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The Effectiveness of Using Alum Made of Uncoated Aluminium Foil Waste on the Containing of Dig Well Water that Contains High Metal Iron and Manganese into Clean Water

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Abstract: ***Water is a primary need that is very important for human life. In the results of observations in the Banjarsari village, researchers found that all residents still use dug well water for various activities, and it contains high levels of iron and manganese so that some people have added alum in their wells to get clear water. The aim of this research is to find out how much effective alum made from uncoated aluminum foil waste is to improve the characteristics of dug well water compared to use commercial alum so that it can provide information for the public to get clean water that meets standard quality. Research shows that the use of alum with the same dose of 800 ppm turns out to be more effective than alum made of uncoated aluminum foil. Well water processed using alum made from uncoated aluminum foil decreased the pH value by 11.6%; Pt-Co color value decrease 66.66%; decrease in NTU 89.3%; decrease in TSS 61.81%; a decrease in Fe 60.88% and a decrease in Mn 40.23% while using commercial alum there was a decrease in the pH value of 13.04%; Pt-Co color value is 74.24%, NTU decrease is 92.76%; decrease in TSS 66.86%; Fe decreases 62% and Mn decrease 46.46%. From the research results, the parameters of pH, color, NTU and TSS have met the standards of the Minister of Health, while the metal parameters of Fe and Mn have not met the standards.***

Keywords: effectiveness, alum, aluminum foil, well water, iron, manganese

1. Introduction

Water is a primary need that cannot be ignored for all living things. Clean water in terms of its quality meets the standards according to its designation, while polluted water can be toxic to both humans and other living things [1]. Fulfillment of water needs in Indonesia can generally be done by taking from surface water, from the ground or from rainwater. For certain areas in Indonesia, many people use underground water to fulfill their daily needs, both for cooking, bathing and washing (MCK), although sometimes it does not meet the quality to be used in fulfilling the necessities of life. The quality of groundwater in each place is not the same depending on the mineral content around the excavation; it also depends on the depth of the well.

Researchers conducted a field survey in the hamlet of Banjarsari by taking several well water samples and then analyzing the levels of Fe and Mn. From the analysis results, the average content of iron (Fe) varies around 4.55 mg/l, while the content of Manganese (Mn) is obtained around 3.25 mg/l. The well water is physically yellowish in color and has an unpleasant odor and causes a yellowish-brown crust on the walls and pipes. The quality of the well water clearly does not meet the standards that have been set, however, due to forced circumstances; the well water is still used for bathing, washing, the needs of livestock and plants except for drinking and cooking.

Based on these problems, the researchers will continue the first phase of research that has been carried out and at the node carrying uncoated aluminum foil waste can be used as raw material to produce alum using 3M KOH and 5 M H_2SO_4 reagents and obtain a maximum yield of 63.69%. The alum produced was then tested for its effectiveness in the tofu industrial liquid waste. With the use of 800 ppm alum, it can reduce the color content of the Pt-Co unit by 60%, the decrease in NTU by 95.8% and the decrease in TDS by 63.33% [2]. Based on the effectiveness test, the research continued to the second stage by utilizing alum from the first stage of research to test the effectiveness of well water in Banjarsari hamlet which contains high levels of iron (Fe) and manganese (Mn) and then compared its effectiveness with commercial alum. Fe and Mn metals in well water are water-soluble compounds, so by using alum it is expected that iron and manganese will coagulate so that they are easily separated or filtered.

