

Gema Lingkungan Kesehatan

Vol. 23, No. 4 (2025), pp 574-581

e-ISSN 2407-8948 p-ISSN 16933761

doi: <https://doi.org/10.36568/gelinkes.v23i4.205>Journal Homepage: <https://gelinkes.poltekkesdepkes-sby.ac.id/>

Effectiveness of Cascade Aerator Overflow System in Reducing Fe Levels in Excavated Well Water

Hani Ramadhani, Zulfikar Ali As*, Muhammad Pahrudin, Junaidi

¹ Department of Environmental Health Polytechnic of the Ministry of Health Banjarmasin, Indonesia*Correspondence: rejhaanshary@gmail.com

Water is an essential resource that profoundly influences the quality of human life. In Indonesia, approximately 73.03% of the population continues to depend on water sourced from protected dug wells for their daily needs. This is particularly evident in Tambak Baru Ilir Village, located in Banjar Regency, South Kalimantan, where residents rely on dug well water as their primary source of potable water. However, the concentration of iron (Fe) in this water source often exceeds the acceptable threshold for drinking water quality, which is set at 0.2 mg/L, presenting a significant public health concern in the region. The objective of this study is to assess the efficacy of the Cascade Aerator overflow system in mitigating Fe levels in dug well water. The research employed a purely experimental design utilizing a Pretest-Posttest Control Group framework, incorporating seven variations of aeration contact time ranging from 0 to 60 minutes. Measurements of Fe concentration, pH, and temperature were conducted, and the data were subjected to linear regression analysis. The findings revealed a substantial reduction in Fe levels, decreasing from 1.125 mg/L to 0.385 mg/L at a 60-minute contact duration, which corresponds to an efficiency reduction of 63%. Concurrently, the pH value increased from 6.3 to 7.8, and the temperature remained within acceptable limits. Regression analysis indicated a strong correlation between contact time and the reduction of Fe levels, with an R^2 value of 93.4%. Although the final Fe concentration did not meet established quality standards, the Cascade Aerator system demonstrates potential as a viable technology for the treatment of well water. Further advancements, such as the integration of filtration units or extending the contact time beyond 75 minutes, are recommended to enhance the effectiveness of this treatment method.

Keywords: Iron content, Dug wells, Aeration, Cascade aerator, Overflow systems

INTRODUCTION

Water is an essential resource that plays a pivotal role in human life. Prior to consumption, it is imperative that water is confirmed to be safe, readily accessible, and devoid of contaminants that may pose health risks. The presence of pollutants in water, including heavy metals, can significantly jeopardize both human health and aquatic ecosystems (Hama Aziz et al., 2023; Saravanan et al., 2024; Sharma et al., 2025). A prevalent issue often encountered in groundwater sources, particularly in dug wells, is the elevated concentration of iron (Fe), which can impart a fishy odor and a yellowish hue to the water due to oxidation. Long-term consumption of such contaminated water may lead to detrimental effects on the digestive system, liver, and other vital organs (Aini et al., 2022; I. Rahman et al., 2024).

According to data from the Badan Pusat Statistik, approximately 73.03% of the Indonesian population depends on water sourced from protected dug wells to meet their daily clean water needs (Kusumawiranti, 2022). In South Kalimantan, a significant 8.87% of the population

utilizes dug well water (Badan Pusat Statistik Indonesia, 2023). The widespread reliance on dug well water in this region is closely associated with the geological characteristics and soil composition prevalent in lowland and swamp areas, which substantially impact groundwater quality. This geological configuration facilitates the dissolution of minerals, including iron, into the groundwater (Zulya et al., 2022).

One of the regions affected by water quality issues is Tambak Baru Ilir Village, located in Banjar Regency, South Kalimantan. The village is home to 732 residents, the majority of whom rely on water sourced from Pamsimas and dug wells as their primary means of access to clean water (BPS Kab. Banjar, 2023). A field survey revealed that one of the dug wells exhibited an iron (Fe) concentration of 4 mg/L, significantly exceeding the clean water quality standard established by the Indonesian Minister of Health Regulation No. 2 of 2023, which mandates a maximum of 0.2 mg/L (Kemenkes RI, 2023). The physical characteristics of the water are concerning, as it is characterized by a yellowish hue, a rusty odor, and the

presence of crusting within the reservoir; these factors pose potential health risks, including skin disorders and discoloration of textiles (Mangarengi et al., 2022; Sari & Yulis, 2021).

These conditions are analogous to those observed in other swampy regions of South Kalimantan, including Tumbang Rungan Village in South Barito Regency, which demonstrates elevated levels of iron (Fe) as a result of acidic soil and the influence of river water tides (Jayalath et al., 2021; Santoso et al., 2024). The dissolution of iron in groundwater typically transpires through the infiltration of rainwater, which transports ferrooxide compounds and subsequently forms soluble compounds such as ferrohdrogen carbonate during the diffusion process (H. Guo et al., 2023; Yin et al., 2025).

