

Potency of Malunggay (*Moringa oleifera*) Seed Powder as Coagulant for Reduction of Total Dissolved Solids, Electrical Conductivity, and pH Level Regulation for Raw Water Treatment

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Abstract: Water is essential for human survival; however, access to safe water remains a global challenge. The use of natural-based coagulants in the Municipality of Talaingod has been limited. Thus, this study was conducted to evaluate the potential of Moringa seed powder as an organic coagulant for wastewater treatment, serving as an alternative to commercially available aluminum sulfate. The study employed a Completely Randomized Design (CRD) with 18 water samples, each subjected to three replications per treatment. The treatments included T1 (Untreated), T2 (2.5 g MSP), T3 (5 g MSP), T4 (7.5 g MSP), T5 (10 g MSP), and T6 (2.5 g Alum). The physicochemical parameters assessed in this study were pH level, total dissolved solids (TDS), and electrical conductivity (EC). Statistical analyses using Levene's test, Welch's ANOVA, and standard ANOVA confirmed significant differences across treatment groups for all three parameters ($p < 0.01$). Moringa treatments (2.5–5 g/500 mL) maintained pH levels comparable to untreated water, while higher doses (7.5–10 g/500 mL) caused a decrease. Alum treatment significantly reduced pH. TDS increased notably with both Moringa and alum treatments, with alum exhibiting the highest value (565.33 mg/L). Similarly, EC followed a comparable trend, with alum dramatically increasing conductivity (1189 $\mu\text{S}/\text{cm}$), whereas higher Moringa doses reduced EC. These findings suggest that Moringa seed powder provides a more stable treatment in terms of water chemistry, whereas aluminum sulfate induces more substantial physicochemical changes.

Keywords: Moringa seed powder; Natural-based coagulant; Aluminum sulfate; Wastewater; Physicochemical.

INTRODUCTION

Water is essential for human existence. In various regions, deep wells, rivers, and other natural sources have been utilized for drinking purposes. Water is a fundamental resource required by all living organisms for survival; however, its availability in an appropriate condition remains a critical concern (Hendrawati et al., 2016). The high-quality availability of freshwater is one of the most pressing global issues in the modern era. As the demand for water increases annually, various forms of pollution have significantly compromised water sources (Genc- Fuhmen et al., 2018).

Similarly, Southeast Asian countries continue to experience severe water pollution, leading to the degradation of the living environment, reduced water availability, and the loss of aquatic ecosystem services

(WEPA, 2024). The scarcity of clean water is primarily attributed to major pollutants, including sewage, industrial effluents, agricultural residues, and harmful chemicals (Bhattarai & Dahal, 2020).

In the Philippines, despite being the fastest-growing economy in Asia as of 2015, the country ranked 33rd out of 48 nations in terms of water security, according to the Asian Development Bank (ADB) (Lee et al., 2020). Water sources in the Philippines are affected by various contaminants, with industrial wastewater containing chemical pollutants such as chromium, cadmium, lead, mercury, and cyanide (Andrews, 2018). Tan (2020) reported that 9 million out of 101 million Filipinos continue to suffer from unimproved, unsafe, and unsustainable water sources.

Thus, this study aims to explore alternative solutions for raw water treatment and provide relevant information

for future applications. While various studies have focused on commercial coagulants, this research investigates the potential of Malunggay seed powder as an alternative coagulant to aluminum sulfate. Specifically, this study aims to identify the characteristics of the water samples with Malunggay seed powder treatment, before and after introduction of treatment in terms of total dissolved solids, pH Level, and electrical conductivity. Compare the efficiency of Moringa Seed Powder to that of Aluminum Sulphate in terms of water quality.

MATERIALS AND METHODS

Research Design

The study employed a Completely Randomized Design (CRD) as its experimental framework. In a CRD, treatments are assigned entirely at random, ensuring that each experimental unit has an equal probability of receiving any given treatment (Jayaraman, 1999).

