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Comparative Evaluation of Physicochemical Properties of Surface Water Treated by Alum and Pawpaw Seed Powder

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ABSTRACT: Surface water treatment is crucial for maintaining water quality and safeguarding public health. Traditional methods like alum treatment have been widely used, but they often come with high costs and environmental concerns. In contrast, natural alternatives such as pawpaw seed powder offer a potentially low-cost and eco-friendly solution. Hence, the objective of this paper is to comparatively evaluate the physicochemical properties of surface water treated by using alum and pawpaw seed powder using appropriate standard methods. Initial water quality parameters included turbidity of 27 NTU, pH of 7.9, total suspended solids (TSS) of 126.8 mg/L, total dissolved solids (TDS) of 267.2 mg/L, and hardness of 321 mg/L. Post-treatment with alum reduced these values to 9 NTU, pH 7.5, TSS 50 mg/L, TDS 135 mg/L, and hardness 95 mg/L. Pawpaw seed powder treatment resulted in reductions to 6 NTU, pH 7.6, TSS 60 mg/L, TDS 160 mg/L, and hardness 130 mg/L. The findings showed significant improvement in water clarity and quality for both treatments, with pawpaw seed powder demonstrating slightly superior turbidity reduction. Cost analysis revealed that alum treatment cost a total of 9000 NGN, whereas pawpaw seed powder treatment cost 5500 NGN, primarily due to lower procurement and transportation costs. The results suggest that pawpaw seed powder is a more cost-effective and sustainable alternative to alum since it was capable of achieving comparable water quality improvements.

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Water treatment is essential for ensuring the safety and quality of surface water for human consumption and various other uses (Bhagwat, 2019; Ojo and Obiora-Okeke, 2022; Kekes *et al.* 2023). Limited availability of sufficient, uncontaminated, and secure water represents a significant challenge worldwide (Pandey *et al.*, 2021). In 2021, roughly 2.2 billion people lacked access to adequately managed drinking water facilities (World Bank, 2021). Surface water is crucial for low-income households as it often serves as their primary source of water for drinking, cooking, and sanitation, directly impacting their health and well-being. As of 2020, an estimated 122 million individuals relied on surface water outlets for their water supply (UNICEF/WHO, 2021; WHO, 2023). Conventional coagulants like *aluminum sulfate* (alum) are widely used in water treatment processes (Malik, 2018). However, there is a growing interest in natural coagulants such as pawpaw seed powder (*Carica papaya*) due to concerns about the environmental and health impacts of chemical coagulants (Unnisa and Bi, 2018; Amran *et al.*, 2021). Alum is one of the most commonly used chemical coagulants in water treatment due to its high efficiency in removing turbidity, colour, and microorganisms (Priya *et al.*, 2018). The effectiveness of alum is well-documented, with studies showing significant reductions in suspended

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solids and pathogens in treated water (Daud *et al.*, 2023). However, the use of alum has some drawbacks, including the production of large volumes of sludge, potential residual aluminum in treated water, and the associated health risks (Kluczka *et al.*, 2017). Natural coagulants such as pawpaw seed powder have been proposed as sustainable alternatives to chemical coagulants (Kristianto *et al.*, 2018). Pawpaw seed powder contains bioactive compounds such as alkaloids, flavonoids, and saponins, which can aid in coagulation and flocculation processes (Owodunni *et al.*, 2023). Studies have shown that pawpaw seed powder can effectively reduce turbidity and microbial load in water (Diver *et al.*, 2023). The use of natural coagulants is also associated with lower sludge production and biodegradability, making them environmentally friendly options (Koul *et al.*, 2022). Comparative studies on the effectiveness of alum and pawpaw seed powder have yielded mixed results. While alum is often found to be more effective in reducing turbidity and colour, pawpaw seed powder has demonstrated comparable performance in specific contexts, particularly in low-turbidity waters (Yimer and Dame, 2021; Ojo 2024). For instance, a study by Bayode *et al.* (2023) found that pawpaw seed powder was effective in reducing turbidity and organic matter in surface water, though it required higher doses compared to alum. The economic feasibility of using alum versus pawpaw seed powder in water treatment involves comparing the costs of procurement, application, and disposal (Diver *et al.*, 2023). Alum is commercially available and relatively inexpensive, but the costs associated with sludge handling and disposal can be significant (Turner *et al.*, 2019). In contrast, pawpaw seeds are often locally available as agricultural waste, potentially reducing raw material costs (Vezar *et al.*, 2024).

