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*Research article*

# The Effect of Aeration Time Variation on Iron (Fe) Content in Well Water

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## Abstract

Iron (Fe) levels in wells that exceed quality standards can cause the water to turn yellow, deposition on the pipe walls, bacterial growth, change in the taste of the water, and turbidity. One way to deal with excessive levels of iron (Fe) in water is aeration. This study aims to determine variations in the length of aeration time on iron (Fe) content in well-healthy Sumber Village, Simo District, Boyolali Regency. This research is a post-only design. The population of this study was all healthy in the houses of residents in Simo Village, Simo District, and Boyolali Regency. The sample is resident well water with a characteristic fishy smell, turbidity, and a yellowish color. Sampling with a quota sampling of 240 liters was taken in the morning before residents used the well. Statistical analysis using the ANOVA test yielded p0.000 <p0.05, so there was a significant effect between the length of aeration time and the healthy water's iron (Fe) content. Follow-up tests used the Tukey HSD test to determine the most effective time for reducing iron (Fe) levels, with the highest mean difference of 0.40833 in the treatment with 9 minutes of aeration time. The results showed that the most effective aeration time to reduce iron (Fe) content to 0.78 mg/l was 9 minutes. This study concluded that the aeration process c to reduce high levels of iron (Fe) in wells.

Keywords: Well water, iron (Fe) content, Length of aeration time.

## 1. Introduction

This Dug wells are one of the groundwater sources derived from soil layers near the surface and are widely used by a portion of the Indonesian population (Handriyani et al., 2020). Groundwater quality is not considered to meet the existing standards unless it undergoes prior treatment. One important parameter in determining the quality of clean water is the dissolved heavy metal content, one of which is iron (Fe). Excessive iron (Fe) can cause health issues in humans (Rachmawati et al., 2016). Therefore, it is necessary to analyze water treatment methods to reduce the iron levels in groundwater from dug wells. The iron levels in dug well water must meet the clean water quality standards set by the Ministry of Health Regulation No. 32 of 2017, which sets the maximum allowable iron content in clean water at 1.0 mg/L.

Iron levels in clean water that exceed the standard and are consumed by humans can lead to health problems, such as skin discoloration due to iron accumulation. In high doses, iron can also damage the intestinal walls (Rivai and Hermanto, 2019). Water with iron levels below the quality standard can be considered clean water. Clean water is a vital resource needed to sustain human life. Humans cannot survive without drinking water, as 70-80% of the human body consists of water, including the brain and blood. Besides humans, plants and animals also need clean water to survive. For instance, plants need water for photosynthesis, while animals need water for drinking (Putri and Anis, 2020).

One way to reduce excessive iron (Fe) levels in water is aeration. Aeration is a method of adding air or oxygen. This process causes an oxidation reaction that forms Fe (OH) precipitates (Rachmawati et al., 2016; Wulandari et al., 2021; Atmono et al., 2019; Munthe et al., 2018; Ulfa et al., 2019). According to Riyanto (2021), the longer the aeration time using a bubble aerator, the greater the reduction in Fe levels. The effectiveness of Fe reduction occurs at the 60th minute, with sample A achieving 36.6%, sample B reaching 30.6%, and sample C reaching 58.3%, where the average Fe content in sample A was 1.105 mg/L, sample B was 1.345 mg/L, and sample C was 0.287 mg/L. Research conducted by Haidar (2020) states that all contact times of aeration with a bubble aerator can reduce iron levels in dug well water, with the most efficient result occurring at a 7-minute contact time, with a reduction percentage of 99.7%. Therefore, the researcher plans to use time variations of 5 minutes, 7 minutes, and 9 minutes in the aeration process using a bubble aerator. In this case, contact time affects the extent of Fe reduction (Karuniawan and Munawar, 2021; Warniati et al., 2015).