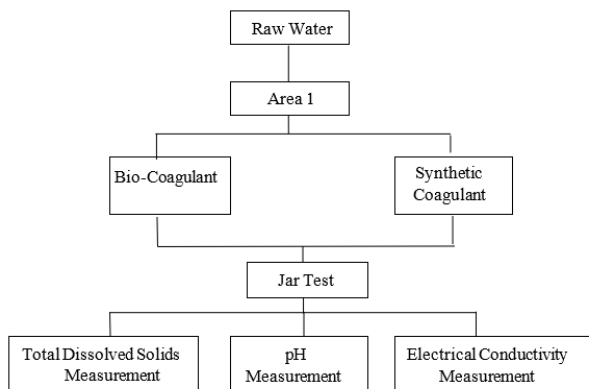


Figure 1. Research Flow Chart

Preparation of Test Equipment

The researcher consulted an electrician for assistance in constructing the Jar test apparatus.



Figure 2. Jar Test Apparatus (Source: Camera and Canva)

Collection of Plant Materials

Moringa oleifera seeds were collected from Sitio Salawao, Sto. Niño, Talaingod, Davao del Norte. The harvested seeds were prepared for pulverization. Prior to processing, they were washed with distilled water and placed in a clean polyethylene plastic bag. Following the recommendations of Ebrahim et al. (2021), the seeds were air-dried for two days.

Preparation of Treatment

The researcher proceeded to the laboratory at Davao del Norte State College to pulverize the Malunggay seeds. The collected pods were cracked to extract the seeds, which were then air-dried. The removed kernels were pulverized using a laboratory mortar and pestle, followed by sieving to obtain a refined powder. Meanwhile, aluminum sulfate was acquired through purchase.



Figure 3. The researcher prepared malunggay for treatment (a. malunggay seeds, b. pulverized malunggay seeds and aluminum sulfate)

Site Description

The study was conducted at a single sampling site. According to the Barangay Health Center of Sto. Niño, Talaingod, the selected site is frequently used by the local community for washing clothes, cleaning dishes, and bathing. However, health officials have indicated that the water in this area is unsafe for use and may pose health risks.

Collection of Water Samples

Water samples were collected at a deep well of Sitio Salawao, Sto. Niño, Talaingod, Davao del Norte, using a container. There were 18 water samples collected in the area with 500ml each. The collected water samples were placed inside a clean plastic container and placed at a room temperature, specifically 20- 22 degrees Celsius.



Figure 4. The researcher collected raw water for Sampling (a. collected raw water in a bottle, b. researcher collects water sample)

Assigning Water Samples

A total of 18 water samples were collected and randomly assigned to six distinct treatment groups. Three samples were treated with aluminum sulfate, while three others were left untreated as a control group. The remaining twelve samples were treated with varying concentrations of Moringa seed powder.

Application of Treatments

Before the application of treatment, the water samples were shaken for one minute. Subsequently, a total of 18 water samples were used, divided into six groups with three samples in each. Three of these samples were left untreated as the control group (T1). The remaining 12 samples were treated with varying dosages of Moringa seed powder: 2.5 grams (T2), 5 grams (T3), 7.5 grams (T4), and 10 grams (T5), with three samples assigned to each dosage. Additionally, three water samples were treated with 2.5 grams of aluminum sulfate (T6).

Afterwards, the treated water samples were rotated at a consistent speed for two minutes using the jar test apparatus. Before the application of treatment, the water samples were shaken for one minute. Subsequently, a total of 18 water samples were used, divided into six groups with three samples in each. Three of these samples were left untreated as the control group (T1). The remaining 12 samples were treated with varying dosages of Moringa seed powder: 2.5 grams (T2), 5 grams (T3), 7.5 grams (T4), and 10 grams (T5), with three samples assigned to each dosage. Additionally, three water samples were treated with 2.5 grams of aluminum sulfate (T6). Afterward, the treated water samples were rotated at a consistent speed for two minutes using the jar test apparatus.

