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Iron Level Reduction Effectivity at Water Treatment Instalation in Purworejo

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Abstract

Background: The iron (Fe) content in drinking water is higher than the standard which can cause technical, physical and health problems. Initial inspection at the outlet of the Drinking Water Treatment Plant in Purworejo showed iron levels of 0.575 mg / lt, so it is necessary to investigate its effectiveness.This study aims to determine the effectiveness of iron reduction level (Fe) in the Drinking Water Treatment Plant (IPAM) in Purworejo.

Methods: This study uses a descriptive observational method, where data is collected, compiled, interpreted and analyzed so that it provides a complete description of the existing problems and then compares them based on theory, literature review, literature, scientific articles and with applicable regulations.

Results: The results of measurements of iron (Fe) levels on an average of 0.976 mg / lt inlet, 0.470 mg / lt outlet and 51.76% effectiveness. Standard iron (Fe) content in Minister of Health Regulation Number 492 year 2010 is a maximum of 0.3 mg / lt. The standard of effectiveness according to the Ministry of Home Affairs Research and Development with a result of 40% - 59.99% is in the ineffective category.

Conclusion: The effectiveness of Iron (Fe) reduction in the Drinking Water Treatment Plant in Purworejo is in the ineffective category.

Keywords: effectiveness, iron content, water treatment plan

Background

Government policies in the field of drinking water are needed to meet the quality of water that is healthy, sufficient quantity and continuous. The commitment of the Government of Indonesia in 2030 is to achieve universal and equitable access to safe and affordable drinking water for all.[1]

Water that humans use to meet their needs must meet the requirements of quality, quantity and continuity.[2]In terms of quantity, it must meet the needs of 60 liters / person / day. The continuity is that water must be available at all times. In terms of quality, water must meet physical, biological and chemical requirements. One of the chemical parameters is iron content (Fe).[3]

In Aglik Village, Grabag District, Purworejo Regency, clean water is a problem felt by the community. The Drinking Water Treatment Plant in Aglik Village, Grabag District, Purworejo Regency is one of the efforts to overcome this problem. However, public complaints regarding the results of the Drinking Water Treatment Installation process, such as water that smells fishy and brownish cloudy still occur.There are even clothes that are washed which at first become white and then gradually become brownish spots. This shows that the iron content at the drinking water treatment plant outlet is still high. The results of laboratory examinations at the Drinking Water Treatment Plant outlet in Aglik Village on February 12, 2020 showed that the iron (Fe) level was 0.575 mg / lt, this level still did not meet the standards required in Permenkes 492 / Menkes / Per / IV / 2010 about Drinking Water Quality Requirements, namely a maximum of 0.3 mg / lt.[4]

Iron levels at concentrations above ± 0.31 mg / l can cause rust marks on clothes and porcelain and cause an unpleasant taste in drinking water. Even though iron (Fe) is needed by the body, in large doses it can damage the intestinal wall. Death is often caused by damage to the intestinal wall. Dried iron (Fe) dust can also accumulate in the alveoli, causing reduced lung function.[5]

Based on laboratory examinations that show iron (Fe) levels which have not met health requirements, looking at community complaints and the negative impact they have, it is deemed necessary to conduct a Research on the Effectiveness of Iron (Fe) Reduction in the Drinking Water Treatment Plant in Aglik Village, Grabag District, Purworejo Regency. . So that we can get a picture of the extent to which the level of reduction in iron (Fe) levels resulting from the Drinking Water Treatment Plant for one month.

Methods

This research uses observational descriptive research, where data is collected, compiled, processed using a computer, presented in the form of tables, graphs, interpreted and analyzed so that it provides complete information on the problems that exist then compares them based on theory, literature review, literature and scientific articles including comparing with Regulation of the Minister of Health of the Republic of Indonesia 492 / Menkes / Per / IV / 2010 about Requirements for Drinking Water Quality so that a conclusion can be drawn.

The population in this study were raw water (inlet) and treated water (outlet) drinking water treatment plants. The sampling technique based on the sampling of piped water in an open distribution system is at the sampling point of the water outlet after treatment, the aim is to check the effectiveness of water treatment and represent the quality of water entering the distribution system.[6]

Sampling and examination of samples were carried out for 1 month working days (22 days) 13 April 2020 - 14 May 2020 in the morning during peak hours of water use with a total sample size of 44 samples including 22 samples of inlet water and 22

samples of outlet water for water treatment plants drink.

