Reduction of iron and manganese concentration in dug well water by using Moramo beach sand as filter media

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Abstract. Well water treatment with aeration-filtration method using the spray aerator and rapid sand filter in decreasing levels of iron (Fe) and manganese (Mn) has been carried out. This study aims to determine the effectiveness of Moramo beach sand in decreased levels of Fe and Mn after aeration-filtration processing. Characterization of Moramo beach sand minerals using XRF showed that SiO₂ content of 98.68%, which means that it is qualified as silica sand. Measurement of concentration of Fe and Mn by using Atomic Absorption Spectroscopy (AAS) method. After the aeration-filtration processing, levels of Fe and Mn can be decreased to be 0.072 mg/L and 0.012 mg/L respectively. The results indicated that the concentrations of Fe and Mn have been under the threshold level of the Health Minister Regulation No. 492/Menkes/IV/2010 of ≥ 0.3 mg/L of Fe and ≥ 0.4 mg/L for Mn. In this case, the effectiveness of treatment in reduce of Fe and Mn ions could be 92.46 % and 98.82% respectively. It implied that Moramo beach sand is potential to be used as a filter media to reduce Fe and Mn concentration in dug well water.

1. Introduction

Indonesia has a lot of natural resources potential. That potential consist of oil, gas, and minerals. Among of mineral materials there are oxide materials that have potential for high technology application such as ZnO, SiO₂, MgO, Al₂O₃, TiO₂. Oxide material especially silica (SiO₂) has been applied in various fields, such as the main material in glass industry and filter media [1].

Silica sand is mineral that consist of silica cristaline (SiO₂) and contain impurities compound that is carried out during sedimentation process. The composition of silica sand are SiO₂, Fe₂O₃, Al₂O₃, TiO₂, CaO, MgO, and K₂O. The characteristic of this mineral usually white colour or other dependent of its impurities, 7 mohs in hardness, density 2.65 kg/m³, melting point 17-15°C, crystalline form hexagonal, specific heat 0.185 with purity 95-97% [2].

Silica sand often be used for raw water treatment to produce clean water. The best sand which is used for filtration if silica content in the sand is greater than 90% [3]. In general, the source of raw water is dug well. Based on data of Central Bureau of Statistics of Kendari [4] shows that 67.90% community of Kendari City used dug well water as source clean water to fulfill their life necessary such as drinking, cooking, washing and bathing. However, dug well water sometimes contain iron and manganese ions, so the water looks yellowish or brownish after contact with oxygen [5]. Based on the Health Minister Regulation No. 492/Menkes/IV/2010 mentioned that maximum level of iron in clean water is 0.3 mg/L, whereas level of manganese is 0.4 mg/L [6].

There are some methods that is used to reduce iron and manganese ions from dug well water such as oxidation, coagulation, electrolytic, ion exchange, aeration, filtration, and aeration-filtration. The last
mentioned often be used to reduce iron and manganese ions in dug well water. Aeration is water treatment method with contacted by oxygen/air. Aeration method has been used for water treatment widely. The aeration process used spray aerator continued with sedimentation process or filtration. Filtration is separation between solid or colloid with water [7]. Water filtration is performed by flow water through the filter media. In general, the filter media that freqently used for water filtration is silica sand. Silica sand can be found along the coast and river at Southeast Sulawesi Province. However, it is not yet known how much silica is contained in the sand. So, we interested in research about mineral characterization of sand from Moramo beach, Southeast Sulawesi Province and its application as a filter media in water treatment to reduce iron and manganese ions by using aeration-filtration method. In this research we use spray aeration and fast sand filtration.

2. Experimental Method
This research used Moramo beach sand as filter media in filtration process. First of all, the sand was washed by using clean water for 15 times to remove impurities that is contained in the sand. After that sand was dried under the sun during 1 day to remove water level in the sand. Furthermore, sand sample was dried using electrical oven at 200°C for 40 minutes to remove more impurities in the pore of sand. The dried sand was sieved using sieve of 60 mesh and 35 mesh, so the final size of the sand between 60 mesh and 35 mesh. Until this process, the sample sand has been ready to be characterized by using spectrometer X-Ray Fluorescence (XRF) to get information about mineral composition of the sand.

Filtration process is performed by using spray aerator and fast sand filtration with various thickness of filter media (15 cm, 30 cm and 45 cm). And finaly, measurement of iron and manganese concentration in water by using Atomic Absorption Spectrophotometry (AAS). The measurement was done at before and after of filtration.