Preparation of Water Sample for Laboratory Testing

After the application of treatments, the treated and untreated water samples were separately placed in distilled water bottles. Subsequently, the samples were stored in an ice box surrounded by ice to maintain stability. The water samples were then transported to Davao del Norte State College for turbidity removal and pH regulation testing.

Data Analysis

After laboratory testing, the researcher computed the average levels of pre-treated and post-treated water samples for both *M. oleifera* seed powder and aluminum sulfate to identify the difference between treatments in terms of total dissolved solids, pH level regulation, electrical conductivity, and their quality.

Statistical Analysis

Data gathered was analyzed using Welch ANOVA to account for unequal variances among treatment groups, followed by the Games-Howell post hoc, to determine significant differences between treatments.

This approach was chosen due to the small sample size and the presence of heterogeneity in variances, ensuring a more robust comparison of means. Moreover, analyses were conducted for pH, Total Dissolved Solids (TDS), and Electrical Conductivity (EC) to assess the effectiveness of different coagulants.

RESULTS

pH Level

Table 1 presents a comparison of mean pH values of water samples subjected to various coagulation treatments, analyzed using a series of statistical tests. The treatments included untreated water (T1), different dosages of *Moringa oleifera* seed extract (T2, T3, T4, T5), and aluminum sulfate (T6).

Levene's test for homogeneity of variances revealed a significant difference among the treatment groups ($p = 0.002$), indicating a violation of the assumption of equal variances. Consequently, Welch's ANOVA was employed, confirming statistically significant differences in pH values across the groups ($p < 0.0001$). This finding was further supported by standard ANOVA results, which showed that the between-group variance was significantly greater than the within-group variance ($F = 43.878$, $p < 0.0001$), highlighting substantial variation in pH levels attributable to the different treatments.

Table 1. Mean of pH Values of Water Samples After Coagulation Treatments

TREATMENTS	pH**	
	Mean ± SD	P value (vs T1)
Untreated	6.64 ± 0.381a	----
Moringa at 2.5 g/500 ml	6.64 ± 0.121a	1.000
Moringa at 5 g/500 ml	6.92 ± 0.015a	0.795
Moringa at 7.5 g/500 ml	6.29 ± 0.188b	0.717
Moringa at 10 g/ 500 ml	5.77 ± 0.527b	0.368
Alum at 2.5 g/500 ml	3.99 ± 0.059c	0.020

Means with the same superscript are not significantly different from each other (p<0.05). **= highly significant differences between treatments (p value <0.01).

The results indicate that untreated water (T1) and the Moringa treatments (T2, T3) exhibited similar pH values, as demonstrated by the absence of statistically significant differences between these groups (p > 0.05). This aligns with the findings of Andrade et al. (2018), who reported that *Moringa oleifera* seed-derived coagulants did not significantly alter the pH of treated water, maintaining stability across varying dosages.

In contrast, the pH value of the 2.5 g aluminum sulfate (T6) treatment was significantly lower than that of the other groups (p = 0.020), with a mean pH of 3.99 ± 0.059. This suggests that aluminum sulfate is more effective at lowering water pH compared to Moringa treatments.

This result aligns with the findings of Andrade et al. (2018), which demonstrated that increasing aluminum sulfate concentrations led to a notable decrease in pH due to the release of hydrogen ions during alum dissolution. Overall, while Moringa treatments did not significantly differ from untreated water, aluminum sulfate treatment resulted in a considerable reduction in pH, highlighting its distinct impact on water chemistry in coagulation processes. Notably, the pH levels of water samples treated with Moringa fall within the standard pH range of 6.5–8.5 set by the World Health Organization (WHO).

