JPPIPA 9(9) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Effect Mass of Silica Sand on Reducing Fe Concentration in Water Purification Systems

Nadia Natalia Simamora[1*], Suparno[1]

[1] Department of Physics Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia.

Received: March 13, 2023
Revised: August 8, 2023
Accepted: September 25, 2023
Published: September 30, 2023

Corresponding Author:
Nadia Natalia Simamora
nadianatalia.2022@student.uny.ac.id

DOI: 10.29303/jppipa.v9i9.3416

Abstract: This study aims to determine the effect of silica sand mass in the air purification system on the decrease in Fe concentration. The type of research used is experimental research. The water purification media used in the research were silica sand and gravel. The mass of gravel used in the water purification system is constant, namely 500 grams. The mass of silica sand used varies, namely 200 grams, 400 grams, 600 grams, 800 grams and 1000 grams. The research was carried out through three stages, namely the stages of preparation, implementation, and data collection. The effect of the mass of silica sand in the air purification system on decreasing the concentration of Fe showed positive results. The results of research with a fixed mass of gravel and varying masses of silica sand showed a decrease in Fe concentration after water purification with a value that met environmental health quality standards and water health requirements Fe (iron) content below 1 mg/L or ppm so that the water worth using.

Keywords: AAS; Fe concentration; Water purification

Introduction

The natural resource needed by all living things, including humans, is water. Water is a basic element for human life (Saniti, 2012; Zahra et al., 2017). In Indonesia, surface water is one of the most widely used sources of raw water, due to the abundant availability of water (Volentino, 2013; Suryani, 2016). This natural water resource must be put to good use by humans and kept clean and fit for use. The use of water for various purposes must be done wisely, taking into account the interests of future generations (Dewa, 2015; Khaira, 2016). Humans in everyday life always use water.

Water suitable for use has certain standard requirements. These standards include physical, chemical and bacteriological requirements, and these conditions are one unit, so that if there is only one parameter that does not meet the requirements then the water is unfit for use (Purwoto & Sutrisno, 2016; Adeko, 2018; Adeko & Ermayendri, 2019). The characteristics of water that is suitable for use are clear, colorless, tasteless, odorless, does not contain pathogenic germs and all living things that endanger human health, does not contain chemicals that can change body functions, does not leave sediment in all distribution networks, does not corrosive and others (Musli & de Fretes, 2016; Sunarti, 2016). This aims to prevent the occurrence and spread of water-borne diseases.

One of the parameters that must be measured to determine water quality is a physical parameter. Kementrian Kesehatan Republik Indonesia (2017) no. 32, concerning environmental health quality standards and water health requirements, there are several parameters that must be examined, including turbidity levels with a maximum level of 25 NTU, TDS (Total Dissolved Solid) dissolved solids with a maximum standard of 1000 mg/L, and maximum iron content 1mg/L. A decrease in water quality can be indicated by an increase in the levels of measured physical parameters. For example, when the levels of color parameters increase, the color of the water changes from brown to black, indicating the presence of chemicals such as metal iron, manganese and cyanide originating from factory waste disposal (Mukarromah, 2016; Masriatini et al., 2019).

How to Cite:
Suparno, S., & Simamora, N. N. (2023). Effect Mass of Silica Sand on Reducing Fe Concentration in Water Purification Systems. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7527–7532. https://doi.org/10.29303/jppipa.v9i9.3416

Total dissolved solid (TDS) is the amount of material dissolved in water. TDS can be used to estimate the quality of drinking water, because it represents the number of ions in the water (Cahyani et al., 2016; Agustina, 2022). To find out the value of TDS can use a standard tool, namely the TDS meter. The World Health Organization (WHO), the drinking water purity standard is a TDS level below 100 ppm (Raghavan et al., 2017). Good water has a TDS level of less than 300-600 ppm (Part Per Million), which has relatively small mineral components (Arvind et al., 2020). If water has a TDS level of 900-1200 ppm (Parts Per Million) or more, it means that the water contains relatively large minerals and is hazardous to health (Pant et al., 2019). Indonesia also issued a TDS Standard by the Ministry of Health of the Republic of Indonesia and the Indonesian National Standard (SNI), namely a maximum TDS value of 500 ppm (Lavanaya & Parameswari, 2018; Irawan et al., 2019).