Based on water sampling from a resident's house in Sumber Village, Simo District, the sample was taken from the resident's well water, which had the characteristics of a fishy odor, cloudy appearance, and yellowish color, with an initial iron content of 1.6 mg/L. These results do not meet the clean water requirements for iron (Fe) content, as stated by the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 on Environmental Health Quality Standards and Health Requirements for Water for Hygiene and Sanitation, Swimming Pools, Solus Per Aqua, and Public Baths, which sets the maximum iron (Fe) content in clean water at 1 mg/L. Based on the introduction above, the researcher will study the effect of varying aeration times on reducing iron (Fe) content in well water in Simo District, Boyolali Regency.

## 2. Research Methods

This study is a pre-experimental research type with a post-test only design. This design was used to observe changes occurring after treatment without comparing them to initial conditions (pre-test). The data obtained were analyzed using descriptive tests to describe the condition of the data and analytical tests to evaluate relationships between variables. The research was conducted in June 2023 in Sumber Village, Simo District, Boyolali Regency, an area characterized by high iron (Fe) levels in the community’s well water.

The population of this study included all wells in residential areas of Sumber Village with high iron content. The sample used in the study was drawn from a dug well in the home of a resident, Mr. Ariyanto. A total of 240 liters of water was collected. The sampling was done purposively based on locations representing the characteristics of the study area, namely high iron content that required further treatment.

Data analysis in this study involved two approaches: univariate and bivariate analysis. The univariate analysis was employed to describe the iron (Fe) content in the well water following aeration treatment. The aeration treatment was conducted using a bubble aerator with varying time intervals of 0 minutes, 5 minutes, 7 minutes, and 9 minutes. Meanwhile, the bivariate analysis was used to assess the relationship between aeration time and changes in iron content in the well water. This approach enabled the observation of the effectiveness of aeration treatments in reducing iron levels.

As part of the statistical analysis, ANOVA testing was employed to assess significant differences in iron levels based on variations in aeration time. The ANOVA test was conducted using statistical software at a 99% confidence level. The results of this analysis provided insights into the effectiveness of bubble aeration in reducing iron levels in dug well water in the study area. The data obtained are expected to serve as a basis for developing water treatment technologies for regions facing similar issues.

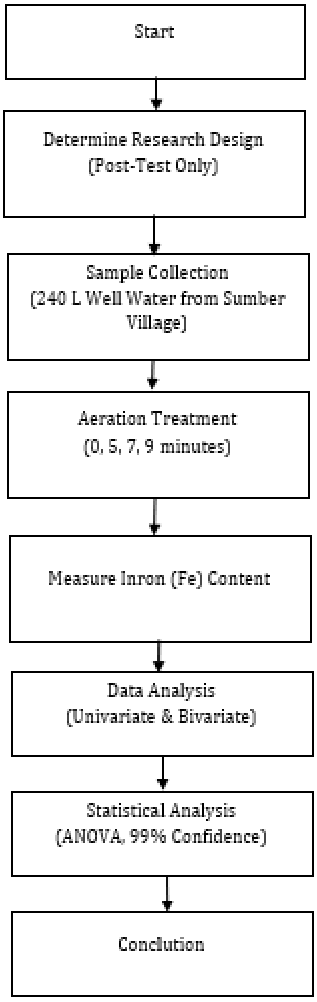


**Figure 1.** Research Flow Diagram.

## 3. Results and Discussion

### 3.1. Result

A study on the iron (Fe) content in well water from Simo District, Boyolali Regency, was conducted to assess changes in iron concentration after undergoing the aeration process. High iron levels in well water can lead to various issues, such as alterations in taste, color, and odor, as well as potential health risks. Aeration is widely recognized as an effective method to reduce iron levels by oxidizing Fe(II) ions into Fe(III), which can subsequently precipitate. Therefore, evaluating iron levels post-aeration is crucial to ensure that the well water meets safe quality standards for community use. This study aims to determine the effectiveness of aeration in reducing iron concentrations in the region The results of the examination of iron (Fe) levels in well water in Simo District, Boyolali Regency, after undergoing the aeration process can be seen in Table 1.