Several studies have been conducted [3] utilizing coagulants from used cans for acid mine water treatment and concluded that using 1.5 grams of coagulant from used cans can reduce TSS 62.47%, Fe metal 13.13%, Mn 35.49% and a change in pH of 3.06%, [4] using alum and clay to reduce Fe and Mn levels by using a combination of 2 g/l clay and 200 mg/l alum can produce the best treated water although not all parameters analyzed meet the requirements. the maximum allowable level while [5] by using the same number of doses it turned out that the effectiveness of using alum from rote recycling was greater than using commercial alum in terms of reducing TSS and turbidity. [6] Testing the effectiveness of alum from used beverage cans in a water purification unit using 300 ppm alum can reduce NTU 98.45% and TDS 78.24%. By using alum to reduce TSS levels in coal wastewater [7] concluded that the more use of alum the greater the decrease in TSS will occur. Comparing the use of alum and PAC to reduce Fe levels in dug wells [8] found that PAC was more effective than alum and obtained PAC effectiveness of 79.38% while alum was 69.72%, while [1] stated that alum produced from aluminum can waste can absorbs Ca metal with an effectiveness of 42.25% and Mg 62.12%. From the research that has been done, the researcher will try to use alum from previous research to treat dug well water which contains high levels of Fe and Mn metals.

The purpose of this research is to find out how much effective alum made from aluminum foil uncoated waste is on improving the characteristics of dug well water compared to using commercial alum so that it can provide information for the public so that they can get water that meets standard quality.

2. Literature Review

Groundwater is a form of water that is in the soil which is generally found in the soil layer, both close to the ground surface and far from the ground surface. Groundwater is a source of clean water but sometimes it is cloudy and dirty depending on the pollutant and the conditions around it. Shallow groundwater or also called phreatic groundwater is the easiest groundwater to obtain because it is located closest to the ground surface, which is approximately 9 to 15 meters deep. Phreatic type groundwater mostly has major constituents with a content of 1.0 – 1000 mg/l. The content of each component is not the same at one point with another depending on the condition of the surrounding soil, so this type of phreatic i water cannot be drunk directly and must undergo processing stages first.

Dug wells are one of the construction wells that are commonly used to collect groundwater for the people of Indonesia to meet their daily water needs with a depth of 7 - 10 meters from the ground surface. Well water can be said to be clean if it meets three parameters, namely physical parameters which include odor, taste, color and turbidity then chemical parameters include organic and inorganic chemistry such as iron, manganese, magnesium, calcium, sodium chromium, sulfur, phosphate and so on. The third parameter is bacteriological parameter which includes fecal coliform and total coliform [9]. The mineral that is often found in large amounts is Fe and if the amount is too large it will be a nuisance to the environment and should not be consumed. According to [10] Permenkes RI no. 32 of 2017 concerning environmental health quality standards and water health requirements for sanitation hygiene purposes, the maximum permissible level of Fe is 0.3 mg/L, while Mn has a maximum concentration of 0.1 mg/l. At sufficiently high concentrations, iron and manganese can cause an unpleasant taste or odor in water and according to the US EPA Standards the permissible levels of iron and manganese are 0.3 mg/l and 0.05 mg/l, respectively.

Iron and Manganese Compounds

Iron (Fe) is a chemical element that is commonly found on earth in both soil and water bodies. Iron is a metal group that is in group VII B in the periodic system of elements with an atomic weight of 55.85, a specific gravity of 7.86 with a melting point of 2450^0C. In the soil layer, it is found in the form of hematite, magnetite, limotite and pyrite iron ores, while in water it is generally in the form of dissolved compounds or in the form of colloidal suspensions as Fe^{+2} (Ferro) usually in the form of FeO, Fe_2SO_4, $FeSO_4$. $7H_2O$, $FeCO_3$, Fe $(OH)_2$, $FeCl_2$ and so on or in the form of Fe^{+3} (Ferry) such as $FePO_4$, Fe_3O_3, $FeCl_3$, Fe $(OH)_3$). Iron at a concentration of >1.0 mg/l causes brownish water, produces an unpleasant taste and can cause brown deposits on pipes, walls or equipment [11] [12].

In drinking water, the iron content is limited to a maximum of 0.3 mg/l, this is determined based on health reasons as well as aesthetic reasons. Water with iron content above 0.3 mg/l causes water to be brownish yellow in color, has a sharp smell, a combination of iron and earthy odors, and the water feels slippery and can cause brown deposits on pipes and walls [13].