The amount of metal content is also a requirement in determining water quality, one of which is ferrous metal (Fe). Fe metal is an essential metal whose presence in certain amounts is needed by living organisms, but in excess it can cause toxic effects (Dewa, 2015; Yudo, 2018). The high content of Fe metal will have an impact on human health which can cause poisoning (vomiting), intestinal damage, premature aging to sudden death, arthritis, birth defects, bleeding gums, cancer, kidney cirrhosis, constipation, diabetes, diarrhea, dizziness, fatigue , hepatitis, hypertension, insomnia (Adeko & Jubaidi, 2021). To measure the amount of Fe metal content in water, you can use an AAS (Atomic Absorption Spectrometer).

Atomic Absorption Spectrometry (AAS) is a tool that is familiar in chemical assays because it has high capability with a low consumption of time, cost, and energy to obtain a fairly good test precision (Irzon & Kurnia, 2013). Atomic Absorbance Spectrometry (AAS) was chosen because it is commonly used for testing element levels in general (Lajunen & Permaki, 2004; Irzon & Kurnia, 2013). Heavy metal analysis was carried out using Atomic Absorption Spectrophotometry (AAS) which is based on the Lambert-Beer law, namely the amount of light absorbed is directly proportional to the level of substance (Warni et al., 2017).

This research was conducted to complement previous research. One of them is the research conducted by Mukarromah et al. (2016) regarding the analysis of the physical properties of water quality in the tamarind springs, Kalijeruk hamlet, Siwuran village, Garung sub-district, district. Furthermore, research conducted by Wonosobo Nainggolan et al. (2017) regarding the effect of multilevel aeration with a combination of sand filters, activated carbon, and zeolite in setting aside Fe and Mn parameters from groundwater at the Ar-Raudhatul Hasanah Islamic Boarding School. Then research conducted by Hindratmo et al. (2021) regarding the content of heavy metals in rivers and soil in several areas of Hila Village, Romang Islands, Southwest Maluku District.

Based on research that has been done by previous researchers, there has been no research on the effect of silica sand mass in water purification systems on decreasing Fe concentrations. Therefore, researchers conducted a study to complement previous research with the aim of knowing the effect of silica sand mass on decreasing Fe concentrations in water purification systems.

Method

This type of research is an-experimental research. All planning to answer research and anticipate difficulties that may arise during the research process is a research design. This research was conducted from September to December 2022 located at the Colloid Laboratory, Faculty of Mathematics and Natural Sciences, Yogyakarta State University. The sample for this research is water taken at Jl. Ambarukmo, Caturtunggal, Kec. Depok, Sleman Regency, Special Region of Yogyakarta. The water purification media used in the research were silica sand and gravel. The research was carried out through three stages, namely the stages of preparation, implementation, and data collection. In the preparation stage, the tools and materials needed are a 2-inch plastic pipe with a length of 50 cm, a water tap, 6 250 ml plastic bottles, 1 liter plastic bottle, digital balance, 3 kg of gravel, and 3 kg of silica sand. At the implementation stage, the research was carried out by first dividing the gravel into 6 parts with a mass of 500 grams, then silica sand was divided into 5 parts with a mass of 200 grams, 400 grams, 600 grams, 800 grams and 1000 grams. Water purification was carried out with a fixed mass of gravel and a varied mass of silica sand. After the results of water purification were obtained, measurements were carried out using AAS in the laboratory to determine the concentration of Fe. The data obtained from the results of laboratory examinations were processed manually using a calculator and presented in the form of tables and graphs and then analyzed descriptively, namely for the effect of mass of silica sand on Fe concentrations in water purification systems. The research flow can be seen in Figure 1.

