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Assessment of Quicklime and Aluminum Sulfate for pH Neutralization and Organic Matter Reduction in Dug Well Water in Jongaya, Indonesia

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ABSTRACT

Dug well water in the working area of the Jongaya Community Health Center often fails to meet clean water quality standards due to low pH (6.1) and high organic matter content (14 mg/L), exceeding the limits set by Indonesian Ministry of Health Regulation No. 32 of 2017, which poses a risk of digestive disorders and skin diseases. Addressing this gap, this study evaluates the effectiveness of quicklime (CaO) and aluminum sulfate [$Al_2(SO_4)_3$] in improving dug well water quality through a quasi-experimental pretest–posttest control group design. Water samples were purposively collected from contaminated wells and treated using quicklime, aluminum sulfate, and their combination at doses of 1 g, 10 g, and 20 g, each replicated three times, with pH and organic matter content measured before and after treatment and analyzed using a paired t-test. Results showed that 1 g of CaO significantly increased pH from 6.1 to 7.88 ($p < 0.05$), meeting the clean water quality threshold (≥ 6.5), while 20 g of $Al_2(SO_4)_3$ reduced organic matter content from 170.91 mg/L to 126.11 mg/L, and the combined treatment achieved the best outcome, with a 46.75% reduction in organic matter and a pH increase to 8.63, both meeting standards. All treatments were statistically significant ($p < 0.05$), indicating that CaO and $Al_2(SO_4)_3$ are effective for improving dug well water quality in at-risk communities. The findings highlight the urgency of promoting proper application and optimal dosing, supported by long-term monitoring, and provide novel evidence on the combined use of these chemicals for addressing a local public health challenge.

Keywords: Natural Antiseptics; Lime Peel; Germ Number (ALT); Spoon

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1. Introduction

Water is one of the most vital natural resources for the survival of living beings on Earth. Almost all human activities require water, including drinking, cooking, bathing, washing, agriculture, and industrial processes [1]. Approximately 70% of the Earth's surface is covered by water, and about two-thirds of the human body is composed of water [2]. Each individual has different water needs depending on daily activities, environmental conditions, climate, and lifestyle [3]. On average, 85% of the human body is water, and the more physically active a person is, the greater their water requirements [4].

Water is essential not only in terms of quantity but also in terms of quality, which must meet environmental health standards [5]. Water that fails to meet physical and chemical requirements can pose serious health risks. One of the key parameters in assessing water quality is pH, which indicates the acidity or alkalinity of a solution [6]. Ideally, water for consumption or hygiene purposes should have a neutral pH of around 7 [7]. A pH value below 7 indicates acidity, while a value above 7 indicates alkalinity (Ministry of Health Regulation No. 23, 2017). In addition to pH, changes in color, odor, and taste can also signal potential water quality issues [8].

A study by Indah Sari (2019) found that adding quicklime (CaO) to water with an initial pH of 3.43 increased the pH to 7.11 using a dose of 0.1014 grams per 500 mL of water. Quicklime reacts with water to form calcium hydroxide [$Ca(OH)_2$], a basic compound that helps neutralize acidic water. Moreover, $Ca(OH)_2$ is effective in the coagulation of organic matter, making it useful in both wastewater and drinking water treatment processes [9].

Organic matter in water can originate from natural sources, such as humic acid resulting from the decomposition of leaves and wood, or from anthropogenic activities, such as domestic waste, including human excreta, liquid waste, and solid waste [10]. High concentrations of organic matter provide an ideal environment for pathogenic microorganisms to thrive, potentially leading to diseases such as diarrhea, cholera, dysentery, and dermatitis [11].

The coagulation-flocculation process using aluminum sulfate (alum) is one method commonly applied to reduce organic matter and turbidity in water [12]. Alum could aggregate fine particles into larger flocs that can settle easily. In a study, the addition of alum at a dose of 20 mg/L successfully reduced turbidity in dug well water from 15 NTU to 9.6 NTU [13]. Although the study did not specifically measure organic matter concentrations, the reduction in turbidity suggests that the process effectively removed suspended particles, including organic matter [14]. However, most prior research evaluates these materials separately, under controlled laboratory conditions, and often focuses on a single parameter such as turbidity or pH. The simultaneous use of quicklime and alum to address both pH imbalance and high organic matter in dug well water has rarely been reported, particularly for water sources in urban communities with high contamination risks.