One commonly employed method for the reduction of iron levels in water is aeration, which involves the introduction of oxygen to oxidize Fe^{2+} to Fe^{3+} , subsequently precipitating it as $\text{Fe}(\text{OH})_3$ (Cordeiro et al., 2025). The aeration process is also effective in diminishing undesirable gaseous substances, including CO_2 , CH_4 , and H_2S , while concurrently elevating the pH of the water (Yang et al., 2023; Zhao et al., 2025). Various types of aerators are utilized, including bubble aerators, aerator trays, and cascade aerators (Agustian et al., 2023). The cascade aerator is particularly advantageous due to its ability to enhance water and air contact in stages, demonstrating a reduction in iron levels of up to 87.30% in multiple studies (Diansari et al., 2022; Priyono et al., 2022). Nevertheless, the effectiveness of this method is significantly influenced by the design of the apparatus, variations in contact time, and environmental parameters such as pH and temperature (Asmawati et al., 2022).

Although the aeration method has been established as effective in reducing metal concentrations in water (Bryant et al., 2024), there has yet to be a comprehensive study that specifically evaluates the efficacy of the Cascade Aerator system with an overflow mechanism on iron (Fe) levels in dug well water, particularly in the swampy regions of South Kalimantan. Furthermore, the systematic investigation of the relationship between variations in contact time and the efficiency of Fe level reduction has not been conducted using a statistical framework. This is significant, as the overflow system facilitates water recirculation, thus enhancing the oxidation efficiency of dissolved iron; however, its actual effectiveness remains largely unexamined (Nayak et al., 2025; van de Griend et al., 2022).

This study aims to evaluate the effectiveness of the Cascade Aerator overflow system in reducing iron (Fe) levels in dug well water under varying contact times. Additionally, the study seeks to analyze the relationship between contact time and the efficiency of Fe level reduction through regression analysis. The findings of this research are anticipated to contribute to the development of adaptive and efficient water treatment systems in inundated regions.

METHOD

This study utilizes a rigorous experimental design characterized by a Pretest-Posttest Control Group framework. This design incorporates initial measurements (prior to treatment) and final measurements (subsequent to treatment) to assess changes resulting from the interventions. The study examines independent variables in the form of Cascade Aerator treatment of overflow systems, varying by contact time, alongside dependent variables represented by reduced iron (Fe) levels in dug well water. Additionally, extraneous variables, specifically temperature and pH, are monitored. Data analysis is conducted through a quantitative statistical approach. Measurements of Fe levels are analyzed using linear regression tests to ascertain the relationship between contact time and the reduction of Fe levels. Furthermore, the efficiency of reduction is computed using the formula: $\text{efficiency (\%)} = [(\text{initial rate} - \text{final rate}) / \text{initial rate}] \times 100$. Temperature and pH data are subjected to comparative descriptive analysis to evaluate changes before and after treatment. Significance testing is performed using statistical software, adhering to a 95% confidence level ($\alpha = 0.05$). The study incorporates seven treatment groups, each exhibiting varying contact times of 0 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, and 60 minutes, including both control and treatment groups. Each group undergoes three trials, culminating in a total of 42 samples.

The instrument utilized in this study is the Cascade Aerator overflow system, which is engineered to mimic a multi-tiered staircase configuration to enhance aeration efficiency. This system comprises multiple vertically arranged and interconnected storage containers, facilitating the gradual flow of water from one container to another via an overflow mechanism, supported by a circulation pump. The principal materials constituting the instrument include wooden frames, PVC pipes, hoses, faucets, and various plastic containers, which function as a medium for shelter. Comprehensive diagrams and configurations of the instrument are illustrated in Figure 1.

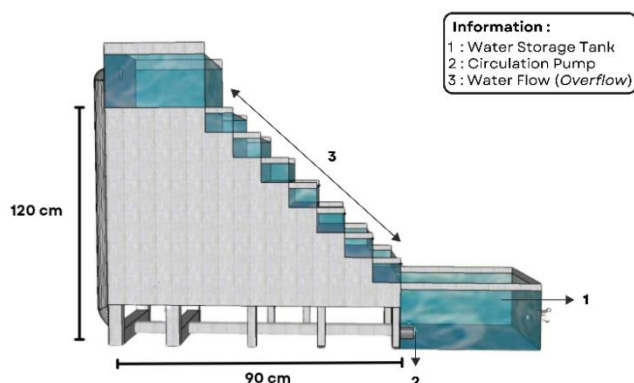


Figure 1. Design of *Cascade Aerator overflow system*

In addition to the design of the Cascade Aerator overflow system, this study employs a range of instruments to accurately measure water quality parameters. Iron (Fe) concentrations were quantified

using a spectrophotometer through the phenanthroline method, a colorimetric technique that generates a reddish-orange complex, the intensity of which correlates with the concentration of Fe²⁺ in the sample. This method is recognized for its high sensitivity and is widely utilized in water quality assessments. Concurrently, the pH and temperature of the water were measured using the KRISBOW brand pH and Temperature Tester, a portable digital device engineered for rapid and precise field readings. This instrument features an LCD display and is capable of measuring pH with a resolution of 0.01 and temperature with an accuracy of ±1°C. The utilization of this device facilitates real-time monitoring of water conditions throughout the aeration process. All measurements were conducted at each point of contact time to assess variations in water quality parameters during the aeration process with the Cascade Aerator, thereby providing a comprehensive evaluation of the system's efficacy in reducing Fe levels and stabilizing pH.

The operational procedure of this apparatus commences with a pumping machine that facilitates the drainage of water from the container via a pipeline to the Cascade Aerator device. Subsequently, the water sample undergoes aeration through the Cascade Aerator, which is configured to a height of 10 cm, and this process is repeated eight times. After aeration, the water is returned to the container and re-circulated through the Cascade Aerator in accordance with the predetermined variations in contact time.