Figure 1. Research Flow

Based on Figure 1, it states that research begins with finding research ideas that are explored through literature study and then designing research. Next, tools and materials are prepared for conducting research. Fe concentration was studied using the AAS tool. The results obtained were then analyzed to obtain conclusions from the research carried out.

Result and Discussion

This study aims to examine the effect of silica sand on Fe concentrations in water purification systems. Data obtained from laboratory results using AAS (Atomic Absorption Spectrometry) to measure the concentration of Fe in water before and after water purification. In the water purification system, the materials used are gravel and silica sand. The mass of gravel used in the water purification system is constant, namely 500 grams. The mass of silica sand used varies, namely 200 grams, 400 grams, 600 grams, 800 grams and 1000 grams. The first water purification is carried out with 500 grams of gravel. The second water purification is carried out with 500 grams of gravel and 200 grams of silica sand. The third water purification is carried out with 500 grams of gravel and 400 grams of silica sand. The fourth water purification is carried out with 500 grams of gravel and 600 grams of silica sand. The fifth water purification is carried out with 500 grams of gravel and 800 grams of silica sand. The sixth water purification is carried out with 500 grams of gravel and 1000 grams of silica sand. The results of research using AAS in the laboratory can be seen in table 1.

Tabel 1. Results of measurements of Fe concentrations

Treatment	Ingredient	Fe concentrations (ppm)	
		Before	After
I	Pebbles 500 grams	0.1322	0.1212
II	Pebbles 500 grams Silica sand 200 grams	0.1322	0.1019
III	Pebbles 500 grams Silica sand 400 grams	0.1322	0.0964
IV	Pebbles 500 grams Silica sand 600 grams	0.1322	0.0909
V	Pebbles 500 grams Silica sand 800 grams	0.1322	0.0874
VI	Pebbles 500 grams Silica sand 1000 grams	0.1322	0.0854

Based on the results of measuring the concentration of Fe using AAS in table 1 shows that before water purification the concentration of Fe contained in the water was 0.1322 ppm. After the first water purification was carried out, the concentration of Fe in water was 0.1212 ppm. The third water clarification resulted in an Fe concentration of 0.1019 ppm. The third water purification obtained Fe concentration of 0.0964 ppm. The fourth water purification obtained a Fe concentration of 0.0909 ppm. The fifth water purification obtained a Fe concentration of 0.0874 ppm. The sixth water purification obtained a Fe concentration of 0.0854 ppm. The concentration of Fe in the water before the purification system was carried out was quite high compared to after the water purification was carried out. In graphical form the decrease in Fe concentration after water purification is more clearly visible, the graph can be seen in Figure 2.

The graph of the results of measuring the concentration of Fe in water has decreased after purifying the water with 6 treatments. The results of the water purification system using gravel and silica sand have met environmental health quality standards and water health requirements, namely the maximum Fe (iron) content of 1 mg/L or ppm. Fe or iron metal is an essential metal whose presence in certain amounts is needed by living organisms, but in excessive amounts it can cause toxic effects. Water containing iron will be yellow and cause a metallic taste of iron in water, and corrode metal materials. Iron is one of the elements which is the result of weathering of parent rock which is commonly found in public waters. A water purification system using gravel and silica sand can reduce excess iron concentrations in water so that the water is fit for consumption without any negative impact on body health.