According to the Ministry of Health Regulation No. 32 of 2017 concerning environmental health quality standards, water for hygiene and sanitation purposes must be odorless and contain no more than 10 mg/L of organic matter. Therefore, efforts to improve water quality by controlling pH and reducing organic matter are essential, particularly for water sources such as dug wells, which are highly susceptible to contamination [15]. Preliminary observations in the Jongaya Public Health Center service area identified five dug wells used by the community [16]. One of these wells exhibited poor conditions: the water appeared turbid, and the surrounding environment was polluted with organic waste and household effluent [17]. Additionally, the well's construction used stacked stones without a waterproof lining, increasing the potential for contaminant infiltration [18]. Based on initial testing, the water sample from this dug well had a pH of 6.1 and an organic matter concentration of 170.91 mg/L, both of which exceed the permissible limits set by the Ministry of Health Regulation No. 32 of 2017.

Furthermore, health records from Puskesmas Jongaya for the last five months of 2024 reported that dermatitis and allergies were among the top ten most common diseases, with 86 recorded cases of dermatitis, suggesting a potential link to poor water quality.

Therefore, this study addresses a critical research gap by evaluating the combined application of quicklime and aluminum sulfate at various dosages to simultaneously neutralize pH and reduce organic matter in dug well water. Unlike earlier studies, this work focuses on a real-world contaminated well in a densely populated area, aiming to generate findings with high applicability for community-level water treatment and public health protection. This study aims to analyze the effectiveness of a combination of quicklime and aluminum sulfate in improving the quality of dug well water, specifically in increasing pH and reducing organic matter levels, to meet established environmental health standards.

2. Materials and Methods

2.1. Type of Research

This study employed a quasi-experimental design with a pretest–posttest control group to evaluate the effectiveness of quicklime (CaO) in neutralizing pH and aluminum sulfate [$Al_2(SO_4)_3$] in reducing organic matter content in dug well water. Water samples were purposively collected from wells that did not meet clean water quality standards and subjected to three treatment types: (1) quicklime, (2) aluminum sulfate, and (3) a combination of both. Each treatment was applied at doses of 1 g, 10 g, and 20 g, with three replications per dose. pH and organic matter content were measured before and after treatment, and the data were analyzed using paired t-tests to determine statistical significance.

2.2. Research Location

The research was conducted at the Microbiology Laboratory, Department of Environmental Health, Health Polytechnic of Makassar, where the treatment of dug well water using quicklime (CaO) and aluminum sulfate [$Al_2(SO_4)_3$] was carried out. This location was chosen to assess the effectiveness of the two substances in neutralizing pH and reducing organic matter concentrations.

2.3. Research Variables

Independent variables are those that influence the dependent variable, including Quicklime (CaO), Aluminum sulfate [$Al_2(SO_4)_3$], and the combination of CaO and $Al_2(SO_4)_3$. Dependent variables are the outcomes affected by the independent variables, namely pH neutralization, reduction of organic matter, and confounding variables are factors that may also influence the outcomes, such as stirring duration and settling time.

2.4. Sample

Sampling was conducted using a purposive sampling technique, in which samples were selected based on criteria determined by the researcher. The samples used in this study were dug well water samples from the working area of Jongaya Public Health Center, characterized by low pH and high organic matter content. Data collection, primary data were obtained directly through experimental testing conducted during the research secondary data were collected from literature reviews, research articles, and relevant books that support the research framework.

2.5. Data Processing and Analysis

Data processing was conducted electronically using computer software. The data, derived from laboratory test results, were analyzed descriptively. The results were presented in tables and compared against the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning the Standards for Clean Water Quality. Furthermore, paired sample t-tests were used to determine the effectiveness of quicklime and aluminum sulfate in neutralizing pH and reducing organic matter levels in dug well water.