Retrieval of data in the form of primary data and secondary data. Primary data is obtained directly from field observations, interviews, and laboratory measurement results including temperature, pH, iron content (Fe). Secondary data is the collection of existing data and obtained from the Aglik Village Office, BP-SPAMS "Warih Rahayu", the Health Laboratory Unit of the Purworejo District Health Office, library searches, reference books, scientific articles, regulations and related literature. with the object of research.

The data that has been collected ,processed and analyzed by a computerized system and presented in tables, graphs and narrative. Data analysis was carried out including the mean value of the results of water sample examination, comparison with previous research results, comparison with applicable standards and the effectiveness value of the Drinking Water Treatment Plant. The effectiveness value of the Drinking Water Treatment Plant is calculated using a formula :

$$\sum P = \frac{A - B}{A} X100\%$$

Note :
∑P : treatment effectivity
A : inlet
B : outlet

According to Yuniastari (2015) the standard value of the effectiveness of the Ministry of Home Affairs Research and Development is below 40% very ineffective, 40% - 59.99% ineffective, 60% - 79.99% quite effective, and above 80% very effective.[7]

Results and Discussion

The Drinking Water Treatment Plant in Purworejo uses filtration and sedimentation techniques. The filtration technique uses silica sand and split gravel. While the sedimentation is in the form of a reservoir for the filtration results. Maintenance of the Water Treatment Plant system is carried out every 6 months in January and July. The maintenance method used is the back wash method, namely by spraying high pressure clean water into the filtration tub repeatedly until the water that comes out looks clear.However, since 2014 to 2020, there has not been any replacement of the filtration material with a new one.

Sampel collection and inspection is carried out for 1 month working days (22 days) April 13, 2020 - May 14, 2020.At the time of the study, it had never rained. Information from BMKG revealed that April to September is the dry season. Temperature and pH measurements are also carried out because they can affect iron (Fe) levels in water. The complete measurement results are shown in the following table and figure 1.

Temperature measurement

In Table 1, it is stated that the results of measuring the water temperature at the inlet have a mean value of 29,500C, at the outlet the average value is 29.360C. Figure 1 shows that the inlet and outlet water temperatures are relatively stable. So temperature does not affect fluctuations in changes in iron levels, both iron levels at the inlet and outlet. The decrease in iron content from the inlet to the outlet is only due to the filtration and sedimentation process of the Drinking Water Treatment Plant.

The temperature of the water itself can be influenced by the substances and the certain processes that occur. High water temperature means that the water contains certain substances (for example, quite a lot of phenol is dissolved in water) or that a certain process is taking place (the process of decomposition of organic matter by energy-producing microorganisms) which releases or

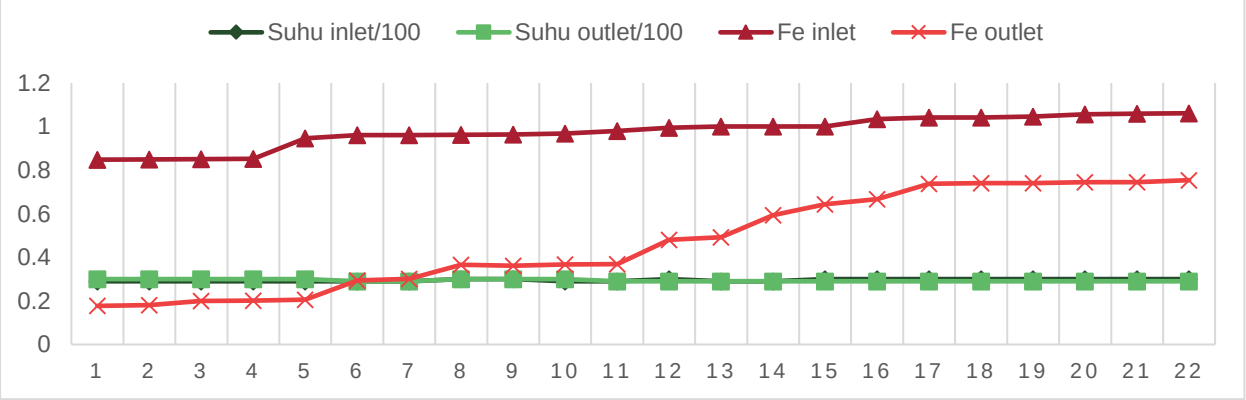
absorbs energy in water.[8]If there is a decomposition process, the bacteria will break down the organic matter by removing CO2 and taking O2 which will produce heat. This heat increasing the racauses the w water temperature.[9]The temperature drop rate is only 0.140C, the decrease is very small, it can be said that the temperature does not affect fluctuations in iron levels. Iron levels are increasing due to other factors thantemperature such as pH and season factors.Determination of the location of raw water sources at the Drinking Water Treatment Plant in Aglik Village is based on Geoelectric Research by CV. Ardhipta Sona Persada Semarang at several locations then selected a good location point.[11]So that the location of the inlet water source (raw) at the Drinking Water Treatment Plant in Aglik Village is in a better location than the other locations.In addition, the process in the drinking water treatment plant also does not affect the temperature of the water because it is only a filtration and sedimentation process and no specific process occurs so the water temperature is not high either. So between the inlet water temperature (raw water), the water temperature in the drinking water treatment plant and the outlet temperature the temperature difference is very small. It can be said that the inlet temperature is almost the same as the outlet temperature.