A detailed cost analysis by Rahman Adrin *et al.* (2024) revealed that while the initial cost of alum is lower, the long-term costs associated with sludge management and potential environmental remediation may make pawpaw seed powder a more cost-effective option in the long run. Additionally, the use of locally sourced pawpaw seeds can stimulate local economies and reduce dependency on imported chemicals. The sustainability of water treatment processes is a critical consideration in the selection of coagulants. Alum production and usage are associated with significant environmental impacts, including greenhouse gas emissions and energy consumption (Panhwar and Bhutto, 2021). In contrast, natural coagulants like pawpaw seed powder are biodegradable and derived from renewable resources, offering a more sustainable alternative (Koul *et al.*, 2022).

Moreover, the disposal of sludge generated from alum treatment poses environmental challenges due to its potential toxicity (de Jesus *et al.*, 2024). Sludge from natural coagulants, on the other hand, is often safer and can be used as fertilizer or soil conditioner, contributing to a circular economy (Nath *et al.,* 2021, Marguti *et al.*, 2018). Hence, the objective of this paper is to comparatively evaluate the physicochemical properties of surface water treated by using alum and pawpaw seed powder.

MATERIALS AND METHODS

Sample Collection and Characterization of Contaminants: Surface water samples were collected from Ala river tributary in Ibule-Soro, South western Nigeria. Samples were collected in clean, sterilized containers to prevent contamination. Initial characterization of the surface water samples was conducted to determine the types and concentrations of contaminants present. The turbidity, pH, total suspended solids, total dissolved solids and hardness were measured using standard methods described in APHA (2017).

Preparation of Alum Solution: Alum solution was prepared by dissolving 0.2 g of *aluminum sulfate* ($Al_2(SO_4)_3$) in 1L of water resulting in a standardized solution for the surface water treatment purpose.

Preparation of Pawpaw Seed Powder: Pawpaw fruits were gathered from a household garden in Ibule-soro, a rural area in Ondo State, Southwestern Nigeria. Plate 1 displays the mature pawpaw tree alongside its fruits. The seeds were separated from the pawpaw fruit, cleansed, and left to dry under the sun for two weeks to eliminate any moisture content. Once dried, the pawpaw seeds were finely ground using a local grinder. The resulting pawpaw seed powder was sifted to ensure a consistent particle size distribution.

Batch Adsorption Experiments: Batch adsorption experiments were conducted to evaluate the adsorption capacity of alum and pawpaw seed powder for various contaminants present in the surface water samples. In each experiment, a 1 litre of water sample was separately treated with 0.2 g of alum solution and pawpaw seed powder being an average treatment dose. The mixture was agitated using a magnetic stirrer to ensure uniform contact between the adsorbent and contaminants. To ensure an efficient coagulation process, the stirring tool was initially operated at a speed of 150 rpm for 3 minutes before being reduced to 60 rpm for a subsequent 30-

minute duration (Vezar *et al.*, 2024). Samples were withdrawn at regular time intervals to monitor the adsorption process. The concentration of contaminants in the samples was analyzed according to APHA (2017).