Manganese (Mn) is a metallic element in group VII B with an atomic weight of 54.93 and a melting point of 1247^0C. Manganese is generally in the form of compounds with various valances, manganese is found in water with valence 2, valence 4 and valence 6 [11] [12]. Manganese compounds that have high solubility in water are $MnCl_2$, $MnSO_4$, and Mn $(NO_3)_2$ salts, while $MnCO_3$, Mn $(OH)_2$ compounds, although they have a valence of 2, both compounds are relatively difficult to dissolve in water.

In natural water systems, iron and manganese compounds are always changing depending on the level of acidity (pH) and oxygen levels in the water [13]. Under reducing conditions, in general, iron and manganese have a valence of two which are soluble in water. In the water treatment system, iron and manganese with a valence of 2 will be oxidized so that they can be converted into compounds of iron and manganese with a greater valence and are insoluble in water, thus making it easier to separate. Iron levels that exceed drinking water quality standards can cause several disturbances, including health problems that can cause nausea, damage to the intestinal wall that can even cause death, physical problems such as color and technical problems that cause corrosive properties.

The coagulation process is the process of clumping colloidal particles into larger flocs and the absorption of dissolved organic matter in the floc so that the impurities present in the water can be separated through a filtering process [14]. Aluminum sulfate [Al_2 $(SO_4)_3.18H_2O$] or better known as alum, lime and chlorine is widely used as a coagulant in water treatment plants because it can precipitate colloidal particles and other polluting materials so that precipitation occurs [15]. Turbidity in water can be minimized by adding other types of coagulants such as ferrous sulfate, Poly Aluminum Sulfate (PAC) and organic polyelectrolytes [5].Coagulation consists of three stages, namely the formation of a floc nucleus, colloid destabilization and particle size enlargement which are the principles widely used in wastewater treatment processes [16]. Alum is a white crystal in the form of gelatin which can attract fine-sized particles so that their weight, size and shape become larger so that they easily settle [17]. The use of alum as a coagulant in the waste treatment process can be done by dissolving it in water first and then mixing it into the water or waste to be processed and stirring homogeneously so that the release of water molecules and ions bound to the alum crystals will be scattered between the molecules. water that acts as a solvent, with the following reaction equation:

$$KAl\ (SO_4)_3.12H_2O\ (s)\ +\ Air\ \rightarrow\ K^+\ (aq)\ +\ Al^{+3}\ (aq)\ +\ 2SO_4{}^{-2}\ (aq)\ +\ 12\ H_2O\ (l)$$

The aluminum ion (Al^{+3}) formed in solution will undergo a hydrolysis reaction and form a colloidal compound Al $(OH)_3$, with the following reaction equation:

$$Al^{+3}\ (aq)\ +\ 3H_2O\ (l)\ \rightarrow\ Al\ (OH)_3\ (s)\ +\ 3H^+\ (aq)$$

The suspended particles will coalesce and form large clumps so that they are deposited more quickly [18].

3. Research Method

The research method used is a descriptive experimental method. Basically, this research is a continuation of the first stage of research, which is to find the best conditions for the manufacture of alum made from uncoated aluminum foil using KOH solution and H_2SO_4 as a reagent. From the first stage of research, it was concluded that using 3 grams of uncoated aluminum then dissolved into 100 ml of 3 M KOH and 100 ml of 5 M H_2SO_4 can produce a maximum yield of 63.69% with Al_2O_3 content of 15.18%. In this study, two stages were carried out where the first stage was the manufacture of alum which was used as a flocculant and the second stage was testing the effectiveness of alum against well water with high levels of Fe and Mn metals and then compared its effectiveness with commercial alum.

Stages of making alum made of uncoated aluminum foil

The aluminum foil that has been cleaned of dirt and then cut into pieces is then weighed 3 grams of uncoated aluminum foil and put into a 500 ml Erlenmeyer then added 100 ml of 3M KOH solution then heated on a hot plate at 70^0C while stirring until the gas bubbles formed run out and all the aluminum has melted. The solution obtained was then cooled and filtered using filter paper. Then the filtrate obtained was added slowly with 100 ml of 5 M H_2SO_4 solution and heated to a temperature of 70^0C until a clear solution was obtained and filtered using whatman 41 filter paper. The obtained solution was then cooled gradually to a temperature of 3^0C until white alum crystals were obtained. The crystals obtained were then washed using 50 ml of 50% ethanol which aims to speed up drying and then put into an oven with a temperature of 105^0C then the results were weighed and quality tests were carried out.

