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IMPROVING IRON AND MANGANESE QUALITY IN GROUNDWATER WITH NATURAL FILTERS METHOD

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Detail Artikel

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Kata Kunci

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.A B S T R A K

Warga di RT 001 / RW 013, Kecamatan Pasie Nan Tigo, Kota Padang pada umumnya telah memanfaatkan air tanah untuk kebutuhan sehari-hari namun airtanah tersebut tidak dapat digunakan untuk minum, mencuci pakaian dan mandi karena air terlihat keruh, berpasir dan bau unpleasat. Jika kondisi air seperti ini biasanya disebabkan oleh kelebihan kandungan zat besi dan mangan di dalam air tersebut. Berdasarkan permasalahan tersebut maka dibuatlah filter air alami untuk mengolah air tersebut dengan menggunakan pasir, kerikil, ijuk, arang tempurung kelapa dalam skala rumah tangga. Tujuan dari penelitian ini adalah untuk mengetahui efektivitas filter air alami dalam menghilangkan zat besi dan mangan dalam air tanah. Material filter alam yang digunakan dalam penelitian ini disusun dengan ketebalan yang bervariasi. Sedangkan untuk penentuan kadar besi dan mangan pada sampel dilakukan dengan metode Standar Nasional Indonesia 06-6989.4-2004 dan 6989.5: 2009. Hasil uji tiga sampel airtanah sebelum dan sesudah penyaringan menunjukkan penurunan kadar besi dan mangan yaitu 58,21% dan 91,58%. Nilai besi dan mangan pada sampel setelah dilakukan pengujian masih dibawah baku mutu air minum.
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A B S T R A C T

The resident in RT 001/ RW 013, Pasie Nan Tigo Subdistrict, Padang City generally has used the groundwater for daily need but that groundwater can not be used for the drinking, washing the clothes and for a bath because the water looked turbid, sandy and unpleasat odor. If the water condition like these conditions, it is usually caused by the overlimit of iron and manganese level in that water. Based of that problems we made natural water filter to treat that water by using sands, gravel, palm fiber, coconut shell charcoal in household scale. The aim of this research is to know the effectiveness of natural water filters to remove the iron and manganese in the ground water. Natural filter material used in this study was arranged with varying thichnesses. As for determining the levels of iron and manganese in the sample carried out by the method of National Indonesian Standar 06-6989.4-2004 and 6989.5:2009. The results of three groundwater sample tests before and after filtering showed the reducing iron and manganese levels namely 58,21 % and 91,58 %. The value of iron and manganese in the sample after being tested is still below the quality standart for drinking water.

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INTRODUCTION

Water is a source of human life and the other creatures. The water quality is one of the problems in RT 001/RW 013 Pasie Nan Tigo Village which consists of 30 (thirty) families. These families still used the groundwater for daily needs. That groundwaters has cloudy, sandy and emit an unpleasant odor. So, almost 70% the people in RT 001/RW 013 do not use the groundwater as a source of drinking water but they only use for washing the clothes. This has been going for years, and for the drinking needs, they commonly have consumed buying refill gallon water. Several analyzes of water quality in the Pasie Nan Tigo sub-district have been investigated by researchers such as analysis of temperature, iron content, pH, levels of chloride and ammonia levels that have been carried out at groundwater sources in Muhammadiyah University of West Sumatra, Padang and the results of the five parameters are still at a level that is appropriate for consumed [1][2]. Another research about groundwater also investigated at Kubu Babussalam Sub-District, Rokan Hilir, Riau. Brownish yellow had commonly colour of the groundwater samples, and it had minimum quality standart of the lowest pH and Fe. The number was 3,8 for lowest pH of groundwater and 2.21.mg was for the highest of Fe content. It means that it was below of the quality standart on Regulation of Minister of Health of Republic of Indonesia no.416/MEN.KES/PER/IX/1990 [3].