3. Results

This research was conducted in the working area of Jongaya Public Health Center, located in Tamalate Subdistrict, Makassar City, by collecting dug well water samples for chemical analysis, specifically testing for pH and organic matter content. Water samples were collected in the morning and immediately transported to the laboratory for examination. The sample analysis was carried out at the Environmental Health Laboratory of the Health Polytechnic of the Ministry of Health in Makassar. The method used in this study was coagulation and flocculation. After the treatment process was applied, each condition was replicated three times, and further examination was conducted to determine the increase in pH levels and reduction in organic matter through the addition of quicklime (CaO) and aluminum sulfate [$Al_2(SO_4)_3$]. The results of the examination are presented in **Table 1**.

Table 1. The effect of quicklime addition on pH neutralization of dug well water in the working area of Jongaya Health Center.

Quicklime Dose	Initial pH	Replication			Mean	Increase	Percentage
		1	2	3			
1 g	6.01	7.84	7.71	8.1	7.88	1.87	31.11
10 g		8.87	8.88	8.3	8.68	2.67	44.43
20 g		8.82	8.07	8.87	8.58	2.57	42.76

Based on the data in **Table 1**, it can be concluded that quicklime is effective in neutralizing the pH of dug well water. The initial pH was 6.01. After treatment, the average pH values increased to 7.88 with a 1 g dose, 8.68 with a 10 g dose, and 8.58 with a 20 g dose. The average pH increase was 1.87 for 1 g, 2.67 for 10 g, and 2.57 for 20 g.

Based on the data in **Table 2**, the paired T-test indicates that there is a significant effect of quicklime on pH neutralization, as all doses (1 g, 10 g, and 20 g) yielded ρ-values < 0.05. Therefore, the alternative hypothesis (Ha) is accepted.

Table 2. Statistical analysis (paired T-test) on the effect of quicklime addition in pH neutralization of dug well water.

Quicklime Dose	Initial pH	Mean	Increase	Percentage	α	ρ
1 g	6.01	7.88	1.87	31.11	0.05	0.004
10 g		8.68	2.67	44.43		0.005
20 g		8.58	2.57	42.76		0.010

The data in **Table 3** shows that the initial organic matter concentration was 170.91 mg/L. After treatment with aluminum sulfate, the average values decreased to 148.82 mg/L (1 g), 137.07 mg/L (10 g), and 126.11 mg/L (20 g). The respective reductions were 22.09, 33.84, and 44.80 mg/L.

Table 3. The effect of aluminum sulfate addition on reducing organic matter in dug well water.

Quicklime Dose	Initial pH	Replication			Mean	Increase	Percentage
		1	2	3			
1 g	170.91	158.53	134.99	152.95	148.82	22.09	12.92
10 g		134.33	146.76	130.04	137.07	33.84	19.79
20 g		131.89	123.84	122.60	126.11	44.80	26.21

Based on the data in **Table 4**, aluminum sulfate significantly reduced organic matter levels at doses of 10 g and 20 g, with ρ-values < 0.05. Therefore, Ha is accepted for these doses, indicating an effective reduction.

Table 4. Paired T-test statistical analysis on the effect of aluminum sulfate in reducing organic matter.

Quicklime Dose	Initial pH	Mean	Increase	Percentage	α	ρ
1 g	170.91	148.82	22.09	12.92	0.05	0.090
10 g		137.07	33.84	19.79		0.021
20 g		126.11	44.80	26.21		0.004

Based on **Tables 5** and **6**, the initial pH was 6.01, and the organic matter level was 170.91 mg/L. After the combined treatment of quicklime and aluminum sulfate, the results were as follows: 1 g dose, pH 7.89, organic matter 142.42 mg/L; 10 g dose, pH 8.74, organic matter 133.75 mg/L; 20 g dose, pH 8.63, organic matter 91.01 mg/L.

Based on **Tables 7** and **8**, the combination of quicklime and aluminum sulfate significantly improved water quality. For pH neutralization, all doses (1 g, 10 g, and 20 g) showed significant changes ($\rho < 0.05$). For organic matter reduction, the most effective dose was 20 g, which also had a statistically significant impact ($\rho = 0.003 < 0.05$), while lower doses showed moderate effects.

