MATERIALS RESEARCH COMMUNICATIONS
Vol. 3, No. 1 (2022) (8 pages)
@ Pusat Publikasi Ilmiah ITS

A NOVEL METHOD FOR INTEGRATED WATER TREATMENT PROCESS (WTP) WITH EMBEDDED SELF CATHODIC PROTECTION SYSTEM

TUBAGUS FADHLI ROBBY*
Department of Materials and Metallurgical Engineering
Institut Teknologi Sepuluh Nopember
Kampus ITS Keputih Sukolilo, 60111, Surabaya, East Java, Indonesia
tbfadhlirobby@yahoo.com

AGUNG PURNIAWAN
Department of Materials and Metallurgical Engineering
Institut Teknologi Sepuluh Nopember
Kampus ITS Keputih Sukolilo, 60111, Surabaya, East Java, Indonesia
agung.pur@mat-eng.its.ac.id

SIGIT TRI WICAKSONO
Department of Materials and Metallurgical Engineering
Institut Teknologi Sepuluh Nopember
Kampus ITS Keputih Sukolilo, 60111, Surabaya, East Java, Indonesia
sigit@mat-eng.its.ac.id

***Corresponding author**

Received 22 May 2022; **Revised** 20 July 2022; **Published** 31 July 2022

Abstract – Clean water is a human need in daily life for washing and bathing and consumption. Clean water treatment technology that is generally used is a clarifier. At this time the treatment of clean water tends to use a clarifier that uses chemicals as a coagulant, regulates acid pH, and as a disinfectant. The problem is that these chemicals in clean water treatment tend to be less economical because they require daily handling, difficult to operate because they use doses based on the jar test, maintenance on chemical tanks, stirrers and pumps is difficult, requires a large warehouse location, expensive transportation, and has an expiration date. This study examines the application of electro-corrosion control material Adjust pH and electro coagulant in clean water treatment or Water Treatment Plant (WTP) on an industrial scale in the FASLABUH TNI AL area, Selat Lampa Natuna. The clean water product from this study will be compared with the clean water quality standard of the Minister of Health No. 32 of 2017. The results of the turbidity, pH, potential value and color testing in the raw water of the FASLABUH TNI AL area of the Lampa Natuna Strait are 80 NTU for turbidity, pH 5, 2, the potential value is -440 mV and 440 TCU after being treated with cathodic protection the result is an increase in the potential value, the potential value increases with the current. The potential value with a more negative value was achieved from a variation of the dose of 100 amperes for the anode adjusted pH which was -1200 mV while for the coagulant anode it was achieved by varying the current dose of 200 with a potential value of -1225 mV. The product of cathodic protection makes the value of turbidity and color decrease in the aluminum anode material used as anode coagulant. The highest turbidity value was achieved by a dose variation of ampere 180 with 0.5 while the highest color value was achieved by a dose variation of ampere 180 with a color value of 0.5 TCU.

Keywords: cathodic protection; water treatment; turbidity; colour; potential.

1. Introduction

Pure water is a human need in daily life for washing and bathing activities and consumption. Pure water treatment has been carried out for a long time with various methods such as using simple filtration using silica sand, advanced filtration using a reverse osmosis membrane (Chapman, 1996; Bray and Fitobor, 2016). The problem is that using simple filtration tends not to reach the quality standard of pure water and using sophisticated filtration is relatively expensive, difficult to operate, and does not last long if the water source is very dirty. At this time the treatment of clean water treatment tends to use a clarifier that uses chemicals as a coagulant, regulates acid pH, and as a disinfectant (Bray and Fitobor, 2016). The problem is that these chemicals in clean water treatment tend to be less economical because they require handling every day, difficult to operate because adjusting the dose based on the jar test, maintenance on chemical tanks, stirrers and pumps is difficult, requires a large warehouse location, expensive transportation, and has an expiration date. This study examines the application of electro-corrosion control material, Adjust pH and electro coagulant in industrial-scale clean water treatment or Water Treatment Plant (WTP) in the FASLABUH TNI AL area, Selat Lampa Natuna. The clean water product from this research will be compared with the clean water quality standard of Minister of Health No. 32 of 2017.