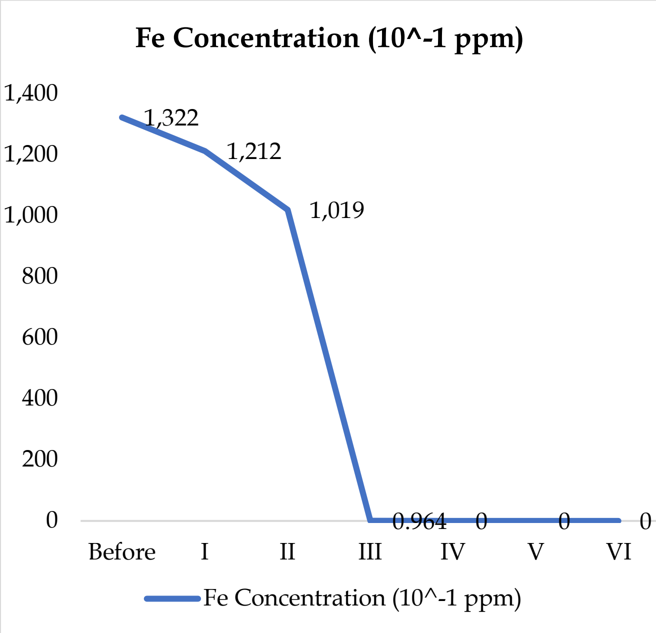

Figure 2. Graph of Fe concentration measurement results

Silica sand is one of the most commonly used filtration media in water purification systems. The use of silica sand in a water purification system aims to remove contaminants such as particles dissolved in water, including Fe (iron). The reduction in Fe concentration in a water purification system will depend on several factors, including the mass of silica sand used. The more mass of silica sand used in the water purification system, the greater the ability of the system to remove Fe from the water. However, too much mass of silica sand can also have a negative impact on system performance. If the mass of silica sand is too much, it will hinder the flow of water and cause the contact time between water and silica sand to be longer. This can result in the growth of bacteria and mold in the system, as well as reduce the efficiency of the water purification system.

High or low concentrations of Fe (iron) in the body can have both positive and negative impacts on human health. The positive impact of Fe concentration on health is oxygen transportation, namely Fe plays a role in the formation of hemoglobin, a protein that helps transport oxygen from the lungs throughout the body. With sufficient Fe concentration, a person can have sufficient oxygen supply to all organs and tissues of the body. Then energy metabolism, Fe plays a role in the process of energy metabolism, namely the conversion of food into energy that can be used by the body. Fe also plays an important role in the growth and development of body cells, especially in children and adolescents. Besides the positive impact, there are also negative impacts caused by Fe concentrations on health, namely concentrations of Fe that are too high in the body can cause hemochromatosis, a condition characterized by excessive accumulation of Fe in organs such as the liver, heart, and pancreas. Then hemochromatosis can cause organ damage and increase the risk of heart disease, diabetes, and cancer. Then the concentration of Fe that is too low can cause anemia, a condition characterized by a low number of red blood cells or low hemoglobin levels. Anemia can cause fatigue, shortness of breath, and other health problems. Too high concentrations of Fe in the brain can cause neurological disorders, such as Parkinson's and Alzheimer's. In the right amount, Fe is very important to maintain human health. However, too high or low concentrations of Fe can have a negative impact on health. Therefore, it is important to maintain the balance of Fe concentrations in the body.

Conclusion

The effect of mass of silica sand in the water purification system on decreasing the concentration of Fe showed positive results. The results of research with a fixed mass of gravel and varying masses of silica sand showed a decrease in Fe concentration after water purification. Fe metal is needed by living organisms in certain amounts, but in excess amounts can cause toxic effects. The results of the Fe concentration after water purification show a value that meets environmental health quality standards and water health requirements for Fe (iron) content below 1 mg/L or ppm so that the water is fit for use.

