Effectiveness of Variations in Silica Sand and Activated Carbon Filter Media in Reducing Iron (Fe) Levels in Well Water

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Track Record Article

Accepted: 03 May 2024
Revised: 18 April 2024
Published: 28 June 2024

How to cite :
Prayoga, Y. G., & Wulandari, W. (2024). Effectiveness of Variations in Silica Sand and Activated Carbon Filter Media in Reducing Iron (Fe) Levels in Well Water. *Contagion : Scientific Periodical of Public Health and Coastal Health*, *6*(1), 646–655.

Abstract

Water sources as a basic human need can affect human health, so they must meet the established clean water quality standards. Therefore, the air source used by humans must be guaranteed and protected from metal ions such as manganese (Mn) and iron (Fe) which are excessive for the body. This research aims to determine the effectiveness of variations in filter media arrangements from a combination of silica sand filters and activated carbon to reduce iron (Fe) levels in well water. The method used is quasi experimental with pre-test and post-test. This research was carried out in Balesari, Sukoharjo from October 2023 to March 2024 with the population of this study consisting of 1 community well water which has high levels of iron (Fe). This research uses a quota sampling technique. The instrument used in this research was a laboratory test for iron (Fe) levels. Analysis was carried out using the Anova test and paired T test. This research uses data analysis based on the use of software in the form of the SPSS application. The results of statistical processing carried out on filter media (I) show that the sig value is 0.002. The filter media (II) and (III) show that the sig value is 0.000. This shows that the significance of the three variations in the filter media arrangement of the combination of silica sand and activated carbon has a sig p value ≤ 0.05, so there is a difference in the reduction in iron (Fe) content before and after treatment from the variation in the filter media arrangement of the combination of silica sand and activated carbon for reduce iron (Fe) content in well water. Conclusion, variations in silica sand and activated carbon filter media are effective in reducing iron (Fe) levels in well water in Balesari Sukoharjo. Suggestions for future researchers include the need for additional media that can absorb dissolved iron content, and the need to add appropriate media so that the filtration process runs optimally.

Keywords: Activated carbon, Iron content, Salica sand

INTRODUCTION

Water is a basic need for all living things in the world. All living creatures in this world really need water to survive (Riski et al., 2023). The need for clean water in Indonesia continues to increase because it is in line with the increasing growth of society to meet daily needs (Lestari et al., 2021). Many spring sources can be found, ranging from ground water, rain water and surface water. The properties of the water element for life in the world cannot be replaced by other elements (Butarbutar, 2024). The source of clean water that some people still use for drinking and meeting other household needs is well water (Syuhada et al., 2021).

There are many sources of clean water that can be found, but not all water that looks physically clean can be consumed (Kurniawati et al., 2020). The quality and quantity of clean water that can be used in daily activities must meet the requirements for clean water quality standards (Wang et al., 2024). The quality and quantity of clean water that can be used in daily activities must meet the requirements for clean water quality standards both physically, chemically and biologically (Djana, 2023). Clean water quality standards have been regulated in Minister of Health Regulation No. 2 of 2023 concerning implementing regulations for government regulation No. 66 of 2014 concerning environmental health. The quality standard for iron (Fe) content for hygiene and sanitation purposes is 0.2 mg/L (Kementerian Kesehatan, 2023). The existence of regulations regarding clean water quality aims to prevent the spread of disease through contaminated water (Nipu, 2022; Ashar et al., 2023). The nature of water is that it easily binds metal ions and organic compounds, of course this has a bad impact on life. The function of having regulations is to monitor and prevent the spread of disease (Suprihatin et al., 2022).

Clean water that is safe for consumption must be free from metal ions such as manganese (Mn) and iron (Fe). Even though these two ions are needed by the body, if they exceed the maximum limits for clean water quality standards it will have a negative impact on humans. Water that can be used for human needs must have a neutral pH, a pH range of 6.5-8.5 (Linton et al., 2020).

Based on observations of water characteristics in this study, researchers took samples from the Balesari well water, Sukoharjo. When taking this water, the researchers saw that there was a well water source with the physical characteristics of the water being cloudy, yellowish in color, having a strong iron odor, not tasting fresh, and forming a yellow precipitate when the water was left to sit. Ions such as manganese (Mn) and iron (Fe) are very dangerous if they enter the human body, because they can cause diarrhea and can cause skin irritation if used (Hapis & Sanuddin, 2021). Health problems that will arise from the presence of iron and manganese ions in the body are damage to the intestinal walls and can cause something more serious, namely death (Suratni Afrianti, 2022).