2. Material and Method

The method used in this study is a clean water treatment method by utilizing the cathodic protection effect on the clarifier, namely the experimental method used to process raw water into clean water by coagulation and deposition of fine particles from the cathodic protection reaction on the clarifier body. The variations used in this study are variations in cathodic protection at the v-notch using a magnesium anode against pH and potential values and cathodic protection using an aluminum anode against potential values, turbidity and color.

2.1. *Material*

The main material in this research is aluminum anode as a coagulant material and magnesium anode as a pH adjusting material, both of which are used as cathodic protection in the clarifier, as shown in Figure 1. The results of the protection can make a clean water product. Aluminum and magnesium anodes manufactured by PT. Rofis Jaya Perkasa while the peat water is taken from the river in the FASLABUH TNI AL area, the Lampa Natuna Strait. Tools that need to be provided are power supply 250A dc, anode and cathode cables 250A, water treatment tank.

(a) (b) (c)

Fig. 1. (a) aluminium anode, (b) reaction aluminium anode, and (c) peat water.

2.2. *Method*

The process of treating clean water using a cathodic protection effect is carried out by placing electrodes on the clean water treatment unit. The positive cable on the electrodes is placed on the body of the clean water treatment unit while the negative cable is placed on each anode, there are 4 divisions of the area that will be cathodic protected, namely v-notch coagulation, coagulation, flocculation and sedimentation. The incoming flow rate is limited to 20m3/hour. The series of positive and negative poles are connected to the dc power supply with the amperage dose as a variation. Figure 2 is the layout of cathodic protection. Variations in the amperage dose of cathodic protection for pH-adjusted anodes were 60A, 80A and 100A, while for the anode coagulant variations were 160A, 180A and 200A. Then the results of this study will be compared with the standards of the Minister of Health for clean water no 32 of 2017 and NACE for potential values. The variations in this study can be seen in Table 1.

Table 1. Variation of parameters in this research

Variation	Code	Current	Potential (-mV)	Turbidity (NTU)	pH	Colour (TCU)
Anoda adjust pH	AP0	0	√	-	√	-
	AP60	60	√		√	
	AP80	80	√		√	
	AP100	100	√		√	
Anoda electrocoagulan	AC0	0	√	√	-	√
	AC160	160	√	√		√
	AC180	180	√	√		√
	AC200	200	√	√		√