3. Results and Discussion
3.1. Mineral characterization of Moramo beach sand

| No | Type of compound | Content (%) |
|----|-----------------|-------------|
| 1  | SiO$_2$         | 98.68       |
| 2  | K$_2$O          | 0.435       |
| 3  | Fe$_2$O$_3$     | 0.386       |
| 4  | CaO             | 0.186       |
| 5  | TiO$_2$         | 0.143       |
| 6  | NaCl            | 0.067       |
| 7  | Nb$_2$O$_3$     | 0.0282      |
| 8  | MoO$_3$         | 0.0201      |
| 9  | ZrO$_2$         | 0.0165      |
| 10 | In$_2$O$_3$     | 0.0085      |
| 11 | SnO$_2$         | 0.0083      |
| 12 | RuO$_4$         | 0.0076      |
| 13 | Sb$_2$O$_3$     | 0.0060      |

Characterization of Moramo beach sand by using X-Ray Fluorescence (XRF) shows that Moramo beach sand contain silica (SiO$_2$) as a main mineral and folowed by other minerals such as showed at Table 1. From the table it can be seen that silica content in Moramo beach sand is 98.68%. The silica content is very high, so the Moramo beach sand belongs to the category of silica sand as mentioned in [2] that silica sand is the sand with silica content more than 95%. The silica sand is a porous material and it is suitable as a filter media.
3.2. Measurement result of iron and manganese in water

Based on the measurement result of iron and manganese in dug well water before and after treatment process is such as showed at Table 2.

| Type of ion   | Dug well water | Treated water | Standard * |
|--------------|----------------|---------------|------------|
|              | Thickness of filter media |               |            |
|              | 15 cm      | 30 cm | 45 cm |            |
| Iron (Fe)    | 0.971      | 0.230 | 0.092 | 0.073 | 0.3 |            |
| Manganese (Mn)| 1.051      | 0.052 | 0.021 | 0.012 | 0.4 |            |

*) Permenkes No. 492/Menkes/Per/IV/2010

Table 2 shows the iron and manganese concentration in dug well water before and after treated using aeration-filtration method and Moramo beach sand as filter media with various thickness (5 cm, 30 cm and 45 cm). Based on the table it can be seen that iron and manganese concentration in treated water is not only reduced, but also already below the threshold value of the standard. The reduction of iron and manganese content in treated water is in line with the increasing of thickness of filter media. It means that thicker filter media is in line with the effectiveness of the water treatment such as shown at Figure 1.

![Figure 1. Relationship of treatment effectivity to the thickness of filter media](image)

Figure 1 shows the relationship of treatment effectivity to the thickness of filter media for reduction of iron and manganese in dug well water. From Figure 1 it can be seen that treatment effectivity to various of thickness of filter media for iron are 76.27 %, 89.88 % and 92.46 %, whereas for manganese are 94.97 %, 97.93 % and 98.82% respectively. There are two mechanism of reduction of Fe and Mn concentration in well water namely filtration and absorption. Filtration is the physical mechanism in which the Fe and Mn ions are trapped by the gap between grains of sand. In this case, the grain size and thickness influence the filtration process where the smaller grain size and thicker of the sand, the more iron ions trapped in the filter media. The absorption is the chemical mechanism in which the Fe and Mn ions are absorbed by the pores of sand. So the more pores of the sand, the more Fe and Mn ions are absorbed by the sand [8]. Based on the results of this research shown that sand of Moramo beach which is used as filter media
for treatment of dug well water by using aeration-filtration method can reduce iron and manganese content in dug well water effectively. Thus Moramo beach sand is quite potential to be used as a filter media in dug well water treatment.

4. Conclusion
The silica ($\text{SiO}_2$) content of Moramo beach sand is $98.68\%$. It means Moramo beach sand belongs to the category of silica sand. Moramo beach sand which is used as filter media for treatment of dug well water by using aeration-filtration method can reduce iron and manganese content in dug well water effectively. The reduction of iron and manganese content in treated water is in line with the increasing of thickness of filter media. This research is ongoing to improve the characterization of Moramo beach sand by activation of the sand using microwave, in order to reduction effectivity of iron and manganese is better.

5. Acknowledgments
This research is funded by Directorate of Research and Community Service, Ministry of Research, Technology and High Education through research grant No. 056/SP2H/DRPM/2018.

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