Effect of Addition of Zeolite and Sodium Chloride on Changes in Bacterial Content and Turbidity in Industrial Wastewater Treatment into Drinking Water using Electrocoagulation Process

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Keywords: zeolite, bacterial, turbidity, electrocoagulation, wastewater

Abstract: The treatment wastewater of electrical industry was investigated through electrocoagulation process. The study was conducted by flowing of 4,5 liters of wastewater into the three cells of electrocoagulation process tank. Each cell is filled 1.5 liters of waste water. The electrocoagulation process is carried out at a voltage of 12 V and interval time for observation of bacterial content and turbidity in the water is done every 10 minutes. Subsequently, the same procedure was performed with added 100 g of the zeolite and at the end of study was added 100 g of zeolite + 0.5 g of NaCl. To determine of bacterial content and turbidity was done using Pour Plate Methode and turbidity meter, respectively. The electrocoagulation process for 120 minutes can be reduced the bacterial content from 5125 CFU/mL to 2769 CFU/mL or equal of 45,97 % and turbidity from 44,10 NTU to 18,24 NTU or equal 58,64 %. The electrocoagulation process for 120 minutes with added of 100 g of zeolite can be reduced the bacterial content from 5125 CFU/mL to 2629 CFU/mL or equal of 48,70 % and turbidity from 44,10 NTU to 16,34 NTU or equal 62,95%. The electrocoagulation process for 120 minutes with added of 100 g of zeolite + 0.5 g NaCl can be reduced the bacterial content from 5125 CFU/mL to 1429 CFU/mL or equal of 72,12 % and turbidity from 44,10 NTU to 1,34 NTU or equal 96,96%. In conclusion the electrocoagulation process with added 100 g zeolite and 0.5 g NaCl is the best condition compared to the other processes.

1 INTRODUCTION

Industrial or domestic wastewater generally contains organic pollutants and heavy metals and has the potential to be reused into clean or drinking water through many methode processes. The water parameters in water drinking that made from wastewater must be accordanced with the regulation of Indonesian Ministry of Health No. 492 / Menkes / Per / IV / 2010. On the Minister of Health regulation No. 492 / Menkes / Per / IV / 2010 mentioned that the water parameters in water drinking are 5 NTU for turbidity, 0 per 100 mL for Coliform bacteria and 0 per 100 mL for Escherichia Coli (E Coli) bacteria.

One methode in water treatment from waste water into drinking water or clean water is electrocoagulation process. Anode and cathode made from aluminum or iron plates are needed to operate of the electrocoagulation process (Kourdali et al, 2018).

When the electrocoagulation process is operated, a coagulant compound will be generated in the wastewater. Coagulant compounds are used as an adsorbant material to absorb organic and inorganic pollutants in wastewater (Díaz et al, 2018)

In generally, pollutants in wastewater are formed from organic and inorganic materials. As a result of mixed organic and inorganic pollutants can reduce the electrical conductivity in the water. If the electrical conductivity process is very low, then the process of forming coagulant compounds in wastewater becomes less and less. To increase the electrical conductivity in wastewater can be added sodium chloride (NaCl) into wastewater (Daniel, 2018). Sodium chloride has has the ability to kill microorganisms (bacteria) and can produce a strong electrolyte solution. Zeolite also can be added in wastewater to increase speed up of reducing

Sutanto, . and Rohadi, N.
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DOI: 10.5220/0009873700002905
In *Proceedings of the 8th Annual Southeast Asian International Seminar (ASAIS 2019)*, pages 67-73
ISBN: 978-989-758-468-8

pollutant in the wastewater. Because zeolite is easy to adsorb pollutants in wastewater.

The combination of zeolite and NaCl into wastewater is intended to help reduce the content of bacteria and pollutants in wastewater (Thanasia, 2019).

Anode and cathode made from aluminum or iron plates are needed to operate of the electrocoagulation process (Ghalwa et al, 2018). If in electrocoagulation process using anode made from aluminum, then the equation of reaction as follows (Kobya et al, 2013):

anode (oxidation process):

$$2Al \rightarrow 2Al^{+3} + 6e^{-} \quad (1)$$

cathode (reduction process) :

$$6H_2O+6e^{-}\rightarrow 6OH^{-}+3H_2 \quad (2)$$

in overall :

$$2Al+6H_2O\rightarrow 2Al(OH)_3+3H_2 \quad (3)$$

The coagulant $Al(OH)_3$ in equation 3 is formed that has a function as an absorbent compound for pollutants or bacteria in wastewater.

The results of the study (Karicappan et al, 2014) showed that in domestic wastewater treatment using electrocoagulation process was able to reduce the total solid content (TS) to 98.45% and Coliform bacteria to 96.34%.

The results of a study on the electrocoagulation process in liquid waste showed that process can reduce lead content (Pb) over of 90% (Eiband et al, 2014).

The equation for calculating the weight of Al^{+3} metal ions that formed in the continuous electrocoagulation process as follows (Kurmar et al, 2010):

$$m =(S)(A)(a_r)(I)/[(Q)(96.500)(n)] \quad (4)$$

where m: mass Al + 3 released by the anode (gram), S: process bath height (cm), A: cross-sectional area of process bath (cm^2), a_r: relative atomic mass, I: electric current (ampere), Q: discharge wastewater (cm^3/sec) and n: change in oxidation number. Based on equation 4 can be explained that in use of high electric currents, so more will be generated of Al^{+3} ions.