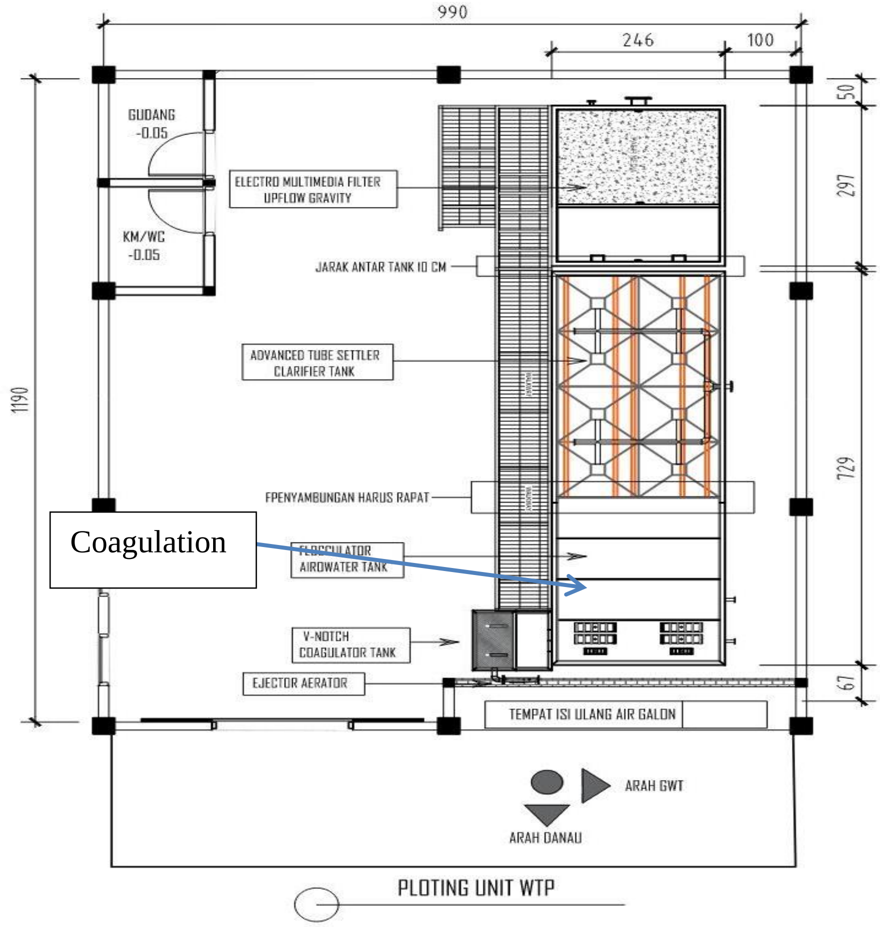

Fig. 2. Schematic of WTP unit.

3. Results and Discussion

3.1. *Characteristics of peat water*

In this study, the water source used was in the downstream area of the Faslabuh Selat Lampa (NATUNA) river area. The water is used for clean water needs in the area including washing, bathing and watering plants. The water is not suitable for use because it contains compounds from peat roots so that the water is not worthy of being called clean water. The results of the characteristics of peat water in the Selat Lampa Faslabuh area (NATUNA) can be seen in Table 2.

Table 2. Lab results from peat water in Lantamal XII Pontianak area

No	Parameter	SNI	Peat Water FASLABUH TNI AL NATUNA	Unit	Method
Physical					
1	Temperature	Temperature Air ± 3˚C	28.5	˚C	SNI-06-6989-23-2005
2	Odor	Normal	Normal	-	Organoleptic
3	Taste	Normal	Normal	-	Organoleptic
4	Total Disolve (TDS)	1000	300	mg/L	SNI-6989:27:2016
5	Colour	50	452	TCU	SNI 6989.80:2011
6	Turbidity	25	80	NTU	SNI 06-6989.25.2005
7	Potential Fe of Cu//$CuSO_4$	-850 sd -1200	-440	mV	NACE 0169 2007
Chemical					
8	pH	6.5-8.5	5.2	Ph	SNI 6989.11:2019
9	$CaCO_3$	500	577	mg/L	SNI 06-6989.12-2004
10	Fluorida, F	1.5	0.11	mg/L	SNI 06-6989.29-2005
11	Sulfat, SO_4	400	493	mg/L	SNI 6989.20-2019
12	Nitrit, NO_2-N	1	0.04	mg/L	SNI 06-6989.9-2004
Organic Chemical					
13	Organic Subs $KMnO_4$	10	20	mg/L	SNI 06-6989.22.2004

The test results shown in Table 2 explain that there are 3 parameters tested, namely physical, chemical and organic chemistry parameters. Tests on physical parameters include temperature, odor, taste, potential value, color and turbidity in water. The water condition in peat water that has been tested is a temperature of 28˚C with water that is odorless and tasteless (normal). The total value of soluble solids is 50 which is in accordance with quality standards. The result of the color value test is 440 TCU which states that the peat water in the Selat Lampa Faslabuh area (NATUNA) does not meet the quality standards set so that if it is used as a sanitary hygien, it will pose a risk to health. Physical parameter testing ended with turbidity testing, the result of turbidity testing on peat water was 80 NTU, this result was very far from the clean water quality standard of 25 NTU. The potential value of peat water in the faslabuh selat lampa reservoir (NATUNA) is -440 mV, this result makes the potential value of Fe to Cu//$CuSO_4$ water not included in the NACE 0169 standard in 2007.

The results of testing chemical and organic chemical parameters have been carried out, there are three tests that are not in accordance with the clean water quality standards, namely the total hardness test which has a value of 577 mg/L from the standard value of 500 mg/L, the Sulfate test has a value of 493mg/L from the standard 400 mg/L and testing for organic substances $KMnO_4$ has a value of 20 mg/L from the quality standard of 10 mg/L. Tests with chemical and physical parameters proved that the peat water in the Faslabuh Selat Lampa (NATUNA) river area was not suitable for use as a sanitation hygine because there were parameters that did not match the clean water quality standards of Minister of Health Regulation No. 32 of 2017.