**Table 1.** Results of Iron (Fe) Level Examination

| No | Time Variation (Minutes) | Fe content of well water after treatment | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| | | Replication | | | | | | |
| | | I | II | III | IV | V | VI | |
| 1 | 0 | 1,2 | 1,2 | 1,2 | 1,2 | 1,2 | 1,2 | 1,19 |
| 2 | 5 | 1,1 | 1,1 | 1,1 | 1,1 | 1,1 | 1,1 | 1,09 |
| 3 | 7 | 1 | 0,9 | 0,9 | 0,9 | 1 | 0,9 | 0,93 |
| 4 | 9 | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 | 0,78 |

Based on Table 1, it shows that the aeration process time most effective in reducing iron levels is the treatment using 7 and 9 minutes, with iron levels below 1 mg/liter (below the maximum permissible level). Meanwhile, the treatments with 0 and 5 minutes are still insufficient to reduce the iron levels in well water to meet the permissible maximum level. For the 0 and 5-minute treatments, iron levels remain between 1.08 and 1.19. In contrast, the 7 and 9-minute treatments can reduce iron levels to as low as 0.75.

The results obtained from the examination of iron levels in dug wells in Simo District, Boyolali Regency, before and after treatment in the treatment group were then entered into a table and analyzed descriptively and analytically. The following are the results of the Univariate test in this study.

**Table 2.** Descriptive Statistics

| Treatment | N | Mean | Std. Deviation | Min | Max |
|---|---|---|---|---|---|
| 0 Minute | 6 | 1,195 | 0,01049 | 1,18 | 1,21 |
| 5 Minutes | 6 | 1,0983 | 0,01472 | 1,08 | 1,12 |
| 7 Minutes | 6 | 0,93 | 0,03406 | 0,89 | 0,98 |
| 9 Minutes | 6 | 0,7867 | 0,02733 | 0,75 | 0,83 |
| Total | 24 | 1,0025 | 0,16147 | 0,75 | 1,21 |

Based on Table 2, it can be seen that the highest mean value from the 4 treatments is 1.950. The highest standard deviation value is 0.03406. Furthermore, the lowest minimum value in this study is 0.75, while the highest maximum value in this study is 1.21.

**Table 3.** Shapiro-Wilk Normality Test

| Treatment | Shairo-Wilk | | |
|---|---|---|---|
| | Statistic | Df | Sig. |
| 0 Minute | 0,96 | 6 | 0,82 |
| 5 Minutes | 0,958 | 6 | 0,8 |
| 7 Minutes | 0,936 | 6 | 0,63 |
| 9 Minutes | 0,988 | 6 | 0,99 |

Based on Table 3 above, the treatment of 0 minutes received a value of 0.820. The treatment of 5 minutes received a value of 0.804. The treatment of 7 minutes received a value of 0.625, and for the treatment of 9 minutes, a value of 0.985 was obtained. Therefore, all data in this study passed the Shapiro-Wilk normality test because they had values above 0.05. Since the data in this study passed the normality test, the next test will be an ANOVA and Homogeneity Test. The purpose of the Homogeneity Test is to determine whether the variance of several data from the population has the same variance or not. If the significance value is $< 0.05$, the data variance is not homogeneous. If the significance value is $> 0.05$, the data variance is homogeneous. The following is the table of the Homogeneity Test result:

**Table 4.** Homogeneity Test

| | Levene Statistic | Df 1 | Df 2 | Sig. |
|---|---|---|---|---|
| Based on Mean | 2,517 | 3 | 20 | 0,09 |
| Based on Median | 2,082 | 3 | 20 | 0,14 |

Based on Table 4, the significance values for based on mean and based on median are 0.087 and 0.135, respectively, which means that all values are $> 0.05$. Therefore, the results of the homogeneity test in this study indicate that the population groups in this study are homogeneous.

**Table 5.** ANOVA Test

| F Count | Sig. | Information |
|---|---|---|
| 351,333 | 0 | Have a meaningful difference |

Based on Table 5, the results of the ANOVA test in this study showed an F-value of 351.333 and a significance value of 0.000. Since $0.000 < 0.05$, this indicates a significant difference between each treatment, namely treatments A, B, C, and D in this study.