To evaluate the effectiveness of the Cascade Aerator overflow system tool across different treatments, the collected data will subsequently be compared with current regulations pertaining to clean water quality. Additionally, to analyze the impact of variations in contact time on the reduction of iron (Fe) levels, a regression analysis will be conducted on samples of dug healthy water for each treatment.

RESULT AND DISCUSSION

Research and Discussion Results

Iron (Fe) levels were analyzed in the control group using raw water that had been allowed to stand for a predetermined duration. The results of the Fe level analysis for this group are presented in Table 1.

Table 1. Analysis of Iron Level Results in the Control Group

Repetition	Contact Time Variation (minutes)							Quality Standards
	0	10	20	30	40	50	60	
1.	1.154	1.138	1.126	1.110	1.094	1.078	1.062	0.2 mg/L
2.	1.082	1.074	1.062	1.042	1.026	1.014	1.006	
3.	1.142	1.130	1.114	1.086	1.066	1.042	1.022	
Average	1.126	1.114	1.101	1.079	1.062	1.044	1.030	

Measurements of iron (Fe) levels in the control group indicated a gradual decline as contact time increased, despite the absence of active aeration treatment. The average initial Fe concentration of 1,126 mg/L decreased to 1,030 mg/L after 60 minutes. This reduction may be attributed to the natural oxidation processes occurring in stagnant water; however, the magnitude of the decrease is relatively modest and remains significantly above the clean water quality standard of 0.2 mg/L. This finding suggests that without active intervention, iron levels in dug well water cannot be effectively diminished.

In the treatment group, aeration was implemented using a Cascade Aerator overflow system, with variations in contact times. The outcomes of iron level measurements post-treatment are presented in Table 2.

Table 2. Results of Iron Level Analysis in the Treatment Group

Repetition	Cascade Aerator Contact Time Variation Overflow System (minute)							Quality Standards
	0	10	20	30	40	50	60	
1	1.154	0.973	0.897	0.740	0.644	0.431	0.366	0.2 mg/L
2	1.078	0.929	0.764	0.672	0.535	0.459	0.342	
3	1.142	1.006	0.917	0.817	0.684	0.592	0.447	
Average	1.125	0.969	0.860	0.734	0.621	0.494	0.385	

In the treatment group, there was a notable reduction in iron (Fe) levels. The mean initial Fe concentration of 1.125 mg/L decreased to 0.385 mg/L following 60 minutes of aeration utilizing the Cascade Aerator overflow system. The most substantial decrease was observed during the 50–60-minute interval, indicating that the aeration process becomes progressively more effective with prolonged contact time. Nevertheless, this final concentration remains above the permissible limit for drinking water as stipulated by the Indonesian Minister of

Health, which establishes a maximum allowable Fe level of 0.2 mg/L.

Furthermore, to evaluate the efficacy of Fe level reduction between the control and treatment groups, the data are presented in Figure 2.

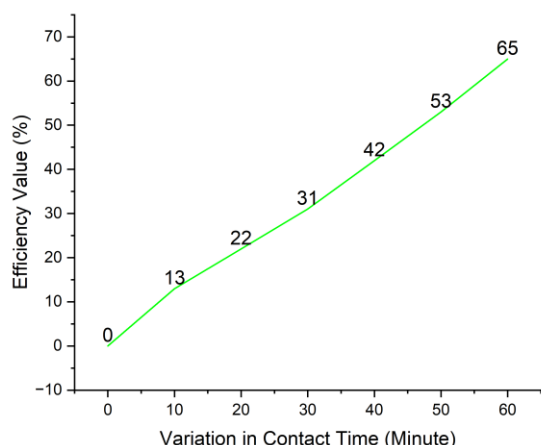


Figure 2. Efficacy of Reducing Ferritin Levels Pre- and Post-Treatment

The efficiency of reducing iron levels in the treatment group exhibited a progressive increase, rising from 13.9% at a 10-minute contact time to 63% at 60 minutes. In contrast, the efficiency observed in the control group remained consistently low, remaining below 9% even after 60 minutes. These findings underscore the necessity of active aeration interventions to achieve a significant reduction in iron levels.

Temperature fluctuations were also observed during the process in both groups. The mean temperature variation is illustrated in Figure 3.

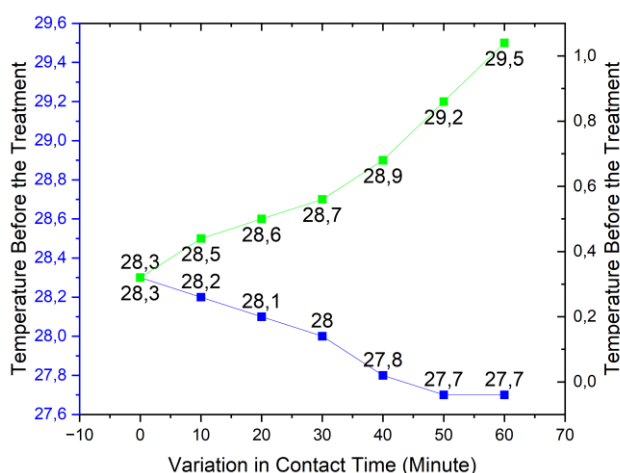


Figure 3. Average Temperature Reduction Pre- and Post-Treatment

The mean water temperature exhibited an increase in both experimental groups, with a notably greater elevation observed in the treatment group. The initial temperature, approximately 27.6°C, rose to 29.5°C by the 60th minute. Despite this increase, the resultant temperature remains within the permitted tolerance limit of $\pm 3^{\circ}\text{C}$ relative to the air temperature (28.6°C), as delineated in the provisions of clean water quality standards. This temperature elevation is hypothesized to

result from the circulation and aeration of water, which facilitates its exposure to ambient air.