Total Dissolved Solids

The average Total Dissolved Solids (TDS) values of the water samples following coagulation treatments were analyzed and are presented in Table 2. Levene’s test for homogeneity of variances identified significant disparities among the treatment groups (p = 0.004), indicating a violation of the assumption of equal variances. Consequently, Welch’s ANOVA was performed, revealing statistically significant variations in TDS values across

treatments (p < 0.0001). Furthermore, standard ANOVA results showed a substantial F-value (F = 220.084, p < 0.0001), confirming that TDS levels differed significantly among the treatment groups.

The results indicate significant variations in TDS values among the treatments. Untreated water (T1) exhibited the lowest TDS value (112.33 ± 12.42), while treatments with *Moringa oleifera* seed powder and aluminum sulfate led to increased TDS levels. Specifically, T2 (2.5 g Moringa), T3 (5 g Moringa), and T6 (2.5 g aluminum sulfate) displayed significantly higher TDS values compared to untreated water, with p-values of 0.011, 0.002, and 0.011, respectively. The highest TDS value was recorded in T6 (2.5 g aluminum sulfate), with a mean of 565.33 ± 51.39, demonstrating that aluminum sulfate was the most effective treatment in increasing TDS levels.

Table 2. Mean of TDS Values of Water Samples After Coagulation Treatments

TREATMENTS	TDS**	
	Mean ± SD	p value (vs Untreated)
Untreated	112.33 ± 12.42b	----
Moringa at 2.5 g/500 ml	233.33 ± 20.60c	.011
Moringa at 5 g/500 ml	239.67 ± 7.23c	.002
Moringa at 7.5 g/500 ml	13.67 ± 8.09a	.003
Moringa at 10 g/ 500 ml	19.67 ± 10.69a	.004
Alum at 2.5 g/500 ml	565.33 ± 51.39d	.011

Means with the same superscript are not significantly different from each other (p>0.05). **= highly significant differences between treatments (p value <0.01)

The significantly higher TDS observed in the alum treatment (T6), measured at 565.33 mg/L, raises concerns, despite the fact that elevated TDS levels can indicate the presence of beneficial minerals such as calcium and magnesium. This finding is consistent with Kitheka et al. (2022), who reported a significant increase in TDS levels with higher concentrations of *Moringa oleifera* seed powder, suggesting a positive correlation between coagulant dosage and TDS concentration. Similarly, Solomon et al. (2020) noted that while both alum and Moringa treatments influence TDS levels, alum typically induces a more pronounced change due to its chemical interactions with dissolved ions during coagulation. These studies corroborate the observed substantial increase in TDS levels, particularly in alum-treated samples, highlighting the potential for elevated

TDS to affect water taste and indicate the presence of residuals or excess ions.

A TDS value this high could impact the taste of the water and may indicate the presence of excess or undesirable contaminants. According to the World Health Organization (WHO), the acceptable limit for Total Dissolved Solids (TDS) in drinking water is 1000 mg/L. The findings of this study suggest that, among the treatments tested, *Moringa oleifera* seed powder was more effective in reducing TDS levels, demonstrating its potential as a superior treatment option.

Electrical Conductivity

Table 3 presents the mean electrical conductivity (EC) values of water samples following coagulation treatments. Levene’s test for homogeneity of variances revealed significant differences among the treatment groups ($p = 0.004$), indicating a violation of the assumption of equal variances. Consequently, Welch’s ANOVA was conducted, confirming statistically significant variations in EC values across treatments ($p < 0.0001$). Furthermore, standard ANOVA results showed a substantial F-value ($F = 79.591, p < 0.0001$), demonstrating that the treatment groups significantly influenced EC levels.

Table 3. Mean EC Values of Water Samples After Coagulation Treatments

TREATMENTS	EC**	
	Mean ± SD	p value (vs T1)
T1- UNTREATED	224.00 ± 26.06a	---
T2- 2.5g MORINGA	393.67 ± 140.08a	.504
T3- 5g MORINGA	403.67 ± 143.11a	.482
T4- 7.5g MORINGA	27.33 ± 16.17b	.005
T5- 10g MORINGA	39.33 ± 21.39b	.005
T6- 2.5g ALUM	1189.00 ± 10.58c	.000

Means with the same superscript are not significantly different from each other ($p > 0.05$). **= highly significant differences between treatments (p value < 0.01)

The results indicate that the alum treatment (T6) notably increased EC values, whereas higher concentrations of *Moringa oleifera* seed powder (T4 and T5) led to a decrease in EC. This variation suggests that different coagulation treatments influence ion concentrations in distinct ways, with alum substantially increasing EC levels.