In addition to the ANOVA test, a Multiple Comparisons test will be conducted to determine the most effective aeration time to be used. The following are the results of the Multiple Comparisons test.

**Table 6.** Multiple Comparisons Test.

| (I) Treatment | (J) Treatment | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| 0 Minute | 5 Minutes | 0,09667 | 0,01364 | 0 |
| | 7 Minutes | 0,265 | 0,01364 | 0 |
| | 9 Minutes | 0,40833 | 0,01364 | 0 |
| 5 Minutes | 0 Minute | -0,09667 | 0,01364 | 0 |
| | 7 Minutes | 0,16833 | 0,01364 | 0 |
| | 9 Minutes | 0,31167 | 0,01364 | 0 |
| 7 Minutes | 0 Minute | -0,265 | 0,01364 | 0 |
| | 5 Minutes | -0,16833 | 0,01364 | 0 |
| | 9 Minutes | 0,14333 | 0,01364 | 0 |
| 9 Minutes | 0 Minute | -0,40833 | 0,01364 | 0 |
| | 5 Minutes | -0,31167 | 0,01364 | 0 |
| | 7 Minutes | -0,14333 | 0,01364 | 0 |

Based on Table 6, the results of the Multiple Comparisons test in this study showed a significance value of 0.000 for all samples. Since 0.000 < 0.05, this indicates a significant difference in the average between each treatment. The effectiveness is measured from the mean difference column, where the most effective aeration time is 9 minutes, as it has a value of 0.40833, which is the highest compared to the other samples.

## 3.2. Discussion

The measurement of iron (Fe) levels in well water in Simo District, Boyolali Regency, was conducted using the aeration method with a bubble aerator and varying times of 0, 5, 7, and 9 minutes. The measurement of iron (Fe) levels in the well water was performed at the Health Office Laboratory of Surakarta City.

The well water used as a sample had physical characteristics of odor and a yellowish-brown color. This occurs due to the presence of iron (Fe) in the water. The well owner uses the well water for hygiene and sanitation purposes, such as bathing and washing. The owner does not use the well water for cooking and drinking because they are aware that the physical condition of the well water is not good.

Iron (Fe) is one of the essential heavy metals that, in certain amounts, is needed by living organisms. However, if the iron (Fe) levels exceed the quality standards, it will have adverse effects on health and the environment. Iron (Fe) at certain concentrations in water can cause a metallic taste or odor in the water. Therefore, it can affect the aesthetic quality of water for daily use. Iron (Fe) that accumulates in the body can have health effects on humans, disrupting metabolic processes in the body (Rachmawati et al., 2016).

In this study, the researcher conducted four treatments, each with six replications. After completing the first, second, third, and fourth treatments with six replications, the samples were immediately tested at the Health Office Laboratory of Surakarta City, and the results were 1.19 mg/l, 1.09 mg/l, 0.93 mg/l, and 0.78 mg/l, respectively. Additionally, the ANOVA test showed a value of 0.000 < 0.05, which means that each treatment or aeration time had a significant difference.

In terms of effectiveness, the most effective treatment in reducing iron (Fe) levels among the aeration times of 0 minutes, 5 minutes, 7 minutes, and 9 minutes was determined using the Multiple Comparisons table. Based on the analysis results, it was found that 9 minutes is the most effective time for reducing iron levels in well water in Simo District, Boyolali Regency. This can be seen from the mean difference value, where the effective aeration time is 9 minutes because it has a value of 0.40833, which is the highest compared to the other samples. This research shows that residence time differences can affect the reduction of iron parameters (Asmawati et al., 2022; Mubarak, 2016).

From the results that meet the clean water quality standards, the third treatment meets the clean water quality standards but is at the borderline, with 7 minutes yielding an average of 0.93. Moreover, the treatment requires only 9 minutes to achieve iron (Fe) levels below the standard, which is 0.78 mg/l. According to the Indonesian Minister of Health Regulation No. 32 of 2017, the maximum iron (Fe) level in water for hygiene and sanitation purposes is 1 mg/l.