One of the clean water resources used by humans is still using water from groundwaters. Groundwater is a part of rainwater that reaches the earth surface and seeps into the soil and becomes groundwater. Before reaching the groundwater, rain water will penetrate several layers of soil and cause the water contain mineral substances in certain concentrations. These mineral substances include calcium, magnesium and heavy metal such as iron. As a result, if we use water that contains high iron and manganese, the yellow crust will form on the faucet pipe and the water will smell as well.

The quality of groundwater can be seen in two seasons Indonesia rainy and dry season. In the rainy season, the water that seeps into the soil can reduce the concentration of existing pollutants. In the dry season, the waste water as a waste seeps into the soil is more dominantly, which can cause the decreasing of water quality. Part of the groundwater in RT 001/RW 013 have an average depth of 1(one) meter to 2(two) meters. From the pre-test result indicates that the content of iron and manganese levels in that area does not fulfill the requirements which was released by The Minister of Health of Republic of Indonesia no. 32, 2017 related to standart of environmental and the water health requirements for hygiene sanitation, swimming pools, water solutions and public baths.

Groundwater often contains large amounts of iron and manganese. The presence of iron and manganese in water causes the color of the water turns into yellow-brown after a while of contact with air. These metals are accumulative, especially in the filtering organs so that it can interfere with the body's physiological functions. The aesthetic can also damage the presence of this metal because it causes black spots on clothes. Water pollutes by this metal usually appears at a high color intesively in water, the color is yellow and even brownish red, and the tastes bitter or sour. Therefore, the Regulation of Minister of Health of Republic of Indonesia no. 32, 2017 gave the rule that the maximum permissible level (Fe) in consumed water is 1 mg/L, and the permissible level of (Mn) in consumed water is 0,5 mg/L[4].

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Mairizki *et.al* also investigated the quality of groundwater in Bengkalis by using geochemistry approach in Coastal of Bengkalis City, they found that most of the groundwater in that area did not allow the requirement of clean water and consumed water [5].

Iron or manganese in water is generally in the form of Fe^{2+} or Mn^{2+} ions as a water soluble and colorless compound. If the water is in contact with air, the Fe^{2+} or Mn^{2+} ions will slowly be oxidized to become ferric compounds (Fe^{3+}) or mangandioxide (Mn^{4+}) compounds which are insoluble in water. These compounds are brown in color and can cause unpleasant odors and tastes. In developing countries such as America and Japan, the regulations on consumed water quality standarts are even more stringent. The maximun allowable total iron and manganese content in consumed water is 0,3 ml/L. To overcome this problem, it needs to be made to provide a household scale water treatment system that can eliminate or reduce iron and manganese content in well water or groundwater. One way to improve the quality of groundwater is by using a natural filter such as sands, gravel, palm fiber, coconut shell charcoal in household scale. This natural filters are easily to find or get, such as sand, gravel, and testing the extent to which iron and manganese levels can be decreased by using natural filters.

The main aim to do water treatment is not only to decrease the problem from biological, chemical and physical contaminants by decreasing them into permitted levels but also to ensure the water is in aesthetically high quality such as the colour, odour, and clearness of the water do not cause bad influence to the consumers. The research about water treatment have been carried out by reserachers such as by using geochemical modeling of the vyredox method, they investigated the connection of oxygen levels and rates of precipitation on manganese and iron. The model used was PHREEQC through radial and linear flow in order to see the performance of geochemical simulations. It was found that oxygen concentration is high enough to precipitate the level of iron and manganese found in groundwater at the water field (at its corresponding partial pressure). According to the PHREEQC, the oxygen concentration was 12,3 mg/L in equilibrium air at their desired temperature of 6 degree centigrade[6]. Another researcher using limestone filter with iron-oxidized bacteria for removing the iron and manganese in groundwater [7], using nanofiltration and ultrafiltration [8], using membran filtration [9], biofiltration [10]. The presence of iron may also occur due to the corrosion in Fe pipes for water distribution system [11]. Potassium permanganate (PP) and sedimentation were used to remove the iron and manganese from groundwater. They used conventional treatment by added alum, flocculation, sedimentation and filtration could remove up the iron (97%) and manganese (18%). However by using PP, it found that the alum increase the removal of manganese but alleviate the iron removal. Alum also enhanced pH to 10 leads to 100% and 95% of Fe^{2+} and Mn^{2+} removal, and enhances the of filter working. [12].