Author Contribution

Suparno: Methodology, and writing—original draft preparation. Nadia Natalia Simamora: Conceptualization, original draft preparation, writing—review and editing, formal analysis, and investigation.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

Adeko, R. (2018). Pengaruh Cangkang Kopi sebagai Adsorben dalam Menurunkan Kadar Besi (Fe) pada Air Sumur Gali. *Journal of Nursing and Public Health*, *6*(2), 85-88. https://doi.org/10.37676/jnph.v6i2.641

Adeko, R., & Ermayendri, D. (2019). Kombinasi Limbah Batu Bara Dan Limbah Cangkang Kopi Sebagai Adsorben dalam Menurunkan Kadar Besi (Fe) Pada

Air Sumur Gali. *Journal of Nursing and Public Health*, *7*(1), 30-34. https://doi.org/10.37676/jnph.v7i1.759

Adeko, R., & Jubaidi, J. (2021). Variasi Kombinasi Ketebalan Cangkang Bintaro Dan Biji Kapuk Dalam Penurunan Tingkat Besi (Fe) Di Sumur Gali Warga Rawa Makmur, Kota Bengkulu. *Journal of Nursing and Public Health*, *9*(1), 82-88. Retrieved from http://repository.poltekkesbengkulu.ac.id/2731/

Agustina, E. (2022). Pengaruh Eco-Enzyme pada Air Baku Sungai Borang Palembang Terhadap Nilai Parameter Conductivity, Total Dissolved Solid (TDS), dan Zat Organik. *Jurnal Kolaboratif Sains*, *5*(6), 284-289. https://doi.org/10.56338/jks.v5i6.2382

Arvind, A., Paul, R., & Bhulania, P. (2020). Implementation of water quality sensing system using internet of things. In *2020 7th International Conference on Signal Processing and Integrated Networks (SPIN)*, 1025-1028. Retrieved from https://ieeexplore.ieee.org/abstract/document/9070832/

Cahyani, H., Harmadi, H., & Wildian, W. (2016). Pengembangan alat ukur Total Dissolved Solid (TDS) berbasis mikrokontroler dengan beberapa variasi bentuk sensor konduktivitas. *Jurnal Fisika Unand*, *5*(4), 371-377. https://doi.org/10.25077/jfu.5.4.371-377.2016

Dewa, R. P. (2015). Analisa Kandungan Timbal (Pb) dan Kadmium (Cd) Pada Air Minum Dalam Kemasan Di Kota Ambon. *Majalah Biam*, *11*(2), 76-82. http://dx.doi.org/10.29360/mb.v11i2.2052

Irawan, Y., Fernando, Y., & Wahyuni, R. (2019). Detecting Heart Rate Using Pulse Sensor As Alternative Knowing Heart Condition. *Journal of Applied Engineering and Technological Science (JAETS)*, *1*(1), 30-42. https://doi.org/10.37385/jaets.v1i1.16

Irzon, R., & Kurnia, K. (2013). Kondisi Temperatur, Waktu, dan pH reaksi untuk Mengoptimasi Prosedur Standar Analisa Platinum dengan Ekstraksi Atomic Absorption Spectrometry. *Jurnal Geologi dan Sumberdaya Mineral*, *14*(4), 51-58. https://doi.org/10.33332/jgsm.geologi.v14i4.78

Kementrian Kesehatan Republik Indonesia. (2017). *Peraturan Menteri Kesehatan Republik Indonesia No.32 Tahun 2017*. Jakarta: Menteri Kesehatan Republik Indonesia.

Khaira, K. (2016). Analisis kadar Tembaga (Cu) dan Seng (Zn) dalam air minum isi ulang kemasan galon di kecamatan Lima Kaum kabupaten Tanah Datar. *Sainstek: Jurnal Sains dan Teknologi*, *6*(2), 116-123. http://dx.doi.org/10.31958/js.v6i2.111

Lajunen, L.H.J. & Peramaki, P. (2004). *Spectrochemical Analysis by Atomic Absorption and Emision*. 2nd ed., Finland.