The first treatment, with a time of 0 minutes or no treatment, yielded an average result of 1.19, which is still above the standard. Meanwhile, the second treatment, with a time of 5 minutes, was still considered ineffective in reducing iron (Fe) levels because the value was still above the standard iron (Fe) level for hygiene and sanitation purposes, which is 1 mg/l.

According to a study conducted by Syahputra (2018) on the reduction of iron (Fe) levels in well water using a Pneumatic System with varying times of 5, 10, 15, 20, and 25 minutes of aeration, it was shown that with an injection time of 5 minutes, iron (Fe) levels could be reduced from 1.65 mg/l to 1.47 mg/l. With a 10-minute injection time, iron (Fe) levels could be reduced from 1.65 mg/l to 1.32 mg/l, while with a 15-minute injection, iron (Fe) levels could be reduced from 1.65 mg/l to 1.15 mg/l. For a 20-minute injection time, iron (Fe) levels could be reduced from 1.65 mg/l to 0.91 mg/l, and with a 25-minute injection, iron (Fe) levels could be reduced from 1.65 mg/l to 0.69 mg/l. The most effective time in the Pneumatic System for reducing iron (Fe) levels is 20 minutes, which meets the permissible threshold of 1 mg/l.

According to research conducted by Batara et al. (2017), the reduction of iron (Fe) using a diffuser aerator in groundwater showed that the use of a diffuser aerator can reduce iron (Fe) levels from 3.57 mg/l to 1.60 mg/l, or by 1.97 mg/l, after 60 minutes of aeration. Meanwhile, in the study conducted by Trisetyani and Sutrisno (2014), the reduction of iron (Fe) levels with three different times—20, 40, and 60 minutes—showed that the initial iron (Fe) level was 3.1 mg/l, and the resulting iron (Fe) levels after treatments of 20, 40, and 60 minutes were 0.4105 mg/l, 0.1179 mg/l, and 0.1691 mg/l, respectively.

In this study, the iron (Fe) levels in water were below the maximum limit for iron (Fe) at the 7-minute and 9-minute marks, with results of 0.93 and 0.78 mg/l. Based on these results, the iron (Fe) levels still exceed the maximum allowable iron (Fe) level in drinking water quality standards, which according to Ministry of Health Regulation No. 492/Menkes/Per/IV/2010, is 0.3 mg/l. However, the results of this study are already below the clean water quality standards, which according to Indonesian Ministry of Health Regulation No. 32 of 2017, the maximum iron (Fe) level for hygiene and sanitation purposes is 1 mg/l. Therefore, further treatment is needed to reduce the iron levels to meet drinking water quality standards, such as by adding filtration or adsorption processes (Joko and Savitri, 2016; Sulastri & Nurhayati, 2014; Rasman and Saleh, 2016).

Filtration is the process of filtering particles and both organic and inorganic impurities in water. Filter media usually consist of sand or a combination of sand, gravel, stones, paper, cloth, fibers, and activated charcoal. Each filter media has the same function, which is to filter out pollutants present in groundwater. Proper filter media can even remove chemical or organic substances in water, such as turbidity, color, oiliness, rust, and mud (Sulastri & Nurhayati, 2014; Rasman and Saleh, 2016; Nainggolan et al., 2017).

The 9-minute aeration process using a bubble aerator is more effective compared to other aeration time variations using a bubble aerator. However, this study still requires additional clean water treatment processes using contact filtration with media such as sand, manganese zeolite, and activated carbon so that the iron (Fe) levels in water can be reduced below the drinking water standard of 0.03 mg/l, according to Ministry of Health Regulation No. 492/Menkes/Per/IV/2010. This will help fulfill the clean water needs of the people in Simo District, Boyolali Regency.

## 4. Conclusion

The iron (Fe) levels with aeration treatment using a bubble aerator with varying times are as follows: 0 minutes at 1.19 mg/l, 5 minutes at 1.09 mg/l, 7 minutes at 0.93 mg/l, and 9 minutes at 0.78 mg/l. The most effective aeration time using a bubble aerator to reduce iron (Fe) levels is 9 minutes, with a value of 0.40833, which is the highest compared to the other samples. This study can serve as a reference and guide for future research on water treatment using aeration with a bubble aerator, considering other factors that can affect the aeration process, such as temperature, pH, oxygen saturation, water characteristics, and water turbulence.