Table 1 Result of temperature, pH and iron level measurement

No	Value	Results					
		Temperature (^{0}C)		pH		Iron (Fe) (mg/l)	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
1	Min	29	29	6,3	6,8	0,848	0,177
2	Max	30	30	6,8	7,1	1,061	0,754
3	Mean	29,5	29,36	6,54	6,9	0,976	0,470

The results of this research are in line with Purwonugroho's research in 2013 concerning the Effectiveness of Zeolite and Activated Carbon Media Filtration in reducing Iron and Manganese levels in Dug Wells.[12]In another study conducted by Nainggolan in 2017 regarding the effect of multilevel aeration with a combination of sand, activated carbon and zeolite filters in removing Fe and Mn parameters in groundwater, it was stated that water filters do not have a significant effect on temperature changes[13]In both studies, the raw water sources and materials used for water treatment do not contain contaminated materials or do not cause certain reactions so that the water temperature is not high.

Figure 1 Graph of measurement results for temperature and Fe (inlet temperature / 100 and outlet temperature / 100)



pH Measurement

Table 1 states that the pH of the water at the inlet has a mean value of 6.54 and at the outlet has a mean value of 6.9. Figure 2 shows that the outlet pH is higher than the inlet pH. A pH less than 7 means an acidic environment. If the pH of the water is in an acidic atmosphere, it will result in a corrosive process that causes the dissolution of iron and other metals in the water. So that in an acidic pH state, the iron levels in the water tend to be high.[8]
The type of processing at the Drinking Water Treatment Plant in Aglik Village is a type of filtration with silica sand and split gravel and sedimentation. So that this type of processing can be used to reduce iron levels.14 The results shown in Figure 2 show a decrease in iron levels so that the iron content in the outlet water is lower than the inlet water. Reducing the iron content in the outlet water causes the water to become more alkaline. So that the pH in the outlet water increases or is higher than that of the inlet water. The lower the pH of a water, the higher the iron level, which results in more burdens on the filtration work so that the level of effectiveness in reducing iron levels is getting lower.

The results of this research are in line with Mashadi's research in 2018 concerning the improvement of the pH, Fe, and Turbidity quality of Dug Well Water with the Filtration Method, showing that variations in filter thickness have an effect on increasing pH and decreasing Fe. Variation in the thickness of sand 20cm, activated carbon 40cm, zeolite 30cm is the variation with the largest thickness that has the most influence.[15]In another study conducted by Mahyudin in 2016 concerning Water Quality Analysis with Filtration Using Silica Sand as Media, it was stated that the thickness of the silica sand filter tested was effective in reducing Fe content, suspended sludge content and increasing pH. The variation of the thickness of the silica sand used is 20 cm, 40 cm and 60 cm. The sand thickness of 60 cm gave the best results with an increase in pH from 6.5 to 7.2.16. In both studies, the results were the same, namely the thicker the filtration material, the better results so that the lower the iron content, the pH also increased.Although there has been a decrease in iron levels at the outlet, Figure 2 also shows a tendency for water pH, especially raw water pH, to decrease over time, meaning that the more acidic and higher the iron content. Seeing the results of previous studies that variations with activated carbon filtration and the thicker the filtration material will give better results in increasing pH and decreasing iron levels. This means that this is because the Drinking Water Treatment Plant in Aglik Village has not used activated carbon and the thickness of the silica sand is still not thick.