Methods that can be used to reduce iron (Fe) and manganese (Mn) levels in water are aeration, sedimentation, filtration, adsorption and electrocoagulation methods. Airation and filters are very effective methods for reducing Fe and Mn compounds in water (Al Kholif et al., 2020). The filter itself is a process for removing suspended solids and a process for reducing solids as measured by the turbidity of water through porous media (Beshr et al., 2023). This process occurs because the particles cannot enter the pore space, so the particles collect and stick to the surface of the media granules, which makes the water cleaner (Ristiyanto, 2020). In the use of filter media to reduce Fe and Mn levels in water, the media currently used in this research are silica sand, activated carbon, zeolite ceramics and gravel.

Silica sand is one of the mining products that is formed from the weathering of acidic igneous rocks. Apart from that, silica sand has a high composition and SiO_2 content, so it functions as a filter media to reduce turbidity levels in water and iron (Fe) levels (Coenraad et al., 2019). Activated carbon such as charcoal is a good filter for organic chemicals, its properties can absorb tastes and odors in water and can be used as a filter (Ristianingsih Badu et al., 2023). Activated carbon such as charcoal also has great potential to remove heavy metals contained in water such as Fe and Mn (Fatmawati et al., 2021). Activated carbon can be defined as an amorphous carbon compound that has high porosity and area, between 500-2,000m^2/g (Kristianingrum et al., 2020). Activating activated carbon, which is also called activated charcoal, usually only aims to increase its surface area, but there are also efforts to increase the adsorption ability of activated carbon so that it can absorb many impurities in water (Fatmawati et al., 2021).

The function of the presence of gravel and zeolite ceramics in the water filtration process also has its own role, namely to reduce solid particles by utilizing the unique pores in the gravel and zeolite ceramics. Apart from that, the presence of zeolite ceramics in the water filtration process has benefits as purifies water and reduces larger solids and helps reduce the Fe levels contained in water (Mahfuzin et al., 2020).

At the research location, namely in Balesari Sukoharjo, researchers have taken water samples and observed the characteristics of the well water, there is a river water source that is murky, yellowish in color, has a strong iron smell and there is yellow sediment if the water is left, apart from that, based on information obtained from local residents, Previously, this area was a rice field area so the water sources around it contained iron. Therefore, researchers want to reduce the iron (Fe) content in well water. Study conducted by Putriani (2020) shows that the iron content contained in well water can be reduced using the aeration method. In his research, the results of the process of reducing iron levels using the cascade aerator and bubble aerator methods obtained quite good results, namely 0.02 mg/l, with an effectiveness percentage of 98.74%, while for the Bubble aerator the results obtained were 0.43 mg /l with an effectiveness percentage of 76.47%, both methods were successful in reducing iron levels, but these results were still not in accordance with quality standards. In this study, researchers wanted to carry out tests using a different method from previous researchers. In this study, researchers used a filtration method using silica sand and active carbon media to reduce dissolved iron levels in well water taken from Balasari, Sukoharjo. The impact resulting from the presence of dissolved iron in water is very dangerous if it enters the human body, so in this study researchers conducted experiments using various filter arrangements with silica sand and activated carbon as media.

METHODS

In this study, the research design was quasi-experimental with pretest-posttest. The population in this study consisted of 1 community well water in Balesari, Sukoharjo. This research used a quota sampling technique by taking one of the residents' house well water which had high levels of iron (Fe). The intervention provided was in the form of 3 enactments requiring 6 repetitions for each enactment. In variation I the filter media is arranged from above, namely polyester fiber cotton, silica sand, activated carbon, then finally the polyester fiber filter cotton again. In variation II the filter media is arranged from above, namely polyester fiber filter cotton, activated carbon, silica sand and finally polyester fiber filter cotton. In variation III the filter media is arranged from above, namely polyester fiber filter cotton, then silica sand media mixed with active carbon filter media, and finally polyester fiber filter cotton. This research was carried out from October 2023 to March 2024, and the instrument used in this research was a laboratory test for iron (Fe) levels. Analysis was used using the Anova analysis test and the paired T test. This research uses data analysis based on the use of software in the form of the SPSS application.