In addition to temperature, pH values were measured both prior to and following treatment. The results detailing the observed changes in pH are presented in Figure 4.

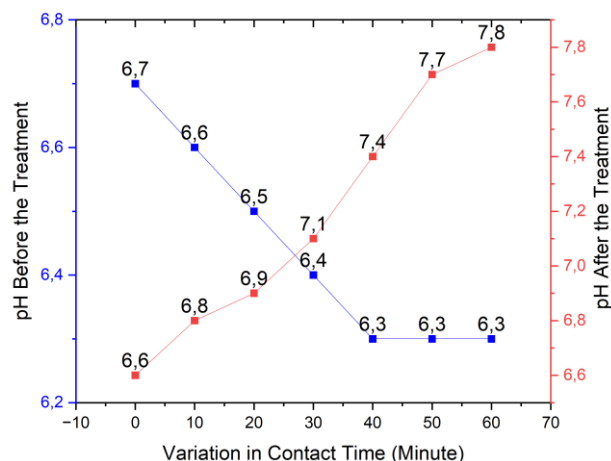


Figure 4. Average pH Reduction Pre- and Post-Treatment

The pH value in the treatment group increased from 6.3 to 7.8, while the control group exhibited a minor increase, reaching only 6.5. This elevation in pH suggests that the aeration process plays a significant role in reducing CO_2 levels in the water, consequently facilitating an increase in pH. Neutral to slightly alkaline pH conditions are conducive to the oxidation of dissolved iron and enhance its deposition.

The relationship between contact time and the reduction of Fe levels was examined through regression analyses. The findings of this analysis are presented in Table 3.

Table 3. Regression Analysis Test

ANOVA ^a					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1.942	1	1.942	129.137	.000 ^b
Residual	.601	40	.015		
Total	2.543	41			

The results of the regression analysis indicated a highly significant relationship between the contact time of aeration and the reduction in iron (Fe) levels, with a significance value (p) of less than 0.001 and a coefficient of determination (R^2) of 93.4%. The quadratic regression graph (Figure 5) illustrates a pronounced decreasing curve, suggesting that Fe levels are likely to achieve compliance with quality standards only if the contact time is extended to approximately 75 minutes. These findings

imply that the duration of aeration is a critical factor influencing the efficacy of treatment systems.

The relationship between contact time and decreased iron levels is illustrated through a regression graph presented in Figure 5.

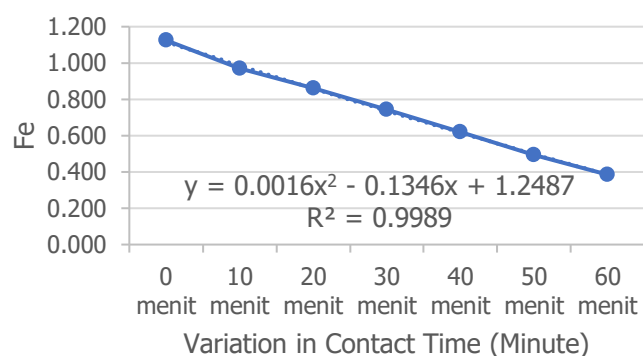


Figure 5. Graph of the Quadratic Regression Equation

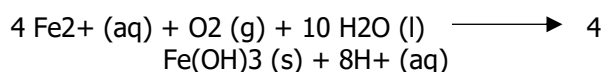
The findings of this study indicate that the implementation of the Cascade Aerator overflow system can lead to a substantial reduction in the concentration of iron (Fe) in dug well water. The average initial Fe concentration was recorded at 1.125 mg/L, which decreased to 0.385 mg/L after a duration of 60 minutes of aeration, resulting in a reduction efficiency of 63%. Although this reduction does not meet the clean water quality standards established by the Indonesian Minister of Health Regulation No. 2 of 2023 (maximum allowable concentration of 0.2 mg/L), these results suggest that the aeration process utilizing this system possesses significant potential for improving water quality.

Several factors may contribute to a decrease in iron (Fe) levels that fail to meet quality standards. First, a contact time of 60 minutes may be insufficient to complete the oxidation reaction and the deposition of Fe. The conversion of Fe^{2+} to Fe^{3+} and the formation of $\text{Fe}(\text{OH})_3$ deposits is a redox reaction that necessitates optimal conditions, including appropriate time, pH, and dissolved oxygen levels (W. Guo et al., 2023; Li et al., 2022). Second, although the final pH is within neutral to slightly alkaline values (7.8), the Fe oxidation reaction is most effective within a pH range of 7.5–8.5, suggesting that it may not be operating at its optimal point (Asmawati et al., 2022). Third, the aeration system employed in this study has not been integrated with advanced preemptive methods, such as filtration or coagulation, which are crucial for capturing fine particles of $\text{Fe}(\text{OH})_3$ that have not yet settled completely. Consequently, it is recommended to increase contact time, adjust the initial pH, or incorporate additional methods to enhance the effectiveness of these systems until they comply with clean water quality standards.