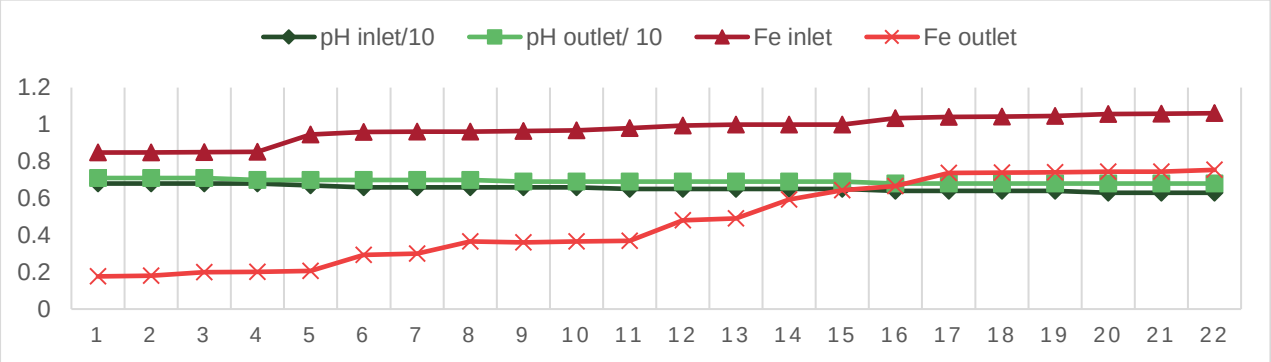
The higher the iron content is also closely related to the season. Increasingly towards the peak of the dry season the substances in groundwater are more dominant because there is no dilution by rainwater so that the concentration of substances present in water such as iron becomes high.

The degree of acidity or basicity of good water is 7 or close to 7. If the pH of the water is too low than 7, it is necessary to carry out a process to increase the pH so that the pH becomes closer to 7 or neutral. In addition to adding activated carbon and increasing the thickness of silica sand in filtration, another effort to increase pH is by pre-processing the raw water (inlet) before the filtration process, namely the Aeration Process. The aeration process is the process of adding oxygen to water by bringing water into contact with air. The aeration process can be in the form of a Tray Aerator, a buble aerator or a cascade aerator.

The technology that is most likely to be applied to the Drinking Water Treatment Plant in Aglik Village is the Tray Aerator or multilevel aerator using iron sheet or galvanized sheet with holes. In addition to the ingredients used, it is easy to get, it is also easy to maintain. Place the aerator preferably before the filtration unit. The function of aeration in addition to raising pH can also reduce iron levels, so that it can reduce the burden of filtration in reducing iron levels.[17]

To increase the effectiveness of aeration, a process is needed to increase the pH of raw water first by adding lime or chlorine with a certain dose according to water conditions. Besides functioning to increase the pH, the addition of lime or chlorine also functions to accelerate sedimentation and to disinfect or kill parasitic bacteria.[18]

Figure 2 Graph of pH and Fe measurement results (inlet pH / 10 and pH outlet / 10)



Iron level measurement (Fe)

Figure 4 shows that the iron content in raw water tends to increase over time. Well water quality can be seen in the rainy season and dry season. In the rainy season, water that seeps into the soil can reduce the concentration of substances in the soil due to dilution by rainwater. With the dilution of rainwater, the iron concentration will be lower.In the dry season, substances in groundwater are more dominant because there is no dilution by rainwater so that the concentration of substances present in water such as iron becomes high which can lead to poor water quality.15 Information from the Meteorology and Geophysics Agency shows that it is estimated that the dry season in the Central Java region will occur from April to its peak in September 2020.[19]This means that the time of this study coincides with the start of the dry season until the middle of the dry season and at the time of this study there was never any rain. Under these circumstances, the iron content in groundwater is getting to the peak of the dry season, the level of dilution is getting lower so that the iron content concentration increases or gets higher.

Figure 4 also shows that although there has been a decrease in iron content at the outlet, the longer the iron content increases and the difference in iron content in the inlet and outlet water has a tendency to decrease. filtration. When a tool is used from day to day, the function of the tool will decrease due to the usage process. The maintenance and replacement period of the filtration media is very long and it can cause the media to no longer be fresh (saturated), so that the decrease level is getting smaller each day.[20] Seasonal factors also have an effect, although not directly. The more it goes to the peak of the dry season the iron content in the water is getting higher.15 This situation will further aggravate the work of the filtration so that the lower the level of reduction in iron content gets to the peak of the dry season.