Effectiveness test stage for well water

The experiment was carried out with a Jar Test in Batch. The alum produced from the first phase of the experiment was then applied to well water with high levels of ferrous metal using experimental alum and commercial alum, respectively, 200 ppm, 400 ppm and 600 ppm and 800 ppm. 250 ml of well water was put into a 600 ml glass beaker then stirred using a Jar Test at a speed of 100 rpm for 1 minute then followed by slow stirring at 50 rpm for 10 minutes and followed by a sedimentation process for 20 minutes in an Imhoff cone so that the flocs formed were formed can precipitate. Well water that has been separated from the formed floc was analyzed according to the observed parameters (pH, color, NTU, TSS, iron content and manganese content).

4. Results and Discussion

Alum characteristics of uncoated aluminum waste

From the experimental results of making alum made from waste aluminum foil uncoated which is reacted using a 3M KOH solution and a 5 M H_2SO_4 solution, it was found that alum has a fairly good quality compared to commercial alum where the Al_2O_3 content of experimental alum is 15.18% while commercial alum contains Al_2O_3 18.9% where the difference is only 19.57%. Table 1 shows the characteristics of experimental alum made from uncoated aluminum foil (Potassium aluminum sulfate) and commercial alum (Aluminum sulfate).

Table 1: Comparison of characteristics of alum

Characteristic	Experimented Alum	Commercial Alum
Formula	KAl $(SO_4)_2.12H_2O$ (Kalium aluminium sufat)	Al_2 $(SO_4)_3.14H_2O$ (Aluminium sulfat)
physical form	Slightly yellowish crystal	Crystal
Odor	Odorless	Odorless
pH	3, 6	3, 5
Al_2O_3	15, 18%	18, 9%

Source: Primer Data, 2022

Characteristics of Dug Well Water used by the sample

The results of the analysis of dug well water samples taken from community wells in Banjarsari hamlet as many as 20 points were then mixed in a tub and stirred perfectly, then a preliminary analysis of the characteristics of the water was carried out with 2 replications then averaged and the results can be seen in table 2.

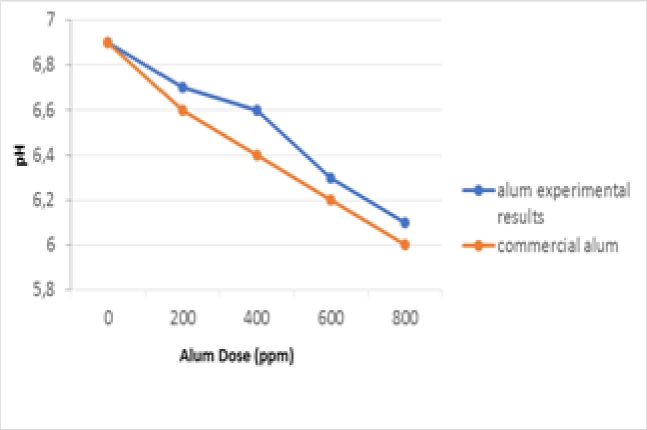
Table 2: Characteristics of the initial dug well water sample

No	Parameters	Units	Maximum Dosis Allowed*	Analysis Result**
1	pH	mg/l	5, 6 – 9, 0	6, 9
2	Color	Pt Co	50	110
3	Odor		Odorless	Bad odor
4	Taste		Tasteles	Rusty taste
5	Amount of Dissolved Solids	mg/l	1000	1320