3.2. *Analysis Influence Magnesium Anode against score Potential on Body Clarifier*

Criteria potential protection cathodic -850 mV or called also on potential. This keeps going to change until finally NACE issued NACE SP 0169 Standard Practice on 2007 which accommodates 3 potential criteria values protection cathodic. Standard Cu/$CUSO_4$ electrode was used considering there is a voltage drop to get accurate measurement. Results of measurement of score potential on clarifier body can be seen in Figure 3.

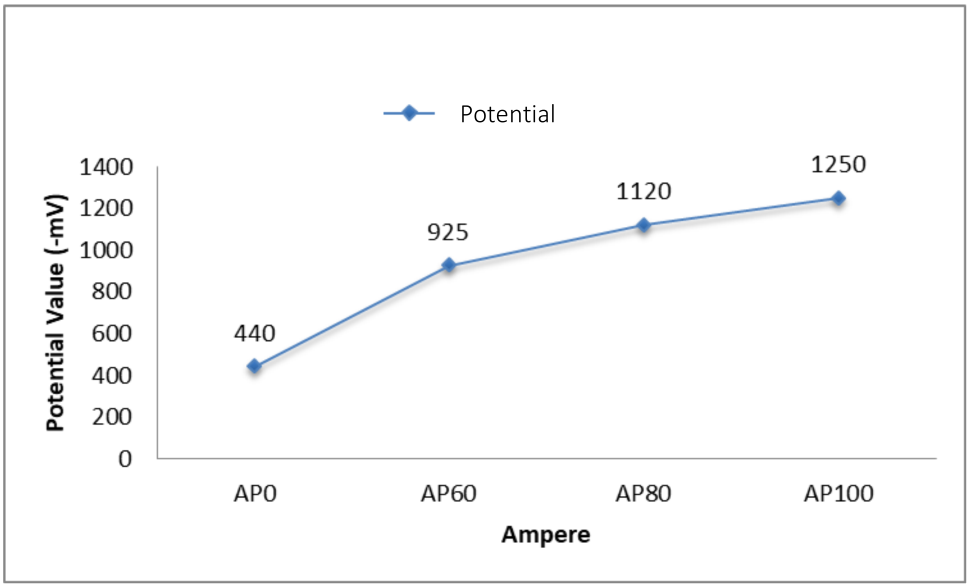

Fig. 3. Relationship between influence of dose current to score potential.

Figure 3 describes the results of testing the potential value of magnesium anode against the clarifier body, the initial potential value without treatment is -440 mV. The more negative potential value after treatment was obtained in the AP100 variation (Adjust pH with 100 amperage dose) which was -1250 mV while the lowest variation was found in the AP60 variation (Adjust pH with amperage dose) which was -925 mV. Increasing the amperage dose makes the potential value higher this happens because of the supply of current flowing to the anode. The existence of a current supply to the anode makes the electron transfer event from the anode to the cathode, the higher the current given, the greater the number of electrons supplied, this makes the potential value higher as the current increases (Kellie, 2016).

3.3. *Analysis Influence Magnesium Anode against pH*

Peat soil is porous and very light, so it has very low buffering capacity, relatively low nutrient content and contains a lot of organic acids which causes the peat pH to be very low (pH between 2.7 – 5.0). The low pH of peat water prevents it from passing the clean water quality standard of Minister of Health No. 32 of 2017. The principle of magnesium anode working to increase pH is the electrochemical method. Reduction and oxidation reactions produce OH^- so that the pH increases (Field *et al*., 2021). The results of the effect of the ampere dose on pH can be seen in Figure 4.