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Figure 3. Graph of the results of measurement of Fe content of quality standard

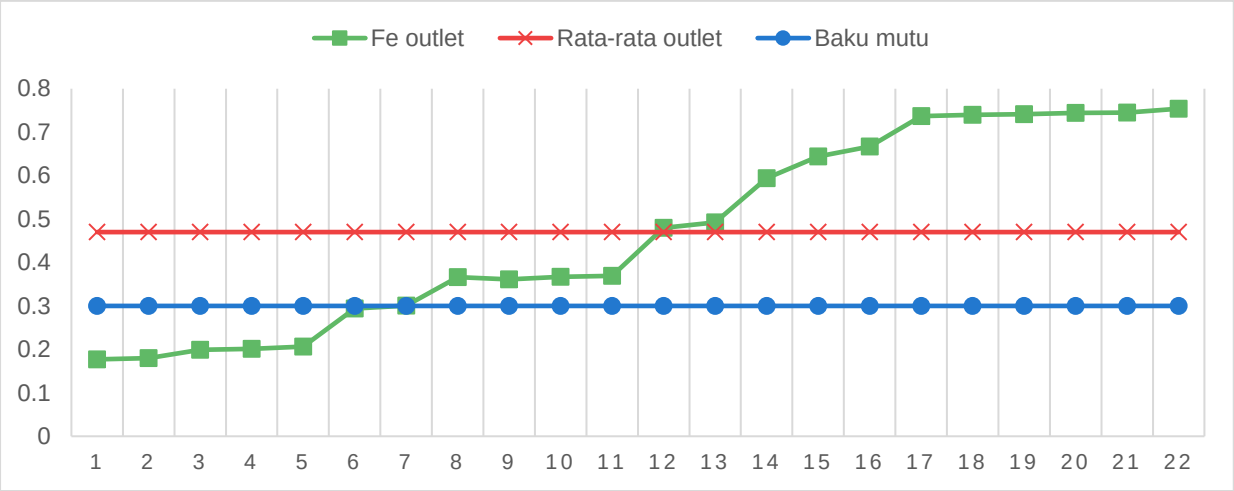

Figure 4. Graph of Fe Decrease Effectiveness

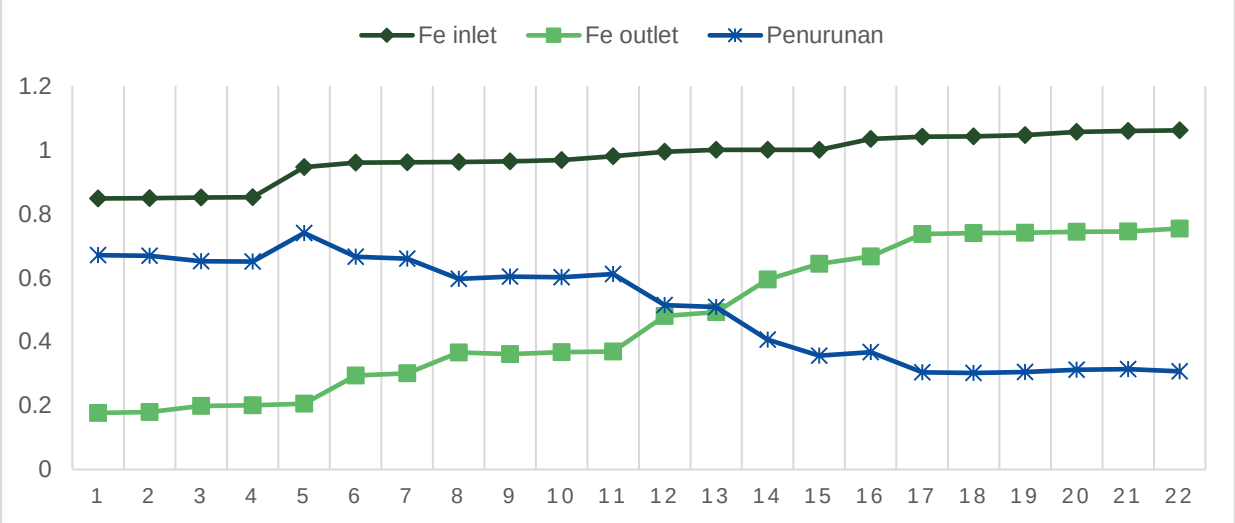

Table 1 and Figure 3 show that iron (Fe) in the inlet has a mean value of 0.976 mg / lt and at the outlet has a mean value of 0.47 mg / lt. Based on Permenkes Number 492 / Menkes / Per / IV / 2010 concerning Drinking Water Quality Requirements, the required iron (Fe) content is a maximum of 0.3 mg / lt, with an average yield of 0.47 mg / lt at the outlet, meaning that still not meeting the required quality standards.[4]