Plate 1: Mature pawpaw tree with its fruits
Source: Field work, 2024

Cost Analysis: A comprehensive cost analysis was conducted to compare the expenses associated with alum and pawpaw seed powder treatments. The cost analysis included expenses related to the procurement, processing, transportation, and application of alum and pawpaw seed powder. Additional costs such as disposal of sludge generated from alum treatment were also considered (Koul *et al.*, 2022). The procurement cost for alum treatment involved calculating the expense of purchasing alum based on market prices and required dosage. Additional processing costs were incurred for mixing and dissolving alum in water, including energy expenses.

Transportation costs included expenses related to moving alum from the supplier to the treatment site. Disposal costs accounted for handling and disposing of the sludge generated from alum treatment in compliance with environmental regulations. For pawpaw seed powder treatment, procurement costs included acquiring and processing pawpaw seeds into powder, considering factors like seed availability and processing expenses. Processing costs encompassed grinding, sieving, and drying pawpaw seeds to produce a uniform powder. Transportation costs involved moving pawpaw seeds and powder to the treatment site, while application costs included expenses for applying pawpaw seed powder to surface water samples. The comparison of costs entailed evaluating the total expenses of alum and pawpaw seed powder treatments to determine their relative cost-effectiveness. Cost per unit volume of water treated was computed for both methods to standardize the comparison, and sensitivity analysis assessed the impact of varying input parameters on treatment costs. Additionally, a cost-benefit analysis weighed the costs of both treatments against their respective benefits in terms of contaminant removal efficiency and environmental sustainability, utilizing cost-effectiveness ratios to gauge their efficiency in achieving desired water quality standards.

Performance Evaluation: The efficacy of alum and pawpaw seed powder treatments was assessed by examining their individual capacity to eliminate impurities from surface water samples, drawing comparisons between the two methodologies. This evaluation aimed to determine the relative effectiveness of each treatment in purifying the surface water.

RESULTS AND DISCUSSION

Effect of Alum and pawpaw leaf powder on surface water treatment: The impact of alum and pawpaw leaves powder treatment on various parameters in the surface water samples are presented in Table 1. Initially, the water exhibited a turbidity value of 27 NTU, pH of 7.9, total suspended solids (TSS) of 126.8 mg/L, total dissolved solids (TDS) of 267.2 mg/L, and hardness of 321 mg/L. Following alum treatment, the turbidity reduced to 9 NTU, pH to 7.5, TSS to 50 mg/L, TDS to 135 mg/L, and hardness to 95 mg/L. Conversely, pawpaw leaves powder treatment resulted in a decrease in turbidity to 6 NTU, a slight increase in pH to 7.6, and slight increases in TSS to 60 mg/L, TDS to 160 mg/L, and hardness to 130 mg/L. This demonstrated the efficacy of both treatments in improving water quality, albeit with varying effects on different parameters.

The implications of the results on water quality were significant. The reduction in turbidity, total suspended solids (TSS), total dissolved solids (TDS), and hardness after treatment suggested an improvement in water clarity, which could enhance aesthetic appeal and potentially increase consumer confidence in the water supply (Koul *et al.*, 2022). According to Sharma *et al.* (2022), the slight variations in pH indicated a minimal impact on the overall acidity or alkalinity of the water, which was crucial for maintaining water quality within acceptable ranges for consumption and aquatic life. Overall, these results suggested that both alum and pawpaw leaves powder treatments had the potential to contribute to the improvement of water quality by reducing impurities and enhancing clarity, thereby supporting environmental health and human well-being (Badawi *et al.*, 2023). However, further analysis and consideration of other factors such as cost-effectiveness, sustainability, and long-term effects were necessary to make informed decisions about water treatment strategies and their implications for overall water quality management.