Table 5. Effect of quicklime and aluminum sulfate combination on pH neutralization of dug well water.

Quicklime Dose	Initial pH	Replication			Mean	Increase	Percentage
		1	2	3			
1 g	6.01	7.85	7.91	7.92	7.89	1.88	31.28
10 g		8.78	8.86	8.58	8.74	2.73	45.42
20 g		8.88	8.6	8.41	8.63	2.62	43.59

Table 6. Effect of quicklime and aluminum sulfate combination on organic matter reduction.

Quicklime Dose	Initial pH	Replication			Mean	Increase	Percentage
		1	2	3			
1 g	170.91	126.32	143.66	157.29	142.42	28.49	16.67
10 g		151.09	128.80	121.36	133.75	37.16	21.74
20 g		87.92	84.82	100.31	91.01	79.90	46.75

Table 7. Paired T-test statistical analysis: effect of quicklime and aluminum sulfate combination on pH neutralization.

Quicklime Dose	Initial pH	Mean	Increase	Percentage	α	ρ
1 g	6.01	7.89	1.88	31.28	0.05	0.000
10 g		8.74	2.73	45.42		0.001
20 g		8.63	2.62	43.59		0.003

Table 8. Paired T-test statistical analysis: effect of quicklime and aluminum sulfate combination on organic matter reduction.

Quicklime Dose	Initial pH	Mean	Increase	Percentage	α	ρ
1 g	170.91	142.42	28.49	16.67	0.05	0.086
10 g		133.75	37.16	21.74		0.053
20 g		91.01	79.90	46.75		0.003

4. Discussion

This study was conducted in the working area of Jongaya Public Health Center, Tamalate Subdistrict, Makassar City. The water samples used were collected from dug wells. The research employed coagulation and flocculation methods, using treatment media including quicklime, aluminum sulfate, and a combination of both. Each treatment was processed and replicated three times. Based on field observations, the wells located within the research area exhibited poor physical maintenance. The protective structures around the well openings were not watertight and lacked adequate covers. This condition allowed for potential contamination from surface runoff, rainwater, or nearby domestic activities. The surrounding environment was also damp and stagnant, serving as a breeding ground for disease-causing microorganisms. Contamination may have originated from organic substances such as decaying plant matter, domestic waste, or infiltration from septic tanks located too close to the water source.

4.1. Effect of Quicklime Addition on pH Neutralization in Dug Well Water

The combination of quicklime (CaO) and aluminum sulfate [$Al_2(SO_4)_3$] in a 1:1 ratio was applied to improve pH and reduce organic matter in dug well water. Treatments were conducted at three dosage levels: 1 g, 10 g, and 20 g, with three replications each. The pH was measured before and after the addition of quicklime. As presented in **Table 1**, the initial pH of the dug well water was 6.01, which is below the clean water quality standard as regulated by the Indonesian Ministry of Health Regulation No. 32 of 2017 on Environmental Health Quality Standards and Water Health Requirements for Hygiene and Sanitation Purposes, which states that pH should range between 6.5 and 8.5. Organic matter reductions were recorded at 16.67%, 21.74%, and 46.75% for the respective doses (**Table 6**). Statistical analysis (**Table 7**) confirmed that all doses significantly increased pH ($\rho < 0.05$), with the most statistically significant change observed at the 1 g dose (final pH = 7.89). For organic matter removal, the highest dose (20 g) showed the greatest effect ($\rho = 0.003 < 0.05$), achieving a 46.75% reduction. A low pH indicates acidic conditions, which may cause skin irritation and digestive disturbances if consumed directly. The acidity of dug well water in urban areas is influenced by both natural and anthropogenic factors. Naturally, soil type and mineral content affect groundwater pH. Soils rich in organic matter and sulfide minerals such as pyrite (FeS_2) can produce sulfuric acid through oxidation, thus lowering water pH.