The relationship between contact time and the reduction of iron (Fe) levels was elucidated through the results of a regression analysis, which produced an R^2 determination coefficient of 0.934. This coefficient

indicates that 93.4% of the variability in the reduction of Fe levels can be accounted for by the duration of aeration contact time. This finding aligns with the principles of redox reaction kinetics, where contact time is pivotal in facilitating adequate interaction between Fe^{2+} ions and dissolved oxygen (Soma et al., 2025; Tang et al., 2024). Prolonged contact time enhances the oxidation of Fe^{2+} ions to Fe^{3+} , which subsequently precipitates as $\text{Fe}(\text{OH})_3$. This study corroborates prior research indicating that aeration efficiency is significantly augmented with extended contact time (Diansari et al., 2022; Priyono et al., 2022).

The scientific mechanism elucidating this relationship encompasses the processes of oxidation and precipitation. The oxidation reaction of Fe^{2+} to Fe^{3+} in aqueous environments occurs at a relatively slow rate, particularly under conditions of low pH. The extended contact time facilitates a greater influx of dissolved oxygen into the water, thereby accelerating the reaction.



In this reaction, an increased contact time leads to a greater quantity of Fe^{2+} ions that undergo oxidation and precipitate. Furthermore, an extended aeration process enhances the surface area available for interaction between water and air, thereby facilitating the transfer of oxygen. This observation corroborates the findings of Agustian et al. (2023), which indicate that the efficiency of the aeration system improves with prolonged retention time and increased turbulence in the water flow.

In addition to the observed decrease in iron (Fe) levels, this study documented a significant increase in pH within the treatment group, rising from 6.3 to 7.8. This phenomenon can be attributed to the principle of aeration, which facilitates the removal of dissolved gases, such as carbon dioxide (CO_2), that contribute to acidity, thereby elevating the pH of the water (Panwar & Tiwari, 2025; M. E. Rahman et al., 2025; Singh & Kumar, 2022). The resultant increase in pH further enhances the oxidation rate of ferrous iron (Fe^{2+}), as the oxidation of heavy metals is more efficient at neutral to alkaline pH levels (Peiffer et al., 2024). Conversely, in the control group, which lacked aeration, the pH remained lower and did not exhibit a significant increase.

The elevation of water temperature from 27.7°C to 29.5°C during the aeration process remains within the acceptable tolerance range established by water quality standards ($\pm 3^\circ\text{C}$ from ambient temperature). This temperature increase is attributable to continuous water circulation and interaction with ambient air, alongside heightened biochemical activity during aeration (Chapra et al., 2021; Slezia et al., 2023). Notably, this temperature variation did not exert a significant adverse effect on the outcomes, as it remained within the normative limits established by the Indonesian Minister of Health.

In comparison to previous studies, the results of the present investigation demonstrate a satisfactory level of effectiveness; however, they are not optimal. Riyanto

et al. (2021) reported a reduction in iron (Fe) levels from 0.689 mg/L to 0.287 mg/L, achieving an efficiency of 58.32% through aeration over a duration of 60 minutes. In contrast, Diansari (2021) documented an efficiency of 49.53% with a contact time of 28 minutes. It is noteworthy that these studies employed variations in aerator design, with some incorporating additional processes, such as filtration. Consequently, to enhance effectiveness in achieving quality standards, it is recommended that the aeration system be integrated with advanced treatment methods, including sedimentation, the addition of coagulants (such as lime), or the utilization of filtration media.

Practical Implications and Prospects for Large-Scale Implementation

The findings of this study suggest that the overflow system of the Cascade Aerator has the potential to be developed as a viable water treatment solution for both household and community-scale applications, particularly in swampy regions such as South Kalimantan, where groundwater exhibits elevated metal concentrations. This system employs simple, readily accessible materials and can be locally assembled without the need for advanced technological equipment. Furthermore, with design enhancements such as the integration of filtration units, the incorporation of settling media, and the implementation of automated contact timing the system can be effectively adapted for community-based water treatment initiatives. The potential for its application is particularly noteworthy in remote areas that lack government-provided piped water treatment facilities.

The system adheres to the principle of appropriate technology, characterized by its cost-effectiveness, simplicity, and environmental sustainability. Furthermore, aeration systems have the capacity to mitigate the concentration of other dissolved gases, such as carbon dioxide (CO₂) and hydrogen sulfide (H₂S), which are frequently encountered challenges in shallow groundwater (Dange & Warkhedkar, 2023; Moore et al., 2024; M. Roy et al., 2022; S. M. Roy et al., 2022). Consequently, this system not only facilitates the reduction of metal contaminants but also enhances the overall sensory and chemical quality of the water.

Limitations of the Study

This research is subject to several limitations. Firstly, the maximum contact time employed is restricted to 60 minutes, which may impede the effectiveness of reducing iron (Fe) levels to an acceptable quality standard. Furthermore, the study has not investigated the potential synergistic effects of combining aeration methods with chemical agents such as lime or other coagulants that could enhance the iron deposition process. Additionally, measurements were conducted exclusively at a single location within a dug well in one village, necessitating caution when generalizing the findings to other regions. The impact of environmental variables, including water discharge, the presence of other metallic content, and

seasonal fluctuations, has also not been comprehensively examined.