The value of the effectiveness of the reduction in Fe content from the measurement results data processing was 51.8%. This means that the level of effectiveness of reducing Fe levels is in the ineffective category. The effectiveness of the reduction in Fe content can be influenced by the quality of the raw water (inlet) itself, especially the iron content. The average iron content in the inlet was 0.976 mg / l, this result exceeds the required quality standard and the longer it is getting higher. The higher the iron content of raw water, the performance of the Water Treatment Plant in reducing iron content is getting heavier so that the level of effectiveness is lower.

Completeness of types and methods of water treatment can also affect the level of effectiveness of a water treatment. The water treatment process to reduce iron (Fe) levels varies from aeration, coagulation and flocculation, sedimentation to disinfection.14 The filtration media also varies such as activated carbon, microfiltration, ultrafiltration and nanofiltration.21 The more complete and varied the water treatment methods are, the level of effectiveness the better.

The Drinking Water Treatment Plant in Aglik Village, Grabag District, Purworejo Regency, only uses filtration and sedimentation methods and has no pre-treatment. The filtration material also only uses silica sand and split stone. The effectiveness result is only 51.8% and the average iron content at the outlet is 0.47 mg / l so that the effectiveness level is lower than that of water treatment with the addition of a variety of other water treatment methods that are more complete. Such as research conducted by La Aba in 2017 concerning Dug Well Water Treatment with Aeration and Fltration methods using aerators and fast sand filters to reduce iron and manganese levels, with the result of an effectiveness level of 76.57%.[22]In Istihara's research in 2019, said the cascade aerator system, the results of removal of iron (Fe) levels with an effective removal of 98.73% .[23] In this study, with the aeration unit the effectiveness of reducing iron levels could be even better.A better level of effectiveness can also be done by adding and or changing the type of filtration material. As in Fitriyah's research in 2018, it was stated that water treatment using Poly Aluminum Chloride (PAC) media can reduce iron (Fe) levels from 1.06 mg / t to 0.02 mg / lt or 98.1% effectiveness level.[24]n Yusniartanti's research in 2017, it was stated that the highest process effectiveness was obtained in the variation of the number of 3-level tray aerators with charcoal and gravel contact media, the iron removal effectiveness was 83.96%.[25]In that study, with the addition of PAC and graded aeration and charcoal, the level of effectiveness in reducing iron levels could be better.Maintenance and maintenance of water treatment plants can also affect the effectiveness of reducing iron levels. Observations at the location of the facilities show that the facilities are in a dirty condition both outside and inside the facilities. This indicates that the maintenance and maintenance of Drinking Water Treatment Plant Facilities has not been going well, not continuous and inconsistent.

From 2019 to May 2020 maintenance was not running optimally. So that the level of effectiveness will get lower over time, even if left over time it becomes completely non-functional. Maintenance and maintenance should be carried out regularly and periodically with the aim of extending the service life of water treatment plant facilities and infrastructure, and so that raw water can be treated properly and the results can meet applicable standards. The maintenance and maintenance includes the Raw Water Unit, Production Unit, Distribution Unit and Service Unit.[26]

Conclusion

The Effectiveness Level of Reducing Iron (Fe) Levels in the Drinking Water Treatment Plant in Purworejo is 51.8%. Based on the value of the Ministry of Home Affairs R&D Effectiveness Standard in the range of 40% - 59.99% so that it is categorized as ineffective.

The solution to improve effectiveness is the existence of a pre-treatment process before filtration, namely by adding lime to increase the pH of the raw water first, then adding a tray aerator unit and adding a variety of filtration materials (activated carbon).

The consideration for the addition of this technology is that besides having a good level of effectiveness (83.96%), the material is easy to obtain and its

maintenance is also easy. Maintenance and maintenance of all units of Drinking Water Processing Installation facilities regularly and consistently is also very necessary to be carried out to extend the service life of water treatment plant facilities and infrastructure, and so that raw water can be treated properly and the results can meet the required quality standards.

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