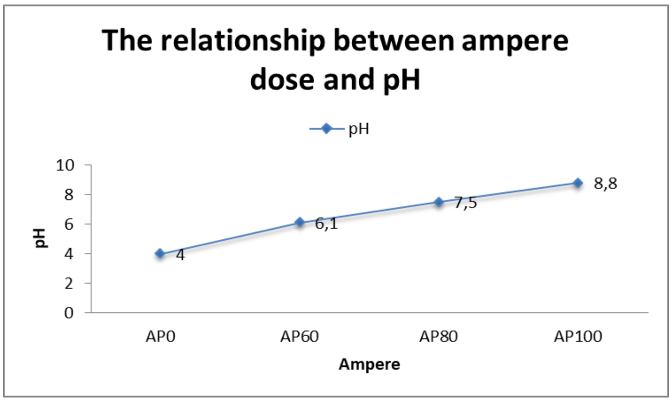

Fig. 4. Relationship between dose ampere and pH.

Figure 4 shows the relationship between ampere dose and pH, explaining that the higher the current given, the pH value will increase, this can occur due to oxidation and reduction reactions producing OH^-, along with increasing currents, the production of OH- is more abundant, the increase in OH^- makes pH values tend to be more alkaline or up. This occurs in all variations. Variations in the 60 ampere dose resulted in a pH value of 6.1. The amperage dose was increased to 80A to produce a pH value of 7.5 and the amperage dose with the highest change in pH value was the 100A ampere dose to produce a pH value of 8.8. The abundance of OH^- production makes water at the 100A amperage dose variation not pass the quality standard of the Minister of Health No. 32 of 2017.

3.4. *Analysis of Influence Anode Aluminum to Score Potential*

The value of this protection potential is measured using standard Cu/$CUSO_4$ electrodes taking into account the voltage drop to get an accurate measurement. The results of the measurement of the potential value on the clarifier body can be seen in Figure 5.

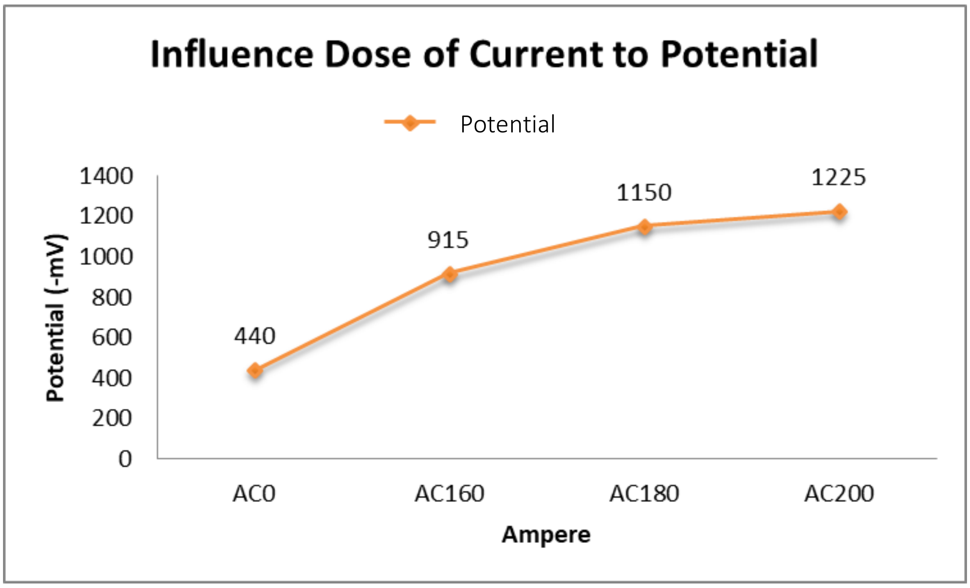

Fig. 5. Influence of dose current to score potential.

Figure 5 explains the results of testing the potential value of aluminum anode against the clarifier body, the initial potential value without treatment is -440 mV. The more negative potential value after treatment was obtained in the AC160 variation (Coagulant Anode with 200 amperage dose) which was -1225 mV while the lowest variation was found in the AP160 variation (Coagulant Anode with 160 amperage dose) which was -915 mV. Increasing the amperage dose makes the potential value higher this happens because of the supply of current flowing to the anode (Chen *et al.*, 2019). The existence of a current supply to the anode makes the electron transfer event from the anode to the cathode, the higher the current given, the greater the number of electrons supplied, this makes the potential value higher as the current increases (Bray and Fitobor, 2016). Aluminum anode has a more positive potential than magnesium this makes the current given larger.