In this research, we tried to make the natural filtration with using such as sands, gravel, palm fiber, coconut shell charcoal in household scale. These tools were easy to get in our surrounding and also using with a certain thickness. Here, we did the eximination to know the decreasing of iron and manganese contents.

RESEARCH METHOD

Chemical, Apparatus and Methods

Chemical

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Distilled water, HNO nitric acid, ferrous metal (Fe) standard solution, acetylene gas. Manganese metal with a purity of 99.0%, acetylene gas with a minimum pressure of 100 psi, a nitric acid diluting solution 0.05 M, a 5% (v / v) nitric acid washing solution, calcium solution, compressed air.

Apparatus

Atomic Absorption Spectrophotometer, Fe and Mn hollow cathode lamp, 250 mL beaker, measuring pipette 5 mL, 10 mL, 20 mL, 30 mL, 40 mL, 60 mL, 100 mL volumetric flask, glass funnel, electric heater, Whatman 40 filter paper, with a pore size of 0.42 µm, spray flask, pH universal indicator paper, thermometer and other glassware.

Procedures

This research was conducted at the Padang Health Laboratory Center Gunung Pangilun Padang West Sumatra where groundwater samples were taken in the area of RT 001 / RW 013 Pasie Nan Tigo Village, as many as 3 samples were physically cloudy and yellow.

The procedure of making the natural filter

The preparation of the tools and materials for the manufacture of water filters were using natural materials, namely: drums, carts, buckets, pipes, measuring cups, markers, meters, stopwatches, gravel, fibers, coconut shell charcoal, and pipe glue. The method for making the water filter was simple, namely: a) Prepare the tools and materials to be used; b) Cut the top of the drum to put in the filter materials, namely gravel, palm fiber, sand, and charcoal, coconut shell; c) The bottom side of the drum was perforated ± 5 cm from below the surface; d) Wash the filter materials to be used and then dry them; e) Put the material into the drum and arrange according to the thickness plan sketch according to Figure 4 below; f) Enter dirty water, compare the water that is put in with that which was collected [13].

Figure 1. Height and thickness measurements in drums [13]

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Table 1.Measurement parameters

No	Measurement Parameter	Reference method
1	Iron	SNI 06-6989.4-2004 [14]
2	Manganese	SNI.6989.5:2009 [15]

Analysis of Iron Levels

Test preparation

Preparation of test samples

a. Enter 100 mL of the shaken sample until homogeneous into the beaker
b. Add 5 mL of nitric acid
c. Heat in an electric heater until the sample solution is almost dry
d. Add 50 mL of distilled water and put it in a 100 mL volumetric flask through filter paper and get 100 mL with distilled water.

Preparation of iron metal standard solution, Fe 100 mg / L

a. Pipette 10 mL of ferrous metal mother liquor, Fe 1000 mg / L into a 100 mL volumetric flask
b. Accurate with a marker diluent solution
c. Preparation of a standard solution for ferrous metal, Fe 10 mg / L
d. Pipette 50 mL of standard solution of ferrous metal, Fe 100 mg / L to a 500 mL volumetric flask
e. Accurate diluent solution mark into the limit mark

Preparation of iron metal working solutions, Fe

a. 0 mL pipette; 5, 10, 20, 30, 40 and 60 mL standard solution of iron, 10 mg / L of Fe, respectively, into a 100 mL volumetric bottle.
b. Add diluent solution until the mark is right so that the iron concentration is 0.0 mg / L; 0.5; 1.0; 2.0; 4.0 and 60 mg / L.
c. Calibration curve creation procedure
d. Optimize the SSA tool according to the instructions for using the tool.
e. Measure each work solution that has been made at a wavelength of 248.3 nm.
f. Create a calibration curve to get the equation for the regression line.
g. Continue measuring the prepared sample.