CONCLUSION

This study demonstrates that the Cascade Aerator system, equipped with an overflow mechanism, can substantially decrease the concentration of iron (Fe) in dug well water. The most pronounced reduction in Fe levels was observed after a contact time of 60 minutes, achieving an efficiency of 63%, reducing the concentration from an initial level of 1.125 mg/L to 0.385 mg/L. Nevertheless, the final concentration of Fe remains above the drinking water quality standard established by the Indonesian Ministry of Health Regulation No. 2 of 2023, which stipulates a maximum permissible limit of 0.2 mg/L.

These findings suggest that employing a singular aeration method, particularly the Cascade Aerator within the overflow system, is insufficient for reducing iron (Fe) levels to comply with drinking water quality standards in dug well water characterized by elevated Fe concentrations. The integration of supplementary treatment methods, including coagulation, sedimentation, or filtration, is necessary to attain a more optimal level of effectiveness.

The results of the regression analysis demonstrated a significant relationship between contact time and the reduction of iron (Fe) levels, evidenced by a coefficient of determination (R²) of 93.4%. Furthermore, the aeration process not only contributed to the decrease in Fe levels but also elevated the pH of the water from 6.3 to 7.8. This process resulted in a temperature increase within acceptable limits, indicating that aeration positively influences additional water quality parameters.

This study presents several limitations, including a restricted variation in contact time (with a maximum of 60 minutes), the absence of advanced treatment units, and the confinement of the research site to a singular water source point. Consequently, the generalization of the findings requires cautious interpretation. Further research employing a more comprehensive design is essential to validate the effectiveness of this method across a broader scale and under diverse environmental conditions.

SUGGESTION

Based on the findings and limitations of the current study, it is recommended that future research investigate the extension of aeration contact time beyond 75 minutes to assess the optimal effectiveness of the Cascade Aerator system in reducing iron (Fe) levels to meet the drinking water quality standard threshold. Furthermore, the implementation of a combination of water treatment methodologies, including the addition of coagulant agents (e.g., lime), sedimentation processes, or filtration techniques, should be considered to improve treatment efficiency and mitigate the presence of Fe(OH)₃ sediment particles in the water.

Further investigations should be conducted at diverse water source locations characterized by varying soil, geochemical, and hydrological attributes, as well as across different seasonal conditions, to enhance the

generalizability of the effectiveness of these systems. To promote sustainability and facilitate operational efficiency at the community level, the development of automated Cascade Aerator systems—incorporating technologies such as sensors, timers, or flow regulators should be examined as a crucial component of appropriate technological innovations in clean water treatment.

