environmental Protection Agency. https://www.epa.gov/sites/default/files/2015-09/documents/permeationandleaching.pdf
10. University of Florida, Institute of Food and Agricultural Sciences, & Florida Atlantic University, Harbor Branch Oceanographic Institute. (2023). *The Role of pH, Alkalinity, and Calcium Carbonate in Shellfish Hatcheries.* https://shellfish.ifas.ufl.edu/wp-content/uploads/pH-and-Alkalinity-Fact-Sheet-for-Hatcheries-Final-Draft.pdf
11. Ketrot, D., Suddhiprakarn, A., Kheoruenromne, I., & Singh, B. (2013). Interactive effects of iron oxides and organic matter on charge properties of red soils in Thailand. *Soil Research*, 51(3), 222-231. https://www.researchgate.net/publication/265413506_Interactive_effects_of_iron_oxides_and_organic_matter_on_charge_properties_of_red_soils_in_Thailand
12. Wang, H., Liu, Z., Xie, Y., & Li, S. (2024). Experimental study on the disintegration behavior of red clay under different pH conditions. *Frontiers in Materials, 11.* https://www.frontiersin.org/journals/materials/articles/10.3389/fmats.2024.1477269/full
13. Mathur, A. (2018). Conductivity: Water Quality Assessment. *ETWQQM – 2014 (Volume 3 – Issue 03).* IJERT. https://www.ijert.org/conductivity-water-quality-assesment
14. Othaman, N. N. C., Isa, M. N. M., Ismail, R. C., Ahmad, M. I., & Hui, C. K. (2020). Factors that affect soil electrical conductivity (EC) based system for smart farming application. *AIP Conference Proceedings, 2203*(1), 020055. https://doi.org/10.1063/1.5142147
15. Purdue Extension. (1993). *Fundamentals of Soil Cation Exchange Capacity (CEC).* https://www.extension.purdue.edu/extmedia/ay/ay-238.html
16. Earle, S. (2015). 5.2 Chemical Weathering. In *Physical Geology* (1st ed.). BCcampus Open Education. https://opentextbc.ca/geology/chapter/5-2-chemical-weathering/
17. Smedley, P. (2004). *Water Quality Fact Sheet: Nitrate. WaterAid.* Retrieved July 16, 2025, from https://nora.nerc.ac.uk/id/eprint/516304/1/Nitrate.pdf
18. News-Medical.net. (n.d*.). Health Benefits of Alkaline Water.* Retrieved July 16, 2025, from https://www.news-medical.net/health/Health-Benefits-of-Alkaline-Water.aspx