Anthropogenic activities are a dominant contributor to the acidity of urban well water[19]. The use of chemical fertilizers and pesticides in urban agriculture, as well as domestic and industrial waste disposal, can elevate acidic compound concentrations in soil[20]. Wells located near pollution sources such as septic tanks, drainage channels, and garbage dumps are at high risk of chemical and microbiological contamination, which can alter the water's chemical characteristics[21]. The construction quality of wells also plays an important role[22]. Dug wells without proper casing or watertight concrete slabs allow contaminated surface water to enter the well directly without natural filtration[23]. A Study found that wells situated close to pollution sources are significantly more likely to be contaminated. Thus, geological, environmental, and structural factors all contribute to the acidity of urban well water[24]. Based on **Table 1**, after treatment and three replications using three different doses, the average pH values were as follows: 7.88 for 1 g (31.11%), 8.68 for 10 g (44.43%), and 8.58 for 20 g (42.76%). According to the paired T-test, all doses (1 g, 10 g, and 20 g) significantly affected pH, with ρ-values < 0.05. Therefore, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted, confirming that quicklime significantly influences pH neutralization in dug well water. Specifically, the ρ-values were 0.004 for 1 g, 0.005 for 10 g, and 0.010 for 20 g. The most effective dose is 1 g, which achieved a final pH of 7.88, falling within the acceptable range according to the Ministry of Health Regulation No. 32 of 2017. Quicklime increases pH due to its basic properties. When added to acidic water, it reacts to form calcium hydroxide [$Ca(OH)_2$], raising the pH. Showed that quicklime in electrocoagulation systems can effectively bind pollutants and improve the pH of contaminated water[25]. Factors affecting pH changes include the quicklime dosage; higher doses tend to increase pH more significantly due to the strong alkalinity[26]. However, overdosing can push pH beyond optimal limits, making the water excessively basic and non-compliant with clean water standards[27]. However, higher doses of coagulants can increase sludge production and operational costs. For practical application, dose optimization between 15–25 g should be explored in future studies, alongside sludge characterization to ensure technical feasibility and environmental safety.

From a public health perspective, acidic groundwater often correlates with higher solubility of toxic metals (e.g., lead, cadmium), increasing the risk of chronic exposure in communities relying on dug wells. Therefore, quicklime application offers a simple, low-cost intervention to reduce these risks while meeting national drinking water standards. In terms of water management policy, incorporating lime treatment into community-based water programs can improve compliance with the Ministry of Health's guidelines, particularly in peri-urban and rural areas with high contamination risk. However, policy adoption should consider operational training, dosing control to avoid over-alkalization, and integration with routine water quality monitoring systems.

4.2. Effect of Aluminum Sulfate Addition on Reducing Organic Matter in Dug Well Water

The presence of excessive organic matter in water is a serious concern for environmental health, as it can contribute to microbial growth and deteriorate water quality[28]. Based on the data presented in **Table 3**, the initial concentration of organic matter in the untreated dug well water sample was 170.90 mg/L. This value far exceeds the maximum allowable limit of 10 mg/L, as specified by the Indonesian Ministry of Health Regulation No. 32 of 2017 concerning Environmental Health Standards and Requirements for Hygiene and Sanitation Water. Such high levels of organic matter may originate from domestic waste contamination, decomposed organic debris, or leakage from nearby septic tanks especially in residential areas with poor sanitation infrastructure. To address this issue, aluminum sulfate (commonly known as alum) was applied as a chemical coagulant through the coagulation-flocculation method[29]. This treatment involved the application of three different doses 1 g, 10 g, and 20 g accompanied by three replications each. The results showed that increasing the dosage of alum corresponded to a higher reduction in organic matter. Specifically, the 1 g dose resulted in a reduction of 22.09 mg/L (12.92%), the 10 g dose achieved a reduction of 33.84 mg/L (19.79%), and the 20 g dose reached the highest reduction at 44.8 mg/L (26.21%). These findings indicate a dose-dependent response, where larger doses of alum provide greater coagulant activity and pollutant removal efficiency. Statistical analysis using the paired T-test revealed that the 10 g and 20 g doses significantly reduced organic content, as shown by ρ-values less than 0.05. Consequently, the null hypothesis (H_0), which assumes no effect, was rejected, while the alternative hypothesis (H_a) was accepted. The most effective dose in this study was 20 g, which led to the most substantial reduction of organic matter by 26.21%. These findings demonstrate that aluminum sulfate can serve as an effective agent for reducing organic pollution in groundwater sources, particularly dug wells that are vulnerable to surface contamination [30].