REFERENCE

- Agustian, D., Windusari, Y., & Hasyim, H. (2023). Metode Pengolahan Air Sederhana untuk Menurunkan Kadar Fe (Besi) pada Air Sumur: Studi Literatur. *Jurnal Ilmiah Permas: Jurnal Ilmiah STIKES Kendal*, 13(3), 813–820. [[Crossref](#)] [[Publisher](#)]
- Aini, F. N., Narto, N., & Haryanti, S. (2022). Penggunaan Metode Cascade Aerator Untuk Penurunan Kadar Besi Dan Mangan Air Sumur Gali. *Sanitasi: Jurnal Kesehatan Lingkungan*, 15(2), 97–104. [[Crossref](#)] [[Publisher](#)]
- Asmawati, I., Nuryani, D. D., Aryastuti, N., & Yunita, D. (2022). Efektifitas Metode Aerasi dalam Menurunkan Kadar Besi Pada Air Tanah di Desa Sidorejo Kecamatan Sidomulyo Tahun 2021. *Indonesian Journal of Health and Medical*, 2(2), 223–233. [[Publisher](#)]
- Badan Pusat Statistik Indonesia. (2023). Statistik Indonesia 2023. In *BPS* (Vol. 1101001). [[Publisher](#)]
- BPS Kab. Banjar. (2023). Kabupaten Banjar Dalam Angka 2023. In *BPS Kabupaten Banjar*. [[Publisher](#)]
- Bryant, L. D., Brockbank, N., & Austin, D. (2024). To mix or not to mix? A holistic approach to stratification-preserving and destratification aeration of drinking-water supply reservoirs. *Water Research*, 261. [[Crossref](#)] [[Publisher](#)]
- Chapra, S. C., Camacho, L. A., & McBride, G. B. (2021). Impact of global warming on dissolved oxygen and bod assimilative capacity of the world's rivers: Modeling analysis. *Water (Switzerland)*, 13(17). [[Crossref](#)] [[Publisher](#)]
- Cordeiro, E. D. A., Mantovani, E. C., Vieira, G. H. S., Silva, J. G. F. D., Haddade, I. R., & Lo Monaco, P. A. V. (2025). Treatment of Ferruginous Water in the Performance of Drip Irrigation Systems. *AgriEngineering*, 7(2), 1–13. [[Crossref](#)] [[Publisher](#)]
- Dange, A., & Warkhedkar, R. (2023). An experimental study of venturi aeration system. *Materials Today: Proceedings*, 72, 615–621. [[Crossref](#)] [[Publisher](#)]
- Diansari, U., Purnaini, R., & Asbanu, G. C. (2022). Perbandingan Efisiensi Cascade Aerator Dan Bubble Aerator Dalam Menurunkan Kadar Besi Air Sumur Bor. *Jurnal Teknologi Lingkungan Lahan Basah*, 10(1), 11–21. [[Crossref](#)] [[Publisher](#)]
- Guo, H., Gao, Z., & Xing, S. (2023). Water-rock interactions: Mineral dissolution. In *Medical Geology: En route to One Health* (pp. 113–127). Wiley. [[Crossref](#)] [[Publisher](#)]
- Guo, W., Yan, W., & Jing, C. (2023). Production of reactive oxygen species from oxygenation of Fe(II)-carbonate complexes: The critical roles of carbonate. *Journal of Hazardous Materials*, 454. [[Crossref](#)] [[Publisher](#)]
- Hama Aziz, K. H., Mustafa, F. S., Omer, K. M., Hama, S., Hamarawf, R. F., & Rahman, K. O. (2023). Heavy metal pollution in the aquatic environment: efficient and low-cost removal approaches to eliminate their toxicity: a review. *RSC Advances*, 13(26), 17595–17610. [[Crossref](#)] [[Publisher](#)]
- Jayalath, N., Fitzpatrick, R., Mosley, L. M., & Marschner, P. (2021). Addition of wheat straw to acid sulfate soils with different clay contents reduces acidification in two consecutive submerged-moist cycles. *Geoderma*, 385, 1–7. [[Crossref](#)] [[Publisher](#)]
- Kemendes RI. (2023). Permenkes No. 2 Tahun 2023 Tentang Peraturan Pelaksanaan Peraturan Pemerintah Nomor 66 Tahun 2014 Tentang Kesehatan Lingkungan. In *Kemendes RI* (Issue 55). [[Publisher](#)]
- Kusumawiranti, R. (2022). Pengelolaan Air Bersih (Pab) Banyumili Berbasis Masyarakat Di Srimulyo Piyungan Bantul. *Populika*, 10(2), 62–72. [[Crossref](#)] [[Publisher](#)]
- Li, X., Graham, N. J. D., Deng, W., Liu, M., Liu, T., & Yu, W. (2022). Structural Variation of Precipitates Formed by Fe(II) Oxidation and Impact on the Retention of Phosphate. *Environmental Science and Technology*, 56(7), 4345–4355. [[Crossref](#)] [[Publisher](#)]
- Mangarengi, N. A.-N. P., Selintung, M., Ibrahim, R., & Quraniah, K. (2022). Removal of Ferrous (Fe²⁺) and Manganese (Mn²⁺) from Shallow Groundwater using Modified Manganese Zeolite in Fixed-Bed Column (Continuous Down-flow Reactor). In H. B., M. F., & A. I.S. (Eds.), *AIP Conference Proceedings* (Vol. 2543). American Institute of Physics Inc. [[Crossref](#)] [[Publisher](#)]
- Moore, W. S., Benitez-Nelson, C., Schutte, C., Moody, A., Shiller, A., Sibert, R. J., & Joye, S. (2024). SGD-OD: investigating the potential oxygen demand of submarine groundwater discharge in coastal systems. *Scientific Reports*, 14(1). [[Crossref](#)] [[Publisher](#)]
- Nayak, J. K., Ganjare, A., & Ranade, V. V. (2025). A Note on Enhancing Aeration via a Vortex-Based Cavitation Device. *ACS Omega*, 10(5), 4561–4568. [[Crossref](#)] [[Publisher](#)]
- Panwar, D., & Tiwari, N. K. (2025). Reliable Prediction of the Aeration Efficiency of Venturi Flumes Using Intelligent Approaches. *Journal of Environmental Engineering (United States)*, 151(2). [[Crossref](#)] [[Publisher](#)]
- Peiffer, S., Maisch, M., Kappler, A., Schmidt, C., Mansor, M., Obst, M., & Frei, S. (2024). Kinetic constraints for the formation of microniches for microaerophilic Fe(II) oxidation. *Geochimica et Cosmochimica Acta*, 364, 211–223. [[Crossref](#)] [[Publisher](#)]
- Priyono, W., Utomo, K. P., & Kadaria, U. (2022). Efektivitas Penurunan Kadar Besi Dari Air Sumur Bor Menggunakan Packed Tower Aerator. *Jurnal Teknologi Lingkungan Lahan Basah*, 10(2), 194–204. [[Crossref](#)] [[Publisher](#)]
- Rahman, I., Wahab, M. A., Akter, M., & Mahanta, T. R. (2024). Iron in Drinking Water and its Impact on Human Health –A Study in Selected Units of Jalalabad