RESULTS

Table 1. Average content (Fe) before and after the silica sand and activated carbon filter

Repetition	Control	Experiment		
		I	II	III
1	5,6	5,04	4,83	4,44
2		5,09	4,87	4,38
3		4,7	4,55	4,55
4		4,75	4,73	4,93
5		4,26	4,55	4,59
6		4,17	4,61	4,61
Average	**5,6**	**4,67**	**4,69**	**4,58**

Based on table 1 above, it is found that the average iron (Fe) content before and after treatment from variations in filter media compositions from a combination of silica sand and activated carbon to reduce iron (Fe) levels in well water in Balesari, Sukoharjo in 2024 from repetition from the first to the sixth repetition, the average control value for iron (Fe) was 5.6 mg/l.

Meanwhile, the average iron (Fe) after treatment from variations in filter media arrangements (I), (II) and (III) from a combination of silica sand and activated carbon to reduce Iron (Fe) levels in well water in Balesari, Sukoharjo respectively each has a value of 4.67 mg/l, 4.69 mg/l and 4.58 mg/l.

Table 2. Effectiveness of Reducing Iron (Fe) Content in the Treatment of Varying Filter Media Arrangements (I)

Repetition	Before	After	Difference	Effectiveness	Clean water quality standard Fe=0.2 mg/l
1	5.6	5.04	0.56	0.1	>threshold value
2		5.09	0.51	0.09	>threshold value
3		4.70	0.9	0.16	>threshold value
4		4.75	0.85	0.15	>threshold value
5		4.26	1.34	0.24	>threshold value
6		4.17	1.43	0.26	>threshold value
Average	**5.6**	**4.67**	**0.93**	**0.17**	

Based on table 2 above, it is known that the iron (Fe) level after treatment has decreased. The average iron (Fe) content before treatment was 5.6 mg/l and the average after treatment from variations in the filter media arrangement (I) from a combination of silica sand and activated carbon was 4.67 mg/l. The average effectiveness of reducing iron content is 0.17%.

Table 3. Effectiveness of Reducing Iron (Fe) Content in the Treatment of Varying Filter Media Arrangements (II)

Repetition	Before	After	Difference	Effectiveness	Clean water quality standard Fe=0.2 mg/l
1	5.6	4.83	0.77	0.14	>threshold value
2		4.87	0.73	0.13	>threshold value
3		4.55	1.05	0.19	>threshold value
4		4.73	0.87	0.16	>threshold value
5		4.55	1.05	0.19	>threshold value
6		4.61	0.99	0.18	>threshold value
Average	**5.6**	**4.69**	**0.91**	**0.16**	

Based on table 3 above, it is known that the iron (Fe) level after treatment has decreased. The average iron (Fe) content before treatment was 5.6 mg/l and the average after treatment from variations in filter media composition (II) from a combination of silica sand and activated carbon was 4.69 mg/l. The average effectiveness of reducing iron content is 0.16%.

Table 4. Effectiveness of Reducing Iron (Fe) Content in the Treatment of Varying Filter Media Arrangements (III)

Repetition	Before	After	Difference	Effectiveness	Clean water quality standard Fe=0.2 mg/l
1	5.6	4.44	0.16	0.21	>threshold value
2		4.38	0.22	0.22	>threshold value
3		4.55	1.05	0.19	>threshold value
4		4.93	0.67	0.12	>threshold value
5		4.59	1.01	0.18	>threshold value
6		4.61	0.99	0.18	>threshold value
Average	**5.6**	**4.58**	**1.02**	**0.18**	

Based on table 4 above, it is known that the iron (Fe) level after treatment has decreased. The average iron (Fe) content before treatment was 5.6 mg/l and the average after treatment from variations in filter media composition (III) from a combination of silica sand and activated carbon was 4.58 mg/l. The average effectiveness of reducing iron content is 0.18%.