Calculation

Iron metal concentration, Fe (mg / L) = C x fp

With the understanding:

C is the concentration obtained from the dilution

fp is the dilution factor

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Percent of retrieval (% recovery,%)

$$\% R = \frac{A-B \times 100\%}{C}$$

with understanding

A is the level of the specimen spiked;

B is the unspiked sample grade;

C is the standard level obtained (target value) [8]

Analysis of Manganese Levels

Preparation of test samples

Prepare a test sample for testing total manganese, with the following steps:

a. Homogenize the test sample, pipette 50 mL test sample and put it in a 100 mL beaker;
b. Add 5 mL of concentrated nitric acid, cover with a watch glass.
c. Heat slowly until the remaining volume is 15 mL -20 mL;
d. If the digestion is not clear (not clear), then add another 5 mL of concentrated HNO3, then cover the beaker with a watch glass and reheat it not boiling. Do this process repeatedly until all the metal dissolves, which can be seen from the color of the precipitate in the test sample to be slightly white or the test sample becomes clear;

Preparation of manganese metal, Mn 100 mg / L

a. Weigh 0.1 g of manganese metal =, put it in a 1000 mL volumetric flask;
b. Add a mixture of 10 mL of concentrated HCl and 1 mL of concentrated HNO3 until dissolved;
c. Add mineral-free water to the mark, homogenize
d. Recalculate the actual level based on weighing.

Preparation of Manganese metal standard solution, Mn 10 mg / L

a. Pipette 10 mL of standard solution of manganese metal, Mn 100 mg / L to a 100 mL volumetric flask
b. Accurate diluent solution into limit mark and homogeneous.

Preparation of manganese metal working solutions, Mn

Make a series of working solutions with 1 (one) blank and at least 3 (three) levels that differ proportionally and are in the measurement range.

Creation of calibration curves and measurement of test samples

Calibration curve creation

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a. Optimize the SSA tool according to the instructions for using the tool.
b. Measure each work solution that has been made at a wavelength of 279.5 nm.
c. Create a calibration curve to get the equation for the regression line.
d. Continue measuring the prepared sample.

Calculation

Manganese metal concentration, Mn (mg / L) = C x fp

With the understanding:

C is the concentration obtained from the dilution

fp is the dilution factor [9]

Measurement was conducted on samples before and after filtration with using natural filters. After that we calculated the percentage calculation of removal of iron and manganese levels.

The removal percentage can be calculated by using the following formula:

$$\sum p\% = \frac{\text{initial Fe level} - \text{final Fe level}}{\text{Initial Fe Level}} \times 100\%$$

RESULTS AND DISCUSSION

Generally, water in nature contains iron and manganese caused by direct contact between the water and the soil layer contains iron (Fe) and manganese (Mn). The presence of iron (Fe) and manganese (Mn) in excess amount in water can raise various problems including the taste of consumed water, it can precipitate and add to turbidity. The concentration of iron and manganese in water soil can have a metallic taste or smell on the water, therefore for water drink high levels of iron and manganese ones are allowed, namely 1 mg / L each and 0.5 mg /L according to the Regulation of Minister of Health of Republic of Indonesia no. 32, 2017 [10].

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Figure 2. Natural filter and drum with height and thickness measurements

Various studies on the reduction of iron content in existing groundwater, this research was carried out by using natural filter that easy to get surrounding as an alternative in order to reduce iron and manganese content in groundwater. In general, filtration is a process that is often used in clean water treatment to separate impurities (particulates) that are present in water. In the process, water leaks pass through the filter media, so it will accumulate on the filter surface and accumulate along the depth of the media through it.