Table 1: Effect of Alum and pawpaw leaf powder on surface water treatment

Parameter	Initial Concentration	Alum Treatment	Pawpaw Leaves Powder Treatment
Turbidity (NTU)	27	9	6
pH	7.9	7.5	7.6
Total Suspended Solids (TSS) (mg/L)	126.8	50	60
Total Dissolved Solids (TDS) (mg/L)	267.2	135	160
Hardness (mg/L)	321	95	130

Cost Comparison of Alum and Pawpaw Leaf Powder Treatment: Table 2 compared the costs associated with alum treatment and pawpaw seed powder treatment in Nigerian Naira (NGN). Procurement costs for alum treatment amounted to 1500 NGN, while there were no procurement costs for pawpaw seed powder treatment. Both treatments incurred processing costs of 1000 NGN each. Transportation costs were higher for alum treatment at 3500 NGN compared to 1500 NGN for pawpaw seed powder treatment. Both treatments had equal disposal costs of 2000 NGN and application costs of 1000 NGN. The total cost of alum treatment was 9000 NGN, while the total cost of pawpaw seed powder treatment was 5500 NGN, indicating that pawpaw seed powder treatment was more cost-effective.

The results indicated that while alum treatment was effective in removing contaminants from surface water, it came with higher costs compared to pawpaw seed powder treatment. This corroborated the findings of Yimer and Dame (2021). The cost analysis revealed that the expenses associated with alum procurement, transportation, and disposal of sludge were substantial, contributing to the overall cost of treatment (Sukmana *et al.*, 2021). In contrast, pawpaw seed powder treatment offered a cost-effective alternative, with lower expenses for procurement and processing. Furthermore, the performance evaluation demonstrated that pawpaw seed powder exhibited comparable or even superior adsorption capacity for certain contaminants compared to alum.

Table 2: Cost Comparison of Alum and Pawpaw Leaf Powder Treatment

Cost Component	Alum Treatment (NGN)	Pawpaw Seed Powder Treatment (NGN)
Procurement Cost	1500	0
Processing Cost	1000	1000
Transportation Cost	3500	1500
Disposal Cost	2000	2000
Application Cost	1000	1000
Total Cost	9000	5500

The findings of this study highlight the potential of pawpaw seed powder as a cost-effective and environmentally friendly alternative to alum for surface water treatment. By utilizing natural adsorbents like pawpaw seed powder, water treatment facilities can reduce costs, minimize environmental impacts, and promote sustainable water management practices. However, further research is needed to optimize the use of pawpaw seed powder and explore its potential application in large-scale water treatment processes.

Conclusion: This research demonstrated that both alum and pawpaw seed powder effectively improves surface water quality by reducing turbidity, TSS, TDS, and hardness. Alum treatment significantly lowered these parameters but incurred higher total costs due to procurement, transportation, and disposal expenses. Pawpaw seed powder treatment proved more cost-effective with similar or better performance in some parameters, despite slight increases in TSS, TDS, and hardness. The study suggests that pawpaw seed powder is a viable, sustainable, and economical alternative to alum for water treatment. Further research is needed to examine the long-term effects and broader implications of using natural coagulants.

Declaration of Conflict of Interest: The author declares no conflict of interest.

Data Availability: Data are available upon request from the author.

REFERENCES

Amran, AH; Zaidi, NS; Syafiuddin, A; Zhan, LZ; Bahrodin, MB; Mehmood, MA; Boopathy, R (2021). Potential of *Carica papaya* seed-derived bio-coagulant to remove turbidity from polluted water assessed through experimental and modeling-based study. *Appl. Sci.* 11: 5715. https://doi.org/10.3390/app11125715

APHA (2017). Standard methods for the examination of water and wastewater (23rd ed.). Washington DC: American Public Health Association.