3.5. *Analysis of influence of anode aluminum against turbidity*

Turbidity is a physical requirement to assess the aesthetics of clean water. Turbidity describes the optical properties of water, which is determined by the amount of light absorbed and emitted by substances in the water. Turbidity is caused by the presence of suspended and dissolved organic and inorganic materials (such as silt and fine sand). The data from the turbidity test results are presented in graphical form in Figure 6.

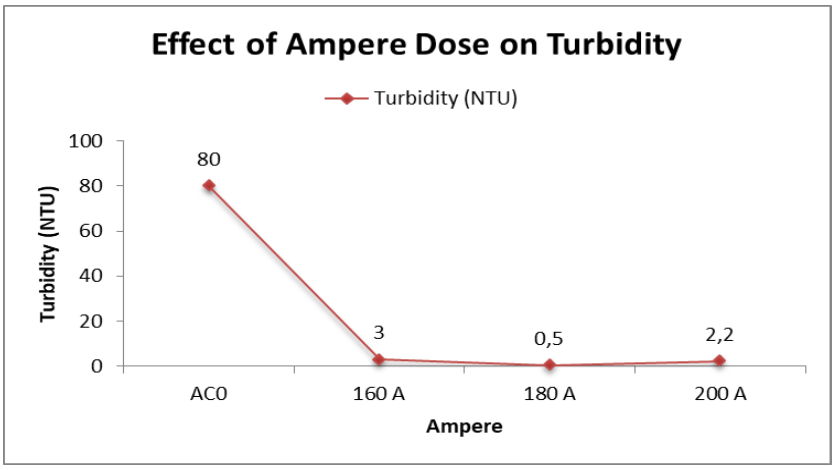

Fig. 6. Effect of dose ampere on turbidity.

Figure 6 explains that there is a decrease in the value of turbidity after the water purification process using aluminum electrodes using the electrocoagulation method is carried out. This can occur due to the release of aluminum ions (Al^{3+}) from the electrode plate (anode) where Al^{3+} ions function as coagulant. The coagulant will form bonds with colloidal particles, suspended solids and contaminants to form $Al(OH)_3$ flocs. Bonding can occur due to negatively charged colloidal particles which will be destabilized by the coagulant during the electrocoagulation process to form micro flocs. Micro flocs that have been formed will combine with other micro flocs which will form larger aggregates so that they are precipitated or floated by hydrogen gas produced at the cathode, this makes the value of turbidity (turbidity) decrease (Lay *et al.*, 2010). The high current density makes the production of Al^{3+} ions more and more, because the large production of Al^{3+} ions can cause the turbidity value to increase again. This phenomenon occurs in the AC200 variation. Variation AC160 (Amperage dose 160) has a turbidity value of 3NTU. The amperage dose is increased to 180 the result is the turbidity value drops to 1NTU. When the ampere dose was increased to 200 the result was the turbidity value increased to 2.2 NTU, this made all samples pass the clean water quality standard of Minister of Health No. 32 of 2017.

3.6. *Analysis of influence of anode aluminum to color*

One of the physical parameters in Permenkes number 32 of 2017 is color. Physical parameters of color greatly affect the aesthetic value in clean water products. The color in the water consists of two kinds, namely, all colors and true colors. False color is a color caused by turbidity-causing particles, fine particles, and metal ions such as iron and manganese, and microorganism particles, industrial dyes, etc. While the true color is the result of the decomposition of natural organic substances. The color in the water is caused by the presence of heavy metals contained in river water such as iron, manganese, etc., as well as dissolved organic matter usually from decaying vegetation, algae growth, and community waste (Jiménez *et al.*, 2019). The ampere dose is an important parameter in the electrocoagulation process which can reduce the color value. The amperage doses used are 160, 180 and 200 A. The results of the color test with variations in the amperage dose of aluminum anode are presented in graphical form which can be seen in Figure 7.