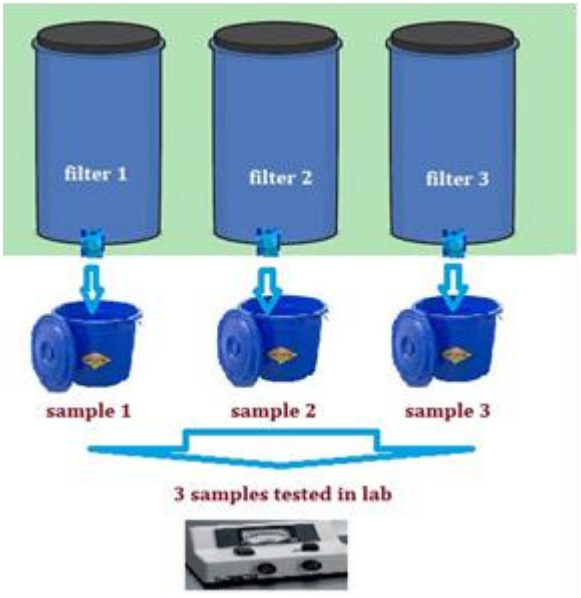

Figure 3. Before and After Sample measurement treatment with Natural Filters

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Based on the general process, the researcher tried to do the treatment in this research by passing the sample water through the filter media ceramics. Groundwater samples were taken from three different sampling points, where to each sample were differentiated based on the distance between the points and the depth of the water source at every house. The sampling point in this study can be seen in Table 2 below.

Table 2. Sampling points based on the location and depth of the sample

Sample	Distance between sampling point	Depth groundwater
Sample 1	-	25 m
Sample 2	25 m	23 m
Sample 3	50 m	20 m

Sampling in research were differentiated based on the depth of the water sample taken. The distance between Sample 1 and Sample 2 ranged from 25 m with the depth of the water source 25 m, sample 2 and 3 ranged also from 25 m with the depth of the water 23 m, sample 3 has 20 depth of the water.

After taking the water samples, then we tested levels of iron and manganese contained in sample water. Preliminary analysis results showed that each groundwater source of three these different samples were found metal elements or organic substances, namely iron (Fe) and manganese (Mn) which exceeded the quality standard that is required. This indicated that the water source was polluted and didnot fullfil the requirements of clean water quality according to Regulation of Minister of Health of Republic of Indonesia no. 32, 2017. So that the research next wass to test the iron content and manganese by using natural filters.

As mentioned in preliminary, that the taking area groundwater samples The area in RT 001/RW 013 Pasie Nan Tigo was once a swampy area. Swamp areas generally contain content high iron. This has been proven with preliminary research, where the content ferrous metal (Fe) and manganese (Mn) ones exceeded the quality standard of clean water quality which have been set. The advanced research stage was carried out with how to analyze a filtered sample using natural filters. The results sample analysis before and after treatment the iron (Fe) ion can be seen in the table 3.

Table 3. Analysis Results of Measurement of Iron Level (Fe) before and after being given treatment

Tested Sample	Fe before filtering (mg/L)	Fe after filtering (mg/L)	Difference (before and after)
Sample 1	0,028	0,028	0
Sample 2	0,034	0,028	0,028
Sample 3	0,067	0,028	0,039