Woxholt (1959) discusses the electrical properties of colloids and their stability, which is relevant for understanding how coagulation impacts EC. The coagulation process destabilizes colloids, causing them to aggregate and settle out of suspension, consequently altering the ionic composition of water. Cheng et al.

(2010) describes "electrostatic patch coagulation" as a mechanism for turbidity and NOM removal, further emphasizing the role of electrical charges in coagulation. Mortadi et al. (2020) examines complex electrical conductivity as a technique for monitoring coagulation-flocculation processes, indicating that EC serves as a valuable parameter for assessing treatment effectiveness. Similarly, Paula et al. (2016) explores the use of *Moringa oleifera* seed extract alongside chemical coagulants in wastewater treatment, highlighting its impact on turbidity removal. Granstrom & Shearer (1958) discuss conductometric control of coagulant dosage, suggesting that EC measurement can optimize treatment processes.

Further research on specific coagulants and their effects on EC across various water types would enhance understanding of this phenomenon.

DISCUSSION

Moringa oleifera demonstrated minimal impact on pH at low concentrations, confirming its suitability as a near-neutral coagulant. The slight pH reduction at higher doses may be attributed to the release of organic functional groups, but values remained within acceptable limits. In contrast, alum significantly acidified the water through hydrolysis, indicating the need for pH correction in practical applications. In a study by Hendrawati (2016), the use of *Moringa oleifera* seed powder as a coagulant to improve the quality of wastewater and groundwater was investigated. A dose of 100 mg/L gave the best result for the wastewater, as the treated water showed the lowest value of turbidity, the closest pH value to 7, and the lowest value of conductivity.

Total Dissolved Solids (TDS) results highlight a dose-dependent effect of *Moringa oleifera*. Lower concentrations increased dissolved solids, likely due to the introduction of organic matter, whereas higher concentrations enhanced coagulation efficiency, resulting in a substantial reduction in TDS. Aluminum sulfate markedly increased Total-Dissolved Solid (TDS), reflecting the addition of dissolved ions during treatment.

A similar trend was observed for Electrical Conductivity, which closely reflects ionic concentration. Higher *Moringa oleifera* doses reduced Electrical Conductivity, suggesting effective removal of charged particles through charge neutralization and flocculation. Conversely, aluminum sulfate significantly increased Electrical Conductivity due to its ionic dissociation. Moreover, aluminum sulfate is effective for coagulation and substantially alters water chemistry. *Moringa oleifera*, particularly at optimal dosages, offers a more balanced approach by maintaining pH and reducing both Total Dissolved Solids and Electrical Conductivity, supporting its potential as a sustainable alternative coagulant.

CONCLUSION

The findings indicate that aluminum sulfate is highly effective in altering water chemistry, significantly reducing pH while increasing Total Dissolved Solids (TDS) and Electrical Conductivity (EC). In contrast, *Moringa oleifera* seed powder, though less potent in these effects, maintains pH and EC levels closer to those of untreated water, demonstrating potential as a natural and eco-friendly coagulant.

These results support the viability of *Moringa oleifera* as a sustainable alternative to chemical coagulants, particularly in low-resource environments or settings where milder modifications to water quality are preferred. This study highlights *Moringa*'s suitability for communities requiring a locally available, cost-effective, and environmentally friendly treatment option. It is particularly beneficial in rural or low-resource areas where access to commercial chemical coagulants may be limited or expensive.