6	Turbidity	NTU	5	86
7	Fe	mg/l	1, 0	4, 55
8	Mn	mg/l	0, 5	3, 25

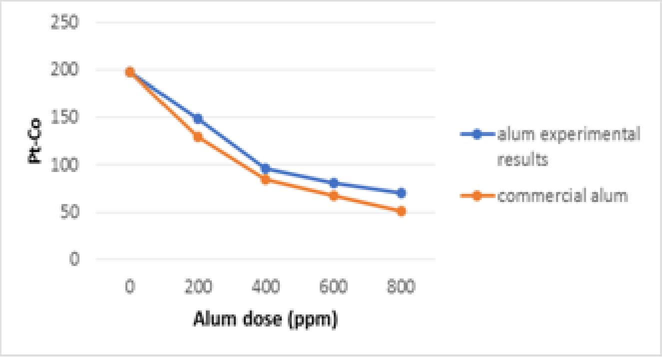
*Permenkes RI no 32 tahun 2017
**Primer Data, 2022

From the results of the preliminary analysis of dug well water, several parameters were found that did not meet the standards set by the Indonesian Ministry of Health, including color, taste, dissolved solids, turbidity, iron content and manganese content. If the water in these conditions is used for cooking and drinking in the long term, it will have a negative impact on health. In order to be used for meeting daily needs, the water must be processed first, one of which is by using alum as an absorbent material and agglomerating dissolved solids and their metal content. With the use of alum made from uncoated aluminum foil waste from the results of previous studies through the process of coagulation of dissolved and suspended solids in water so that it can be used for cleaning well water so that it can change the characteristics of dug well water easily, simply and cost-effectively. In the test of the effectiveness of the alum experimental results, an analysis of several parameters was carried out. The results of the effectiveness of the experimental alum applied to dug well water in Banjarsari hamlet then compared the results of the effectiveness test on commercial alum and the results are shown in graph 1 to graph 6.



Graph 1: Decrease in pH of dug well water after using alum

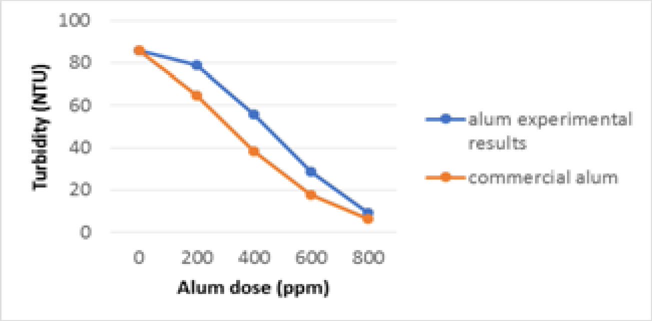
The pH value of the well water before being processed was 6.9 while the alum used had a pH of 3.5 – 3.6, the larger the dose of alum used the lower the pH of the processed well water. The use of alum dose of 200 ppm obtained the highest pH value for both experimental use of alum and commercial alum use, while with increasing use of alum dose the pH value of water decreased. From table 3 and table 4, it can be seen that the use of alum at a dose of 800 ppm has the lowest pH of processed water, namely 6.1 for the use of experimental alum and 6.0 for the use of commercial alum, can be seen on the graph 1. According to research [13] [19] the more alum is added, the pH of the treated water decreases because alum contains aluminum and sulfate, therefore the dosage of alum must be adjusted so that there is no decrease in the pH of the treated water. If the pH < 7 will form a lot of positive ions such as Al (OH) $^{+2}$, Al (OH) $^{+4}$ which can destabilize the negative charge.