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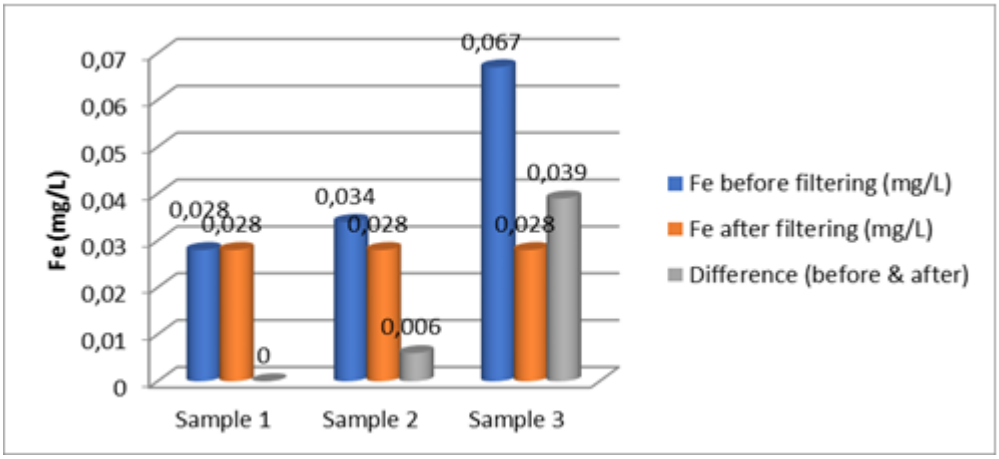
The table 3 shows that the value of iron content before doing filtering is in the range of 0,028 - 0,067 mg/liter. The value of this iron content is still fulfill the permitted quality standard, namely 1 mg / liter. Results of research on iron levels decrease after using the natural filters, where the difference range from 0 to 0,0039. The decreasing of iron level in groundwater can be seen in Figure 4 below.

Figure 4. The Decreasing of iron levels (Fe) in groundwater



Meanwhile, the measurement of manganese (Mn) on the water sample obtained can be seen in table 4 below.

Table 4. Results of Level Measurement Analysis Manganese (Mn) before and after being given treatment

Tested Sample	Mn before filtering (mg/L)	Mn after filtering (mg/L)	Difference (before and after)
Sample 1	0,038	0,013	0,025
Sample 2	0,425	0,05	0,375
Sample 3	0,641	0,054	0,587

The table 4 shows that the value of manganese content before doing filtering is in the range 0,038 – 0,641 mg /L. One of these manganese content samples is above the permitted quality standard, namely 0,5 mg/L. The results of the research on manganese levels are decreased after using the natural filter, where the difference range is from 0,025 to 0,587.

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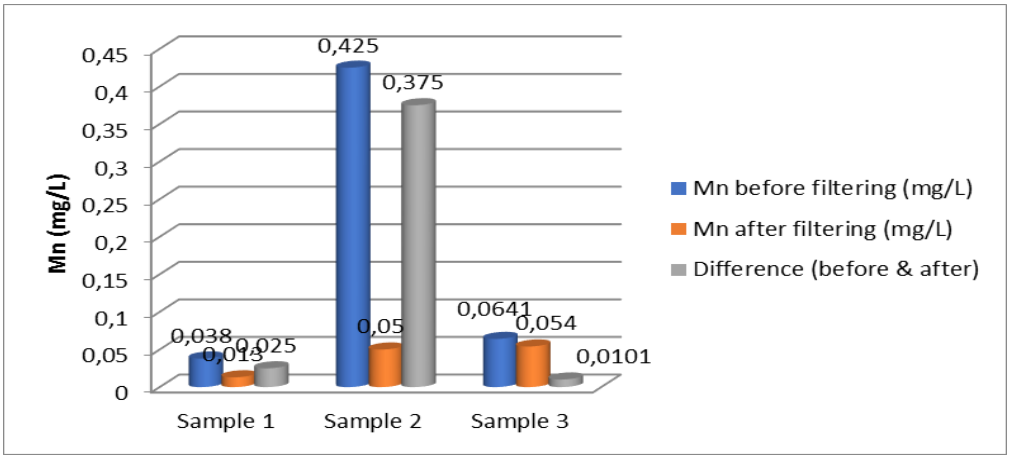
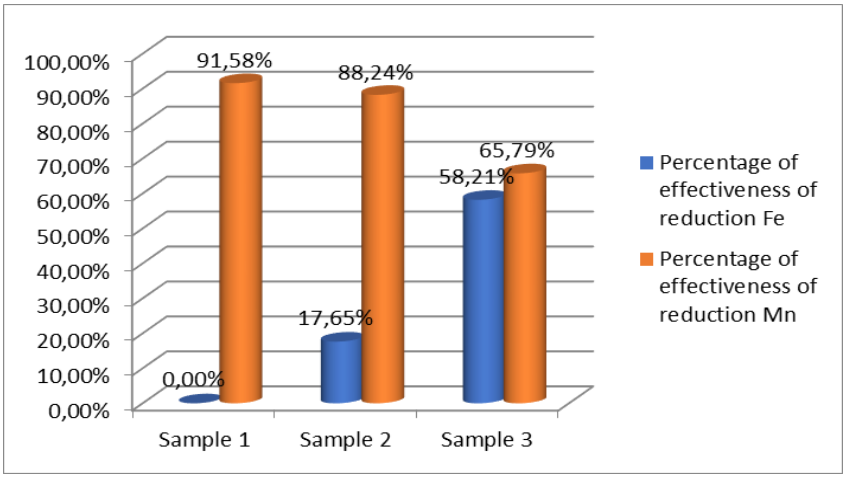
Figure 5. The Decreasing of manganese levels (Mn) in groundwater