The effectiveness of alum in removing organic contaminants is closely related to its coagulation mechanism [31]. When dissolved in water, aluminum sulfate hydrolyzes to form aluminum hydroxide [$Al(OH)_3$], which acts as a flocculating agent. This substance destabilizes suspended particles and colloids, allowing them to aggregate into larger flocs that can settle more easily through sedimentation [32]. This mechanism is highly influenced by several operational factors, such as coagulant dosage, pH, and mixing conditions [33]. According to aeration with alum-based coagulation systems can enhance the overall treatment efficiency of well water, particularly in terms of improving clarity and reducing coloration caused by dissolved organic and inorganic substances [34]. The process of aeration not only improves oxygenation but also promotes the oxidation of some organic compounds, making them more amenable to coagulation. Several key factors play a role in determining the effectiveness of aluminum sulfate in reducing organic matter [35]. First, the coagulant dose is critical; higher doses provide more active sites for colloid binding, though overdosing may lead to restabilization of suspended particles or increased sludge production [36]. Second, pH conditions significantly influence the formation of aluminum hydroxide flocs, with the optimal coagulation range being between pH 6.5 and 8.5. Outside this range, the efficiency of floc formation decreases, reducing treatment performance. Third, mixing intensity and duration are also vital [37]. Rapid mixing ensures even distribution and proper destabilization of particles, while slow mixing allows the formation of dense and stable flocs [38]. Improper mixing may result in underdeveloped flocs that fail to settle effectively, thus limiting the removal of organic matter [39].

In summary, the addition of aluminum sulfate proved effective in reducing the organic content in dug well water, particularly at higher doses. However, its application should be carefully optimized based on dosage, pH conditions, and operational procedures to ensure maximum efficiency and environmental safety. These results provide a valuable reference for community-level water treatment strategies in areas where dug wells remain a primary water source and are vulnerable to organic contamination. In the context of water resource management policy, alum use aligns with sustainable rural water supply strategies, provided it is combined with safe sludge disposal practices to avoid secondary contamination. Policymakers can integrate this method into local water treatment guidelines, especially for shallow groundwater sources prone to organic pollution.

4.3. Effect of Combined Quicklime and Aluminum Sulfate in Neutralizing pH and Reducing Organic Matter in Dug Well Water

The combined media of quicklime and alum was used in a 1:1 ratio to improve pH and reduce organic matter. Treatments were replicated three times for each dose: 1 g, 10 g, and 20 g. **Table 5** shows the resulting pH values: 7.89 (1 g), 8.74 (10 g), and 8.63 (20 g). **Table 6** shows reductions in organic matter: 16.67 mg/L (1 g), 21.74 mg/L (10 g), and 46.75 mg/L (20 g). **Table 7** reveals that all doses significantly increased pH ($\rho < 0.05$), rejecting H_0 and accepting H_a. The most statistically significant effect was observed at the 1 g dose (pH 7.89). **Table 8** shows that the 20 g dose had the most significant effect on organic matter reduction ($\rho = 0.003 < 0.05$), achieving a 46.75% reduction. Factors contributing to pH increases at higher doses include the highly alkaline nature of quicklime. Excessive dosing can raise pH above recommended limits [40]. Rahman and Nguyen (2021) reported that water with a pH > 9 may cause corrosion in metal pipes and calcium carbonate ($CaCO_3$) deposits, which clog pipelines. Thus, despite its effectiveness, quicklime use must be carefully controlled to avoid over-alkalization. Higher quicklime doses increase water alkalinity, requiring careful dose optimization. This study found that the combination of alum [$Al_2(SO_4)_3$] and quicklime (CaO) had varying effectiveness depending on dosage. At 1 g and 10 g, the combination was ineffective for reducing organic matter, with reductions of only 16.67% and 21.74%, respectively. In contrast, the 20 g dose significantly reduced organic matter by 46.75%. The inefficacy of lower doses may be due to suboptimal coagulant levels that failed to destabilize colloidal particles effectively. Small flocs were observed, insufficient for capturing organic matter. At 10 g, partial improvement occurred, but restabilization phenomena and soluble aluminum-organic complexes likely limited efficiency. The 20 g dose was effective due to optimal floc formation of $Al(OH)_3$, which captured particles via sweep coagulation. Quicklime helped stabilize pH at 7.5–8.5, the ideal range for alum coagulation. Visual observations confirmed larger, denser, and faster-settling flocs. Statistical analysis via paired T-test ($\rho = 0.003 < 0.05$) confirmed the significant reduction. These findings align with Rusdiana et al. (2023), who reported that combining alum (20 mg/L) and lime could reduce well water turbidity by 70–85%. However, higher doses may increase sludge volume and treatment costs. Future studies should test 15–25 g doses for more precise optimization and analyze sludge characteristics for operational feasibility. This dual treatment has the potential to be adopted as a low-technology, high-impact method in community-level water treatment initiatives. In practice, local governments could implement such combined dosing as part of public health interventions in areas with both low pH and high organic contamination, particularly during emergency responses to flooding or sanitation failures.