- Cantonment. *Bangladesh Armed Forces Medical Journal*, 56(2), 58–64. [[Crossref](#)] [[Publisher](#)]
- Rahman, M. E., Mahmud, K., Uddin, M. K., Shamsuzzaman, S. M., Shukor, M. Y. A., Ghani, S. S. A., Akter, A., Nabayi, A., Sadeq, B. M., Chompa, S. S., & Halmi, M. I. E. B. (2025). Impact of aeration on plant growth-promoting rhizobacteria assisted phytoremediation capability of arsenic in artificial wetland system. *International Journal of Phytoremediation*, 27(6), 810–831. [[Crossref](#)] [[Publisher](#)]
- Riyanto, E., Taufik, M., & Saputri, M. (2021). Analisis Penurunan Kadar Besi (Fe) dalam Air Sumur Gali dengan Metode Variasi Waktu Aerasi Filtrasi Menggunakan Aerator Gelembung dan Variasi Saringan Pasir Lambat. *Surya Beton: Jurnal Ilmu Teknik Sipil*, 5(1), 2. [[Crossref](#)] [[Publisher](#)]
- Roy, M., van Genuchten, C. M., Rietveld, L., & van Halem, D. (2022). Groundwater-native Fe(II) oxidation prior to aeration with H₂O₂ to enhance As(III) removal. *Water Research*, 223. [[Crossref](#)] [[Publisher](#)]
- Roy, S. M., Tanveer, M., & Machavaram, R. (2022). Applications of gravity aeration system in aquaculture—a systematic review. *Aquaculture International*, 30(3), 1593–1621. [[Crossref](#)] [[Publisher](#)]
- Santoso, H. B., Yunita, R., Hadisa, A. R., & Rahman, M. F. (2024). Bioaccumulation of Iron (Fe) in the Sea Catfish (*Arius sagor*) from the Coastal Swamp of Kuala Tambangan, South Kalimantan, Indonesia. *Egyptian Journal of Aquatic Biology and Fisheries*, 28(2), 657–673. [[Crossref](#)] [[Publisher](#)]
- Saravanan, P., Saravanan, V., Rajeshkannan, R., Arnica, G., Rajasimman, M., Baskar, G., & Pugazhendhi, A. (2024). Comprehensive review on toxic heavy metals in the aquatic system: sources, identification, treatment strategies, and health risk assessment. *Environmental Research*, 258. [[Crossref](#)] [[Publisher](#)]
- Sari, Y., & Yulis, P. A. R. (2021). Reduction of Fe Levels in Groundwater Using Aeration-Filtration Method with Tray Aerator System. *ALKIMIA: Jurnal Ilmu Kimia Dan Terapan*, 5(1), 110–115. [[Crossref](#)] [[Publisher](#)]
- Sharma, M., Kant, R., Sharma, A. K., & Sharma, A. K. (2025). Exploring the impact of heavy metals toxicity in the aquatic ecosystem. *International Journal of Energy and Water Resources*, 9(1), 267–280. [[Crossref](#)] [[Publisher](#)]
- Singh, D., & Kumar, M. (2022). Study on aeration performance of different types of piano key weir. *Water Supply*, 22(5), 4810–4820. [[Crossref](#)] [[Publisher](#)]
- Sleziak, P., Jančo, M., & Danko, M. (2023). Dynamics of water temperature in a small mountain catchment. *Acta Hydrologica Slovaca*, 24(1), 43–51. [[Crossref](#)] [[Publisher](#)]
- Soma, Y., Komatsu, A., Kaji, Y., Yamamoto, M., & Igarashi, T. (2025). Experimental and modeling studies on the oxygen ingress behavior at the crevices of stainless steels in high-temperature water. *Corrosion Science*, 251. [[Crossref](#)] [[Publisher](#)]
- Tang, Z., Tang, X., Xiao, Z., & Liu, H. (2024). Kinetic research of scorodite formation via oxidative coprecipitation from arsenic-bearing solution. *Process Safety and Environmental Protection*, 191, 658–675. [[Crossref](#)] [[Publisher](#)]
- van de Griend, M. V., Warrenner, F., van den Akker, M., Song, Y., Fuchs, E. C., Loiskandl, W., & Agostinho, L. L. F. (2022). Vortex Impeller-Based Aeration of Groundwater. *Water (Switzerland)*, 14(5). [[Crossref](#)] [[Publisher](#)]
- Yang, P., Tang, K. W., Yang, H., Tong, C., Zhang, L., Lai, D. Y. F., Hong, Y., Tan, L., Zhu, W., & Tang, C. (2023). Contrasting effects of aeration on methane (CH₄) and nitrous oxide (N₂O) emissions from subtropical aquaculture ponds and implications for global warming mitigation. *Journal of Hydrology*, 617. [[Crossref](#)] [[Publisher](#)]
- Yin, Y., Wang, T., & Zhang, C. (2025). Numerical study of the land-sourced iron precipitation and its effects on porewater flow at subterranean estuaries. *Chemical Geology*, 682. [[Crossref](#)] [[Publisher](#)]
- Zhao, J., Zhang, M., Pu, Y., Jia, L., Xiao, W., Zhang, Z., Ge, P., Shi, J., Xiao, Q., & Lee, X. (2025). Dynamic and high methane emission flux in pond and lake aquaculture. *Journal of Hydrology*, 653. [[Crossref](#)] [[Publisher](#)]
- Zulya, F., Adnan, F., Dewi, Y. P., Nugroho, S., Malik, I. M., Tirana, Y., Rahni, R., Difachwan, M. Z., Widiyanto, R. F., Faizah, M. I. N., & Waryati, W. (2022). Perancangan Cascade Aerator Untuk Menurunkan Parameter Besi Dan Mangan Dalam Pengolahan Air Sumur. *Jurnal Teknologi Lingkungan UNMUL*, 6(2), 18–23. [[Crossref](#)] [[Publisher](#)]