Table 5. Results of the effectiveness of variations in silica sand and activated carbon filter media in reducing iron (Fe) content

Type	Mean	Std Deviation	95% Cl	t	df	Sig
Filter 1	0.93167	0.38437	0.52830 - 1.33503	5.937	5	0.002
Filter 2	0.91000	0.14085	0.76218 - 1.05782	15.825	5	0.000
Filter 3	1.01667	0.19180	0.81539 - 1.21795	12.984	5	0.000

Based on table 5 above, the results of the Paired T Test obtained a significance figure of 0.002 in the T test control test with filter media (I). This shows that the sig P value ≤ 0.05. For the control iron content test results with filter media treatment (II) and (III), a significance result of 0.000 was obtained, indicating a sig P value ≤ 0.05.

DISCUSSION

Initial data from the results of measuring the iron content of well water in this study showed an average (Fe) of 5.6 mg/l and in this study the researchers wanted to see a decrease in dissolved iron levels in the well water of Balasari, Sukoharjo by using media. filters in the form of silica sand and activated carbon. Reducing iron levels in well water requires filtration, this is in line with research conducted by Matsiyevska (2020) which says that the reduction in iron levels in drinking water can be reduced by using the filter method. So in this study the researchers wanted to see whether the differences in arrangement had an effect on the filter results obtained.

In table 1.2, variations in filter arrangement (I) with an arrangement of silica sand media over active carbon media show the results of filtration water with an average iron content of 4.67 mg/l with an average reduction percentage of 0.17%. In table 1.3, variations in filter arrangement (II) from a combination of activated carbon on silica sand obtained a reduction of 4.69 mg/l with an average effectiveness of reducing iron content of 0.16%, and in table 1.4 the final arrangement variation namely filter variation (III), researchers combined or mixed filter media in the form of a combination of silica sand and activated carbon, obtaining filtration results that reduced iron levels to 4.58 mg/l with a reduction percentage of 0.18%.

From the results of this study, based on the data obtained, it shows quite good effects from each treatment with variations in filter media arrangement (I), (II) and (III). The combination of silica sand and activated carbon shows that there is a difference before and after filtration treatment in reducing iron (Fe) levels in well water in Balesari, Sukoharjo. Initial data, the average control value of iron before filtration was 5.6 mg/l and after filtration with filter variations, the best results were shown in the results of filter variation (III) with results obtained of 4.58 mg/l. with a percentage of 0.18%, while the filter variation (I) showed a result of 4.67 mg/l with a reduction percentage of 0.17%, and in the filter variation (II) the results obtained were 4.69 mg/l and a reduction percentage of 0.16%, this shows that the variation in filter (III) has a better combination of silica sand and activated carbon.

This research is in line with research conducted by Fatimura & Masriatini (2019) that the use of a backwash filter using additional ferrolite can reduce dissolved iron levels in well water. In this study the average initial dissolved iron level was 4.58 mg/l to 0.32 mg/l. From this data, using ferrolite and handling the filter by backwashing produces better results than just using filter media in the form of silica sand and activated carbon. as well as on research conducted by Wasistoadi Budiarto (2020) The use of filters using silica sand and active carbon media to reduce iron levels in water obtained good results of 95.07% iron levels being reduced.

The three filter variation arrangements have had good results in reducing dissolved iron levels in well water. From the data obtained in table 1.5 shows a sig P value ≤ 0.05. This can be concluded that there is a difference in the process of reducing iron levels with The filtration method uses silica sand and active carbon media, but the results of this filtration still do not meet the quality standard requirements for dissolved iron content in clean water which have been regulated in Minister of Health Regulation No. 2 of 2023 concerning implementing regulations for government regulation No. 66 of 2014. The dissolved iron content is 0.2 mg/L. The lack of results obtained in this study could be caused by the filter media used in this study, in small quantities, so that filtration using silica sand and activated carbon was not optimal in helping to reduce the levels of dissolved iron in well water.

CONCLUSIONS

Based on the results of research that has been carried out, variations in silica sand and activated carbon filter media are effective in reducing iron (Fe) levels in well water in Balesari Sukoharjo, with the best data results resulting from filtration being shown in filter variation III with the results obtained being 4. 58 mg/l with a percentage of 0.18% water. However, the data from this test still does not meet the quality standard requirements that have been regulated in Minister of Health Regulation No. 2 of 2023 concerning implementing regulations for government regulation No. 66 of 2014. The dissolved iron content is 0.2 mg/L.

Suggestions for future researchers include the need for additional media that can absorb dissolved iron content, and the need to add appropriate media so that the filtration process runs optimally.

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