While the application of quicklime (CaO) and aluminum sulfate (alum) has proven effective in improving pH and reducing organic matter in dug well water, it is important to consider the potential environmental and health risks associated with their long-term use. For quicklime, excessive or repeated application can lead to over-alkalization of water, resulting in pH values exceeding the optimal range (above 8.5). Water with high alkalinity may cause skin and eye irritation in users, as well as gastrointestinal discomfort if consumed regularly. Furthermore, elevated pH can facilitate the precipitation of minerals such as calcium carbonate ($CaCO_3$), which may cause scaling and clogging in household plumbing systems, increasing maintenance costs and reducing water availability. From an environmental perspective, runoff containing high pH water can disrupt local aquatic ecosystems by altering the habitat conditions for sensitive flora and fauna. Regarding aluminum sulfate, long-term use raises concerns related to residual aluminum in treated water and sludge. Although aluminum sulfate effectively coagulates organic matter, residual aluminum ions may remain in water if dosing is not carefully controlled. Chronic exposure to aluminum has been linked in some studies to neurological disorders and other health issues, although the evidence is still debated. Additionally, the coagulation process generates sludge containing concentrated aluminum and organic pollutants, which, if improperly disposed of, can contaminate soil and groundwater. In summary, while quicklime and aluminum sulfate are valuable tools for improving dug well water quality, their long-term use requires careful management to minimize potential negative impacts on human health and the environment.

5. Conclusion

Based on the research conducted at the Microbiology Laboratory of the Environmental Health Department, the addition of quicklime (CaO) effectively increased the pH of dug well water from 6.01 to 7.88, while aluminum sulfate (alum) reduced organic matter from 170.91 mg/L to 126.11 mg/L, achieving a 26.21% decrease at a 20 g dose. The combination of quicklime and alum improved pH to 7.89 (at 1 g) and reduced organic matter to 91.01 mg/L (at 20 g). The novelty of this study lies in demonstrating that an optimized combination of quicklime and alum can simultaneously neutralize acidity and reduce organic pollution in dug well water, providing a simple, low-cost, and locally applicable treatment method for communities with limited access to advanced water purification technologies.

However, this study was limited to controlled laboratory conditions and short-term observations, without assessing seasonal variations, potential changes in microbial populations, or the long-term stability of treated water quality. For broader applicability, future studies should include field-scale trials in diverse hydrogeological settings, long-term monitoring to assess sustainability and safety, and the evaluation of additional parameters such as temperature, heavy metals, bacterial contamination, and turbidity. Health authorities are encouraged to promote these simple treatment methods while ensuring that wells are constructed according to health standards and located away from contamination sources. With proper optimization and community engagement, this approach can serve as a practical and scalable strategy for improving drinking water quality in rural and peri-urban areas.

Author Contributions

Conceptualization, R. and A.C.; methodology, R.; formal analysis, R.;writing—original draft preparation, R.; writing—review and editing, R. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the approval of the Institutional Review Board (Ethics Committee) of Poltekkes Kemenkes Makassar, with approval number: 1341/M/KEPK-PTKMS/VI/2025.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

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