Badawi, AK; Salama, RS; Mostafa, MMM (2023). Natural-based coagulants/flocculants as sustainable market-valued products for industrial wastewater treatment: A review of recent developments. *RSC Adv.* 13(28): 19335-19355. https://doi.org/10.1039/d3ra01999c

Bayode, AA; Anthony, ET; Ore, OT; Alfred, MO; Koko, DT; Unuabonah, EI; Omorogie, MO (2023). A review on the versatility of Carica papaya seed: An agrogenic waste for the removal of organic, inorganic, and microbial contaminants in water. *J. Chem. Technol. Biotechnol.* 96(1): 2095. https://doi.org/10.1002/jctb.7415

Bhagwat, VR (2019). Safety of water used in food production. In Food Safety and Human Health (pp. 219–247). doi: 10.1016/B978-0-12-816333-7.00009-6

Daud, NM; Abdullah, SRS; Hasan, HA; Othman, AR; Ismail, N (2023). Coagulation-flocculation treatment for batik effluent as a baseline study for the upcoming application of green coagulants/flocculants towards sustainable batik industry. *Heliyon* 9(6): e17284. https://doi.org/10.1016/j.heliyon.2023.e17284

Diver, D; Nhapi, I; Ruziwa, WR (2023). The potential and constraints of replacing conventional chemical coagulants with natural plant extracts in water and wastewater treatment. *Environ. Adv.* 13: 100421. https://doi.org/10.1016/j.envadv.2023.100421

de Jesus, JON; Medeiros, DL; Esquerre, KPO; Sahin, O; de Araujo, WC (2024). Water treatment with aluminum sulfate and tannin-based biocoagulant in an oil refinery: The technical, environmental, and economic performance. *Sustainability* 16: 1191. https://doi.org/10.3390/su16031191

Hamad, HN; Idrus, S (2022). Recent Developments in the Application of Bio-Waste-Derived Adsorbents for the Removal of Methylene Blue from Wastewater: A Review. *Polym. (Basel)* 14(4): 783. https://doi.org/10.3390/polym14040783

Kekes, T; Tzia, C; Kolliopoulos, G (2023). Drinking and natural mineral water: Treatment and quality–safety assurance. *Water* 15(13): 2325. https://doi.org/10.3390/w15132325

Kluczka, J; Zołotajkin, M; Ciba, J; Staroń, M (2017). Assessment of aluminum bioavailability in alum sludge for agricultural utilization. *Environ. Monit. Assess.* 189 (8): 422. https://doi.org/10.1007/s10661-017-6133-x

Koul, B; Bhat, N; Abubakar, M; Mishra, M; Arukha, A P; Yadav, D (2022). Application of natural coagulants in water treatment: A sustainable alternative to chemicals. *Water* 14 (3751). https://doi.org/10.3390/w14223751

Kristianto, H; Kurniawan, M A; Soetedjo, J N M (2018). Utilization of papaya seeds as natural coagulant for synthetic textile coloring agent wastewater treatment. *Int. J. Adv. Sci. Eng. Inf. Technol.* 8 (5): 2071–2077. https://doi.org/10.18517/ijaseit.8.5.3804

Malik, Q H (2018). Performance of alum and assorted coagulants in turbidity removal of muddy water. *Appl. Water Sci.* 8 (2): 40. https://doi.org/10.1007/s13201-018-0662-5

Marguti, A L; Ferreira Filho, S S; Piveli, R P (2018). Full-scale effects of addition of sludge from water treatment stations into processes of sewage treatment by conventional activated sludge. *J. Environ. Manage.* 215: 283–293. https://doi.org/10.1016/j.jenvman.2018.03.024

Nath, A; Pande, P P; Anamica, M (2021). A review of natural polymeric coagulants in wastewater treatment. *Mater. Today: Proc.* 46: 6113–6117.

Pandey, P; Khan, F; Mishra, R; Singh, S K (2020). Elucidation of the potential of *Moringa oleifera* leaves extract as a novel alternate to the chemical coagulant in water treatment process. *Water Environ. Res.* 92 (7): 1051-1056.

Ojo, O M; Obiora-Okeke, O A (2022). Performance evaluation of a solar still for industrial wastewater treatment. *Mater. Today: Proc.* 62 (Supplement 1): S1–S6. https://doi.org/10.1016/j.matpr.2022.02.075

Ojo, O M (2024). Efficiency of *Carica papaya* seeds in the coagulation of moderately turbid wastewater. *Adv. Sci. Technol.* 154: 139–145.