Lavanaya, M., & Parameswari, R. (2018, August). Soil Nutrients Monitoring for Greenhouse Yield Enhancement Using Ph Value with Iot and Wireless Sensor Network. In *2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT)*, 547-552. Retrieved from https://ieeexplore.ieee.org/abstract/document/8753083/

Masriatini, R., Sari, N., & Imtinan, Z. (2019). Analisa Kualitas Fisik Air Sungai Lematang di Kabupaten Lahat. *Jurnal Redoks*, *4*(1), 27-35. https://doi.org/10.31851/redoks.v4i1.3072

Mukarromah, R., Yulianti, I., & Sunarno, S. (2016). Analisis Sifat Fisis Kualitas Air Di Mata Air Sumber Asem Dusun Kalijeruk, Desa Siwuran, Kecamatan Garung, Kabupaten Wonosobo. *Unnes Physics Journal*, *5*(1), 40-45. Retrieved from https://journal.unnes.ac.id/sju/index.php/upj/article/view/13637

Musli, V., & de Fretes, R. (2016). Analisis Kesesuaian Parameter Kualitas Air Minum Dalam Kemasan Yang Dijual Di Kota Ambon Dengan Standar Nasional Indonesia (SNI). *Arika*, *10*(1), 57-74. Retrieved from https://ojs3.unpatti.ac.id/index.php/arika/article/view/429

Pant, D., Bhatt, A., Khan, M., Nautiyal, O. P., & Adhikari, P. (2019). Automated IoT based Smart Water Quality Assessment System. In *2019 8th International Conference System Modeling and Advancement in Research Trends (SMART)*, 98-104.

Purwoto, S. P., & Sutrisno, J. (2016). Pengolahan Air Tanah Berbasis Treatment Ferrolite, Manganese Zeolite, dan Ion Exchange. *WAKTU: Jurnal Teknik UNIPA*, *14*(2), 21-31. https://doi.org/10.36456/waktu.v14i2.134

Raghavan, S. S., Loganathan, V., Rathod, V., & Sharvani, G. S. (2017). Cloud enabled water contamination detection system. In *2017 2nd International Conference on Computational Systems and Information Technology for Sustainable Solution (CSITSS)*, 1-4.

Saniti, D. (2012). Penentuan alternatif sistem penyediaan air bersih berkelanjutan di wilayah pesisir Muara Angke. *Jurnal Perencanaan Wilayah dan Kota*, *23*(3), 197-208. https://doi.org/10.5614/jpwk.2012.23.3.2

Sunarti, R. N. (2016). Uji kualitas Air minum isi ulang disekitar kampus UIN Raden Fatah palembang. *Bioilmi: Jurnal Pendidikan*, *2*(1). https://doi.org/10.19109/bioilmi.v2i1.1116

Suryani, A. S. (2016). Persepsi Masyarakat Dalam Pemanfaatan Air Bersih (Studi Kasus Masyarakat

Pinggir Sungai Di Palembang). *Aspirasi*, *7*(1), 33-48. https://doi.org/10.46807/aspirasi.v7i1.1278

Volentino, D. (2013). Kajian Pengawasan Pemanfaatan Sumberdaya Air Tanah di Kawasan Industri Kota Semarang. *Jurnal Wilayah Dan Lingkungan*, *1*(3), 265-274. https://doi.org/10.14710/jwl.1.3.265-274

Warni, D., Karina, S., & Nurfadillah, N. (2017). Analisis Logam Pb, Mn, Cu dan Cd Pada Sedimen di Pelabuhan Jetty Meulaboh, Aceh Barat. *Jurnal Ilmiah Mahasiswa Kelautan Perikanan Unsyiah*, *2*(2). Retrieved from https://jim.usk.ac.id/fkp/article/view/4862

Yudo, S. (2018). Kondisi pencemaran logam berat di perairan sungai DKI Jakarta. *Jurnal Air Indonesia*, *2*(1). https://doi.org/10.29122/jai.v2i1.2275

Zahra, F., Fitriah, A. A., & Basuki, F. R. (2017). Rancang Bangun Filter Air Cocoes Jaguar Untuk Mengolah Air Gambut Di Desa Sungai Tering, Kecamatan Nipah Panjang, Kabupaten Tanjung Jabung Timur, Jambi. *EduFisika*, *2*(2), 12-17. Retrieved from https://online-journal.unja.ac.id/EDP/article/view/4141