Graph 2: Decrease in the color of dug well water after using alum

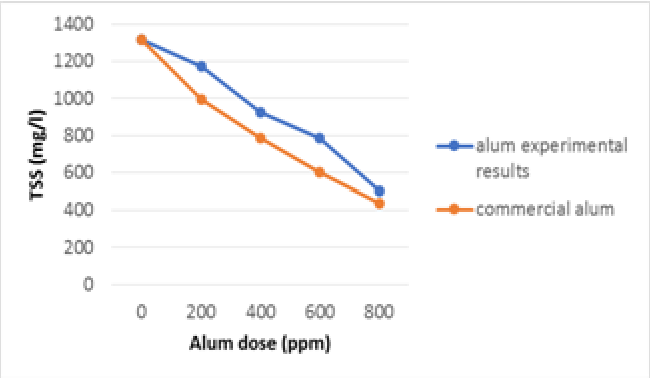
The color of dug well water is caused by the presence of organic compounds and inorganic compounds dissolved in the water. The results showed that the higher the dose of alum used, both experimental and commercial alum showed a decrease in the value of Pt-Co, but the effectiveness of alum from the experiment only reached 66.66%, while commercial alum decreased the value of Pt-Co to 74% as see in grap2. Alum functions as a coagulant that can cause a chemical reaction where the negative charges around the dissolved particles in the form of colloids will be neutralized by positive ions from the coagulant so that the colloidal particles will attract each other and agglomerate to form flocs that are easier to settle and separated from the water so that it can reduce the value of color and turbidity [20].

Turbidity is a description of the optical properties of water by the presence of solids, especially suspended materials and is slightly affected by color. The level of water turbidity will be known by the amount of NTU (Nephelometric Turbidity Unit) after an application test is carried out using a turbidimeter. The results showed that using alum with the same dose of 800 ppm, commercial alum could reduce the turbidity of treated water from 86 NTU to 6.23 NTU, which means it was able to reduce turbidity by 92.79%. While alum research results made from uncoated aluminium foil can only reduce turbidity from 86 NTU to 9.2 NTU with an effectiveness of 89.3% as seen in graph 3.



Graph 3: Decrease in turbidity of dug well water after using alum

In addition to turbidity or turbidity, the water characteristic that needs to be measured is total suspended solid (TSS). TSS is a solid that is present in a solution but is not dissolved so that it can cause turbidity and cannot settle directly. TSS is a residue of total solids retained by a sieve with a particle size of 2 milli microns or larger than colloidal particles. The smaller the TSS value, the clearer the water obtained. The results showed that with the same dose of 800 ppm the use of commercial alum was able to reduce the TSS value from 1320 mg/l to 437.45 mg/l in other words its effectiveness could reach 66.86%, while the effectiveness of alum made from uncoated aluminum foil only reached 61, 81% as see in graph 4.

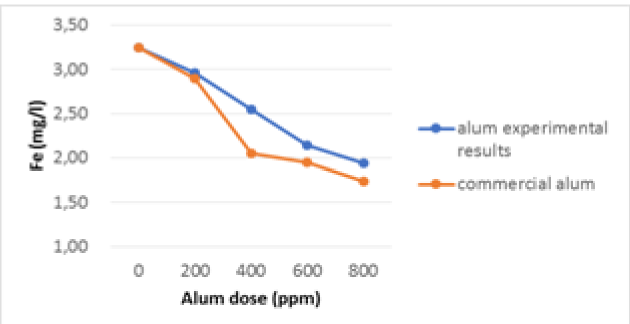


Graph 4: Decrease in total suspended solids in dug well water after using alum

Turbidity is closely related to the level of suspended substances because turbidity in water is caused by the presence of these suspended substances. Suspended substances contained in water consist of various substances which are floating organic materials such as cellulose, fat or protein or can also come from inorganic materials such as mud or sand. Decreasing turbidity and TSS can use alum as a coagulant, this is in line with several studies that have been carried out by [4] [7] [8] [13] [14].