One key strength of this study is the clear and systematic approach to determining the effectiveness of aeration time in reducing iron (Fe) levels. By testing multiple time intervals, the study offers precise data on the optimal duration for aeration. Additionally, the results can be directly applied to real-world water treatment processes, making it a practical guide for improving water quality in various settings.

Despite its strengths, this study has some limitations. It focuses solely on aeration time as a variable, without accounting for other factors that may influence iron reduction, such as initial

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**Author Contributions**

**Conceptualization**: Ma'arif Ardhi Saputro, Dwi Astuti; **methodology**: Ma'arif Ardhi Saputro; **investigation**: Ma'arif Ardhi Saputro, Nurzawani Md Sofwan; **writing—original draft preparation**: Ma'arif Ardhi Saputro; **writing—review and editing**: Ma'arif Ardhi Saputro, Dwi Astuti, Nurzawani Md Sofwan; **visualization**: Ma'arif Ardhi Saputro. All authors have read and agreed to the published version of the manuscript.

**Conflict of interest**

Example "All authors declare that they have no conflicts of interest.".

water composition, pH levels, and temperature. Furthermore, the study does not explore the long-term performance or maintenance requirements of the bubble aerator, which are important for practical applications. Expanding the range of variables and including cost analysis could enhance the overall applicability of the research.

Future research could explore the combined effect of aeration time with other factors, such as varying pH levels, temperature, and different types of aerators. Investigating how bubble aeration interacts with different water sources (e.g., groundwater, surface water) would also provide valuable insights. Additionally, studies focusing on energy efficiency and cost optimization of the aeration process could improve the economic feasibility of large-scale water treatment systems.

## References

Asmawati, I., Dina DN., Nurul, A., Dian Y. (2022). Efektivitas Metode Aerasi dalam Menurunakn Kadar Besi pada Air Tanah di Desa Sidorejo Kecamatan Sidomulyo Tahun 2021.*Jurnal Indonesian Journal of Health and Medical 2(2).*

Atmono, Natalina, Dodo K., (2019). Penurunan Kadar Besi (Fe) Menggunakan variasi sudut kemiringan dengan Metode Cascade Aerator. *Jurnal Rekauasa 3(2).*

Batara, K., Zaman, B., Oktiawan, W., Teknik, D., Fakultas, L., & Universitas, T. (2017). *Pengaruh Debit Udara Dan Waktu Aerasi Tehadap*. *6*(1).

Haidar, B. (2020). *Efisensi Variasi Lama Waktu Aerasi Bubble Aerator Terhadap Penurunan Kadar Besi (Fe) Air Sumur Gali Desa Purwogondo Kabupaten Jepara Tahun 2020* (Satu). Program Studi Sanitasi Lingkungan Program Sarjana Terapan Jurusan Kesehatan Lingkungan Purwokerto.

Handriyani, K. A. T. S., Habibah, N., & Dhyanaputri, I. G. A. S. (2020). Analisis Kadar Timbal (Pb) Pada Air Sumur Gali Di Kawasan Tempat Pembuangan Akhir Sampah Banjar Suwung Batan Kendal Denpasar Selatan. *JST (Jurnal Sains Dan Teknologi)*, *9*(1), 68–75. https://doi.org/10.23887/jstundiksha.v9i1.17842

Joko, T dan Savitri R. (2016). Variasi Penambahan Media Adsorpsi Kontak Aerasi Sistem Nampan Bersusun (Tray Aerator) terhadap Kadar Besi (Fe) Air Tanah Dangkal di Kabupaten Rembang. *Jurnal Kesehatan Lingkungan Indonesia 15(1).*

Karuniawan, H. dan Munawar, A. (2021). Variasi Tray Aerator dengan Penambahan Media Kaolin dan karbon aktif untuk Menurunkan Fe dan Mn Terlarut di Air Sumur. IJurnal Envirous *1 (2).*