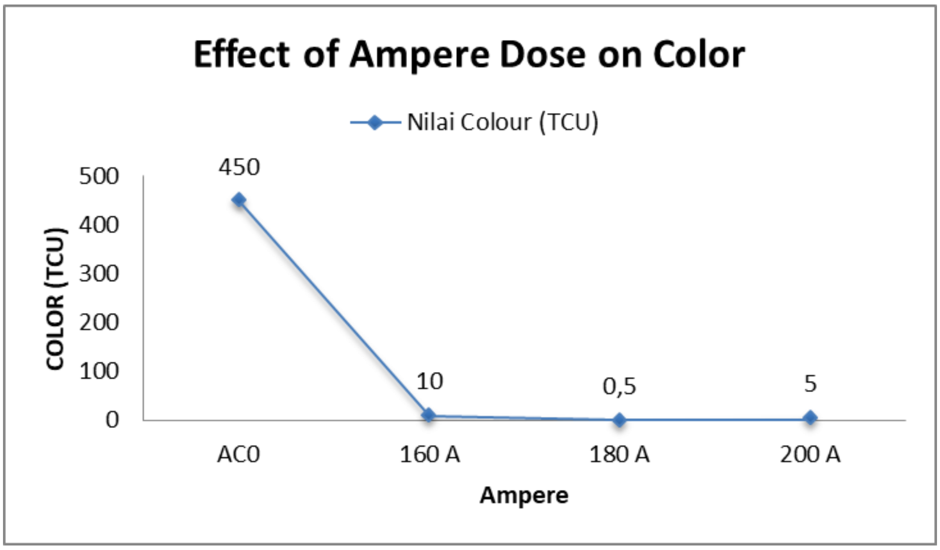

Fig. 7. Effect of dose ampere on color.

Figure 7 explains that there is a decrease in color values in all variations. Color in water is caused by the interaction of colloidal particles, suspended solids, organic compounds and other impurities in water. The decrease in color can occur due to the binding event of negatively charged colloidal particles, during the electrocoagulation process, by a positively charged coagulant to form floc and settle. The higher the current density value, the more Al^{3+} ions are produced, the more Al^{3+} ions are produced, the more colloidal particles are bound. This causes the color value caused by the presence of colloidal particles and other impurities to decrease. The large amount of Al^{3+} ion production at the anode and Hydrogen (H_2) and Hydroxide (OH^-) at the cathode in excess made it pushed by hydrogen so that it floated, then failed to settle (Chapman, 1996). This phenomenon occurs at a dose of 200 amperes, the color value increases again by 5TCU from the previous variation, the dose of ampere 180, the color is 0.5TCU. This makes all samples pass the clean water quality standard of Minister of Health No. 32 of 2017.

Acknowledgments
This research was supported by PT Rofis Jaya Perkasa and Institut Teknologi Sepuluh Nopember (ITS) Surabaya.

References

Bray, R.T. and Fitobor, K. (2016), "Sizes of iron hydroxide particles formed during ferric coagulation processes", *Desalination and Water Treatment*, Vol. 64, pp. 419-424.
Chapman, D. (1996), "*Water Quality Assesment - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring*-Second edition", Cambridge University Press, UK.
Chen, L., Pinto, A. and Alshawabkeh, A.N. (2019)," Activated Carbon as a Cathode for Water Disinfection through the Electro-Fenton Process", *Catalysts*, Volume 9, 601, pp. 1-17.
Field, R.W., She, Q., Siddiqui, F.A., et al. (2021), "Reverse osmosis and forward osmosis fouling: a comparison", Discover Chemical Engineering, Volume 1, No 6, pp. 1-14.
Jiménez, S., Andreozzi, M., Micó, M.M., et al. (2019), "Produced water treatment by advanced oxidation processes", *Science of the Total Environment*, Vol. 666, pp. 12–21.
Kellie, G. (2016), "Advances in Technical Nonwovens, Woodhead Publishing, UK.
Lay, W.C.L., Chong, T.H., Tang, C.Y., et al. (2010), "Fouling propensity of forward osmosis: investigation of the slower flux decline phenomenon", Water Sci Technol, Vol. 61, No. 4, pp. 927–936.