Additionally, because *Moringa oleifera* does not significantly alter water chemistry, it is a safer option for long-term use, minimizing the risk of adverse effects. Overall, while aluminum sulfate exhibits stronger coagulation performance, *Moringa oleifera* offers an optimal balance between effectiveness and environmental sustainability, making it an ideal natural alternative for wastewater treatment.

Conflict of Interest

There are no conflicts of interest declared by the authors.

REFERENCES

- Aduri, A., & Ebenso, B. (2019). Qualitative exploration of local knowledge, attitudes and use of *Moringa oleifera* seeds for home-based water purification and diarrhoea prevention in Niger State, Nigeria. *Journal of Water, Sanitation and Hygiene for Development*.
- Al-Sahari, M. A.-G. (2020). Natural coagulants for wastewater. In *Prospects of fresh market wastes management in developing countries*.
- Andrews, Gabriella (2018) "Resolving the Water Pollution Crisis in the Philippines: the Implications of Water Pollution on Public Health and the Economy," *Pepperdine Policy Review*: Vol. 10, Article 2.
- Bhattarsi, R., & Dahal, K. R. (2021). Review Of Water Pollution With Special Focus On Nepal. 104.Cheng, Y. L., Wong, R. J., Lin, J. C. T., Huang, C., Lee, D., & Lai, J. Y. (2010). Pre-Treatment of Natural Organic Matters Containing Raw Water using Coagulation. In *Separation Science and Technology* (Vol. 45, Issue 7, p. 911). Taylor & Francis. <https://doi.org/10.1080/01496391003666890>Cui, H., Huang, X., Yu, Z., Chenab, P., & Cao, X. (2020). Application progress of enhanced coagulation in water treatment.
- Elgeed, B., & Abdalsalam, M. (2023). Evaluation the efficacy of *Moringa oleifera* seed powder on physico-chemical parameters of white Nile river water. *International Journal of Science Academic Research*. Federal Democratic Republic Of Nepal (2019). Data collection survey on water supply and waste water sector in Nepal. Gautam, S., & Saini, G. (N.D.). Use of natural coagulants for industrial wastewater treatment. *Journal of Environmental Science and Management*, 553-578. Granstrom, M. L., & Shearer, S. D. (1958). Conductometric Control of Coagulant Dosage in Treatment Plants. *American Water Works Association*, 50(3), 410. <https://doi.org/10.1002/j.1551-8833.1958.tb16184.x>
- Hendrawati, Rani, I., & Yuliasri. (2016). The use of *Moringa Oleifera* Seed Powder as Coagulant to Improve the Quality of Wastewater and Ground Water. 1.
- Iwuozor, K. (2019). Prospects and challenges of using coagulation-flocculation method in the treatment of effluents. *Advanced Journal of Chemistry- Section A*.
- Jiayi, X., Xuelai Z., Lingen, Z. (2022) A review: Progress and perspectives of research on the functionalities of phase change materials, *Journal of Energy Storage*, Volume 54, 2022, 105341, ISSN 2352-152X, <https://doi.org/10.1016/j.est.2022.105341>.
- Kim, T. (2015). T test as a parametric statistic. *Korean Journal of Anesthesiology*. 68. 540. [10.4097/kjae.2015.68.6.540](https://doi.org/10.4097/kjae.2015.68.6.540).
- Kitheka, J. U., Munguti, J. M., & Gikungu, M. W. (2022). Effects of *Moringa oleifera* seeds on the physicochemical properties and microbiological quality of borehole water from Botswana. *Journal of Water, Sanitation and Hygiene for Development*, 12(9), 659–667. <https://doi.org/10.2166/washdev.2022.206>
- Kumar, V., Othman, N., & Asharuddin, S. (2017). Applications of natural coagulants to treat wastewater.
- Lee, H., Son, J., Joo, D., Ha, J., Yun, S., Lim, C., & Lee, W. (2020). Sustainable Water Security Based on the SDG Framework: A Case Study of the 2019 Metro Manila. 3.
- Mohammed, S.S. (2015) Effect of pH on the Turbidity Removal of Wastewater. *Open Access Library Journal*, 2: e2283. <http://dx.doi.org/10.4236/oalib.1102283>
- Mortadi, A., Chahid, A., Elmelouky, A., Chahbi, M., Ghyati, N. E., Zaim, S., Cherkaoui, O., & Moznine, R. E. (2020). Complex electrical conductivity as a new technique to monitor the coagulation-flocculation processes in the wastewater treatment of the textile Industry. *Water Resources and Industry*, 24, 100130. <https://doi.org/10.1016/j.wri.2020.100130>
- National Center For Biotechnology Information (2024). PubChem Compound Summary for CID 24850,