Mubarak A. (2016) Keefektifan Waktu Aerasi Menggunakan Bubble Aerator dalam Menurunkan Kadar Besi (Fe) Air SUmur Desa Kebarongan Kemranjen Banyumas.*eprint ums.* https://onesearch.id/Record/IOS2728.44186

Munthe, A.A., Jasmen M., Realita.(2018) Analisa Penurunan Kadar Besi (Fe) dengan Metode Waterfall Aerator dan Multiple Platform Aerator. *Jurna; Mutiara Kesehatan Masyarakat 3(2).*Putri, N. P., & Z, A. F. (2020). Manfaat Air Minum bagi Kesehatan Peserta Didik pada Tingkat MI/SD. *Al-Adzka: Jurnal Ilmiah Pendidikan Guru Madrasah Ibtidaiyah*, *10*(1), 33. https://doi.org/10.18592/aladzkapgmi.v10i1.3622

Nainggolan, AH., Ahmad PMT, Hafizhul Kh. (2017). Pengaruh Aerasi Bertingkat dengan Kombinasi Saringan Pasir, Karbon Aktif, dan Zeolit dalam Menyisihkan Parameter Fe dan Mn dari Air Tanah di Pesantren Ar-Raudhatul Hasanah. *Jurnal Dampak* 14(1).

Rachmawati, S., Joko, T., & Dewanti, N. (2016). Perbedaan Variasi Penambahan Media Adsorpsi Kontak Aerasi Sistem Nampan Bersusun (Tray Aerator) Terhadap Kadar Besi (Fe) Air Sumur Gali Di Desa Jatihadi Kecamatan Sumber Kabupaten Rembang. *Jurnal Kesehatan Masyarakat (e-Journal)*, *4*(3), 904–910.

Rasman dan Muh. Saleh (2016). Penurunan Kadar Besi (Fe) dengan Sistem Aerasi dan Filtrasi pada Air Sumur Gali (Eksperimen). *Jurnal Higiene 2(3).*

Rivai, A., & Hermanto, A. (2019). Efektivitas Metode Cascade Aerasi Dan Kombinasi Filtrasi Dalam Menurunkan Kadar Besi (Fe) Pada Air Sumur Gali. *Sulolipu: Media Komunikasi Sivitas Akademika Dan Masyarakat*, *17*(1), 89. https://doi.org/10.32382/sulolipu.v18i1.724

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), 1–9.

Sulastri, S., & Nurhayati, I. (2014). Pengaruh Media Filtrasi Arang Aktif Terhadap Kekeruhan, Warna Dan Tds Pada Air Telaga Di Desa Balongpanggang. *WAKTU: Jurnal Teknik UNIPA*, *12*(1), 43–47. https://doi.org/10.36456/waktu.v12i1.825

Syahputra, B. (2018). *Penurunan Kadar Besi (Fe) Pada Air Sumur Secara Pneumatic System (Iron (Fe) Removal in Dug Well By Pneumatic System)*.

Trisetyani, I., dan Sutrisno. (2014). *Penurunan Kadar Fe Dan Mn Pada Air Sumur Gali Dengan Aerasi Gelembung Udara Di Desa Siding Kecamatan Bancar Kabupaten Tuban*. *12*, 35–42.

Ulfa, S., Sulaiman H, Muhammad R. (2019) Pengaruh Tray Aerasi Terhadap Penurunan Kadar Besi (Fe) Air SUmur Bor. *Jurnal Kesehatan Lingkungan 16 (2).*

Warniati, NK., Tony K.T., Dismo K. (2015) Efektivitas Cascade Aerator dalam Menurunkan Kadar Fe dalam Air Tanah. *Jurnal Kesehatan Lingkungan 5 (1).*

Wulandari,S., Nany Dj., Pujiono. 2021.Efektivitas Multiple Platform Aerator terhadap Penurunan Kadar Besi (Fe) pada Air Bersih di PT X. *Jurnal Kesehatan SIliwangi*, 1(2). DOI: https://doi.org/10.34011/jks.v2i2.723.