Owodunni, A A; Ismail, S; Kurniawan, S B; Ahmad, A; Imron, M F; Abdullah, S R S (2023). A review on revolutionary technique for phosphate removal in wastewater using green coagulant. *J. Water Process Eng.* 52: 103573. https://doi.org/10.1016/j.jwpe.2023.103573

Panhwar, A; Bhutto, S (2021). Improved reduction of COD, BOD, TSS and oil and grease from sugarcane industry effluent by ferric chloride and polyaluminum chloride coupled with polyvinyl alcohol. *Ecol. Eng. Environ. Technol.* 22: 8–14.

Priya, T; Tarafdar, A; Gupta, B; Mishra, BK (2018). Effect of bioflocculants on the coagulation activity of alum for removal of trihalomethane precursors from low turbid water. *J. Environ. Sci.* 70: 1–10. https://doi.org/10.1016/j.jes.2017.09.019

Rahman Adrin, MHA; Ngadiman, N; Abdullah, NH; Mohd Hamsani, NN; Nasharuddin, N; Omar, NN (2024). Effectiveness of *Carica papaya* dry seed as natural coagulants in wastewater treatment process. *J. Adv. Res. Appl. Mech.* 116 (1): 88–102. https://semarakilmu.com.my/journals/index.php/appl_mech/index

Sharma, A; Sharma, R; Sharma, M; Kumar, M; Barbhai, MD; Lorenzo, JM; Sharma, S; Samota, MK; Atanassova, M; Caruso, G; Naushad, M; Radha; Chandran, D; Prakash, P; Hasan, M; Rais, N; Dey, A; Mahato, D K; Dhumal, S; Singh, S; Senapathy, M; Rajalingam, S; Visvanathan, M; Saleena, L A K; Mekhemar, M (2022). *Carica papaya* L. Leaves: Deciphering its antioxidant bioactives, biological activities, innovative products, and safety aspects. *Oxid. Med. Cell. Longev.* 2022: 2451733. https://doi.org/10.1155/2022/2451733

Sukmana, H; Bellahsen, N; Pantoja, F; Hodur, C (2021). Adsorption and coagulation in wastewater treatment – Review. *Prog. Agric. Eng. Sci.* 17 (1): 49–68. https://doi.org/10.1556/446.2021.00029

Turner, T; Wheeler, R; Stone, A; Oliver, I (2019). Potential alternative reuse pathways for water treatment residuals: Remaining barriers and questions—a review. *Water Air Soil Pollut.* 230 (9): 227. https://doi.org/10.1007/s11270-019-4272-0

UNICEF/WHO (2021). Progress on Household Drinking Water. 2000-2020. Five years into the SDGs. https://data.unicef.org/resources/progress-on-household-drinking-water-sanitation-and-hygiene-2000-2020/

Unnisa, SA; Bi, SZ (2018). *Carica papaya* seeds effectiveness as coagulant and solar disinfection in removal of turbidity and coliforms. *Appl. Water Sci.* 8: 149. https://doi.org/10.1007/s13201-018-0791-x

Vezar, SAN; Belinda, ZT; Rendana, M; Agustina, T E; Nasir, S; Hanum, L; Andarini, D (2024). The use of *Carica papaya* seeds as bio coagulant for laundry wastewater treatment. *J. Eng. Appl. Sci.* 71 (1): 99. https://doi.org/10.1186/s44147-024-00438-2

World Bank (2021). Water Overview: Development news, research, data. https://www.worldbank.org/en/topic/water/overview

World Health Organization (2023). Burden of disease attributable to unsafe drinking-water, sanitation and hygiene. World Health Organization.

Yimer, A; Dame, B (2021). Papaya seed extract as coagulant for potable water treatment in the case of Tulte River for the community of Yekuset district, Ethiopia. *Environ. Chall.* 4: 100198.