- Aluminum Sulfate. Retrieved April 13, 2024 from <https://pubchem.ncbi.nlm.nih.gov/compound/Aluminum-Sulfate>.
- Omer, N. 2021 Water Assessment- Science, Assessments and Policy. Book Citation Index in Web of Science™ Core Collection (BKCI).
- Palanca-Tan, R. 2020 The Journal of Social, Political, and Economic Studies; Washington Vol. 45, Iss. 1/2, (Spring/Summer 2020): 46-62.
- Paula, H. M. De, Ilha, M. S. De O., & Andrade, L. S. (2016). Chemical coagulants and Moringa oleifera seed extract for treating concrete wastewater. *Acta Scientiarum. Technology/Acta Scientiarum. Technology*, 38(1), 57. <https://doi.org/10.4025/actascitechnol.v38i1.25699>
- Sahoo, D. & Anandhi, A. (2023). Conceptualizing turbidity for aquatic ecosystems in the context of sustainable development goals. *Environmental Science: Advances*. 2. 10.1039/d2va00327a.
- Sarker, B., Keya, K., Mahir, F., Nahin, K., Shahida, S., & Khan, R (2021). Ground Water Pollution: Causes and Effects of Urbanization and Industrialization in South Asia. 34.
- Solomon, M. M., Abate, D., & Tadesse, A. (2020). Comparative study on the coagulating potentials of alum and Moringa oleifera in raw water treatment. *Direct Research Journal of Agriculture and Food Science*, 8(3), 35–42.
- Tahraoui, H.; Toumi, S.; Boudoukhani, M.; Touzout, N.; Sid, A.N.E.H.; Amrane, A.; Belhadj, A.-E.; Hadjadj, M.; Laichi, Y.; Aboumustapha, M., et.al Evaluating the Effectiveness of Coagulation–Flocculation Treatment Using Aluminum Sulfate on a Polluted Surface Water Source: A Year-Long Study. *Water* 2024, 16, 400. <https://doi.org/10.3390/w16030400>
- Tetteh, E., & Rathilal, S. (2020). Evaluation of different polymeric coagulants for the treatment of oil refinery wastewater.
- Town, L, Darlur, C., Issa, J. A., Babiker, M. O. & Ohaj, M. 2015 Determination of inorganic chemical parameters in drinking water in districts of the province of Puno in the region Puno-Peru. 3 (12), 1208- 1214.
- Umass Water Resource Research Center. (2023). Analysis Method for pH and Alkalinity, U.S. EPA 2019 National Reuse Water Action Plan. September.
- Vega, A., Araujo, R. C., & Garcia, J. C. (2018). Evaluation of natural and synthetic coagulants for surface water treatment without pH adjustment. *Water*, 10(12), 1680. <https://doi.org/10.3390/w10121680>
- Water Environment Partnership In Asia. (2024). Fourth Phase Final Report 2024. Ministry of the Environment, Japan.
- World Health Organization. 2007. Revised background document for development of WHO Guidelines for Drinking-water Quality Woxholt, W. G. (1959). Electrical Conductivity and the Stability of Colloids. *American Water Works Association*, 51(7), 885. <https://doi.org/10.1002/j.1551-8833.1959.tb21174>.