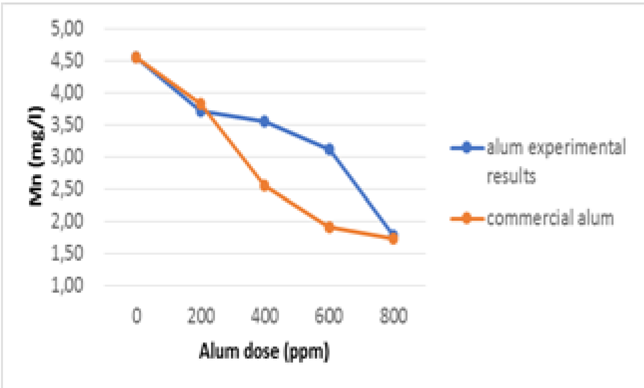
Measurement of iron levels in dug well water before adding alum obtained 4.55 mg/l and after being given alum with various doses it decreased. With a dose of 800 ppm on the use of alum, the results of research made from uncoated aluminum foil can reduce levels of ferrous metal from 4.55 mg/l to 1.78 mg/l with an effectiveness of only 60.88%, while the use of commercial alum with the same dose can reduced Fe metal content from 4.55 mg/l to 1.73 mg/l with an effectiveness of 62.0% as seen in graph 5. Alum can reduce iron metal content in well water because alum which functions as a coagulant can bind to colloidal particles in the water and form clumps (flocs) so that it is easy for precipitation to occur. The reaction is as follows:

$Al_2(SO_4)_3 \rightarrow 2Al^{+3} + 3(SO_4)^{-2}$
$2Al^{+3} + 6(OH)^{-} \rightarrow 2Al(OH)_3$
$2Fe^{+2} + 2Al(OH)_3 \rightarrow Fe(OH)_3 + 2Al^{+2}$



Graph 5: Decrease in iron metal content in dug well water after using alum

With the addition of alum, the charge of colloidal particles is neutralized so as to allow particles that are already neutral to collide with each other and stick together with each other so that they become large particles and easily settle. From the results of the reaction produces a compound Ferric hydroxide [Fe $(OH)_{3]}$ in the form of lumps then precipitation occurs. This kind of reaction will occur with manganese, this is in line with research conducted [21] in the study of coagulation-flocculation jar tests as the basis for designing peat water treatment plants, it was found that there was an increase in the chemical quality of peat water. According to [4] the coagulation process using alum will be effective to precipitate Fe metal at pH > 6.4. In natural water systems, iron and manganese compounds are always changing depending on the level of acidity (pH) and oxygen levels in the water [13]. Under reducing conditions, in general, iron and manganese have a valence of two which are soluble in water. In the water treatment system, iron and manganese with a valence of 2 will be oxidized so that they can be converted into compounds of iron and manganese with a larger valence and are insoluble in water, thus making it easier to separate. Iron levels that exceed drinking water quality standards can cause several disturbances, including health problems that can cause nausea, damage to the intestinal wall that can even cause death, physical problems such as color and technical problems that cause corrosive properties.



Graph 6: Decrease in manganese metal content in dug well water after using alum

Measurement of manganese content in dug wells before adding alum was 3.25 mg/l. With the addition of alum in dug well water, it seems to have decreased but with less effectiveness than the decrease in iron metal content. The addition of research alum made from uncoated aluminum foil can only reduce manganese metal from 3.25 mg/l to 1.94 mg/l with an effectiveness of 40.23%, while the use of commercial alum can reduce manganese from 3.25 mg/l to 1.74 mg/l with an effectiveness of 46.46%. According to [13] water treatment using an oxidation process with an aeration system of manganese reduction will be effective at pH 7 – 8 and according to [22] the manganese metal deposition process is very effective at pH 11. The treated dug well water samples have a pH between 6.9 – 6 0.0 so that the effectiveness of the use of alum is said to be small and from the analysis results, the manganese content is still around 1.74 – 1.94 mg/l, which means that the processed dug well water is not suitable for consumption.

5. Conclusion

From the results of this study, it can be concluded that based on the parameters examined, with the use of the same dose, the effectiveness of commercial alum was greater than that of research alum made from uncoated aluminum foil, with an average difference in effectiveness of below 10%. Of the six parameters measured, only pH, color, turbidity and suspended matter content met the requirements of the Minister of Health RI no. 32 of 2017 while the iron and manganese parameters still do not meet the permitted requirements. For this reason, it is recommended that in the water treatment process in order to reduce the content of iron and manganese more effectively, it is necessary to adjust the pH so that the formation of iron and manganese compounds with large valences is easier to form and can form lumps so that they can easily be separated by settling or filtering

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