The percentage of the effectiveness of iron (Fe) and manganese (Mn) reduction is shown in Figure 6 below.

Figure 6. Table of percentage of effectiveness of iron (Fe) and manganese (Mn) reduction



The Figure 6 shows that the percentage of effectiveness of iron reduction is ranged from 0% - 58,21% and manganese is ranged from 65,79% - 91,58%. The operation time of this research was 2 h with the result that the maximum removal efficiency of Fe is 81,72% and Mn 83.63%. Iron oxidized bacteria catalyze the oxidation of adsorption process as well as the dissolved Fe(II) and Mn(II) to undissolved Fe(III) and Mn(IV) [7]. For metal rejection, these membranes have performed higher removal on Fe with TS40, TFCSR3 and GHSP membranes are having more than 82%, 92% and 86% respectively. Whereas, removal on Mn only achieved up to 60%, 80% and 30%, for TS40, TFC-SR3 and GHSP membranes respectively [10]. Using PP, it found that the alum increase the removal of manganese but

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alleviate the iron removal. Alum also enhanced pH to 10 leads to 100% and 95% of Fe^{2+} and Mn^{2+} removal, and enhances the of filter working period [12].

Chemical parameter test that has been carried out to the content of Fe and Mn can be concluded that the farther is soil depth from the water source, then the lower the metal content produced. This is possibly caused by the presence of layers rock and sand (particles smooth) which inhibits adsorption of levels metal into the most subsoil in. This situation makes a process filtration against Fe and Mn runs naturally, so the amount of Fe and Mn found in groundwater surface is bigger compare with groundwater in the deepest layers. In terms of yield water quality, natural filtering produces usable water as a source of water for consumed / utilized. This natural filter can be an alternative simple processing for the public to fulfill the requirements of clean water.

CONCLUSION

Based on the results and discussion obtained it can be concluded as follows:

1. Natural filter such as gravel, palm fiber, coconut shell charcoal could reduce the levels of iron (Fe) and manganese (Mn) in groundwater with decreased Fe-total by 0,045 mg/L, with an average of 0,015 mg/L and total the effectiveness of Fe is 58,21%. The decrease level in Mn-total was 0,4101 mg/L, with an average 0,137 mg/L and the total effectiveness of Mn amounted to 91,58%.
2. The groundwater treatment by using natural filters are effective for lowering iron ions (Fe) and manganese (Mn) and already in accordance with water quality standards clean for consumption.

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