The equipments for the electrocoagulation process consists of process tank, DC source (direct current), anode and cathode. Process tank must be made from insulator materials, anodes and cathode can be made from aluminum or iron (Shanthi et al, 2011).

If the electrocoagulation process is added Na_2SO_4 (Sodium Sulfate) or NaCl (Sodium Chloride) in wastewater, then can be formed strong electrolyte. Therefore the solution is easy to conduct electric current which can increase the coagulant compound to absorb pollutant in wastewater (Rios et al, 2014).

The electrocoagulation process with the addition of NaCl as much as 740 mg/L can be reduced the chemical oxygen demand (COD) up to 98% and total suspended solid (TSS) up to 93% (Thirugnanashambandam et al., 2013). Hypochlorite (HOCl) compounds as byproducts will be produced at during occur of process. Hypochlorite is an oxidizing agent which can kill bacteria in waste water. The mechanism of hypochlorite formation can be explained by reaction equation as follows :

$$NaCl\rightarrow Na^{+}+Cl^{-} \quad (5)$$

$$2Cl^{-}\rightarrow Cl_2+2e \quad (6)$$

$$Cl_2+H_2O\rightarrow HOCl+Cl^{-}+H^{+} \quad (7)$$

$$HOCl\rightarrow OCl^{-} + H^{+} \quad (8)$$

The electrocoagulation process that added NaCl can be increased the dissolution of Al from the anode (Eskibalci et al, 2018). In studies conducted with the addition of 0.5 gr/L of NaCl on stirring speed of 180 rpm and a residence time of 55 seconds can be reduced total suspended solid (TTS), detergents, oils and fats, total phosphate and turbidity up to 100% (Agustin et al, 2008).

The process of adsorption of metal ion by zeolites can be explained as follows (Meng et al, 2017) :

$$Na_2\text{-}Z+M^{+} \longrightarrow MZ+Na^{+} \quad (9)$$

$$Z\text{-}H + M^{+} \longrightarrow MZ + H^{+} \quad (10)$$

where M^{+} is a metal ion that absorbed by zeolite. The approach equation of Freundlich isotherm in ion exchange process as follows (Hong et al,2019):

$$c_e= k (q_e)^n \quad (11)$$

where c_e: M^+ concentration in solution at equilibrium (meq/L), k: constant, q_e: the amount of absorbed M^+/ zeolite weight at equilibrium (meq/g), n: constant. If n is between 2 and 10, the adsorption process is very faster and can be approached in isoterm Langmuir equation as follows (Li et al, 2018):

$$q_e=q^0kc_e/(1+kc_e) \quad (12)$$

where q_e: the amount of absorbed M^+/zeolite weight at equilibrium (meq/g), q^0: maximum absorption capacity on the surface/weight of zeolite (meq/g), k : constant, c_e: M^+ concentration in solution at equilibrium (meq/L). Equation 12 changed to as follows (Munagapati et al, 2017):

$$1/q_e=(1/q^0k)(1/c_e)+1/q^0 \quad (13)$$

By making a curve of the relationship between $1/q_e$ to $1/c_e$, can be obtained slope $1/q^0k$ and intercept $1/q^0$. The constant value and maximum absorption capacity (q^0) of zeolite can be estimated easily (Padilla et al, 2018).

2 METHOD

The research method consists of materials, equipments and work procedures.

2.1 Materials

The materials needed are the Aluminum HTC 16-35 as an electrode, zeolite, NaCl and industrial electronics wastewater

2.2 Equipments

The equipments needed are process tanks, DC sources, ampermeters, flow meters, AAS (Atomic Absorption Spectrophotometer), Soxhlet, pH meters, turbidity meters and colony counter

2.3 Procedure

2.3.1 Measuring Wastewater Quality

The parameters of wastewater measured were metal concentration using AAS, turbidity using turbidimeter and bacterial using colony counter. The measurement results shown as follows: bacterial is 5125 CFU/mL and turbidity is 44,10 NTU.

2.3.2 Constructing Research Equipments

The series of research tools can be seen in figure 1. The equipments needed are a DC source, an avometer, a wastewater storage tank, an electrocoagulation process tank, a sewage settling tank and a water reservoir.

2.3.3 Research Implementation

The resaerch was conducted by flowing 4.5 liters of wastewater from storage tank into an electrocoagulation tank which was divided into three cells. The DC source is turned on at a voltage of 12 V and the electric current can be read on the ampere meter. The process is turn off after 10 minutes. Water from the electrocoagulation process tank was drained into the sewage settling tank. After a few minutes sediment are formed at the bottom of the tank. Bacterial content in the water of sewage settling tank is measured by the Pour Plate Method and turbidity by a turbidimeter. Re-measurements were carried out with a processing time of 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 and 120 minutes. Subsequenty, research was carried out by adding 100 g of zeolite and a mixture of 100 g of zeolite with 0.5 g of NaCl.

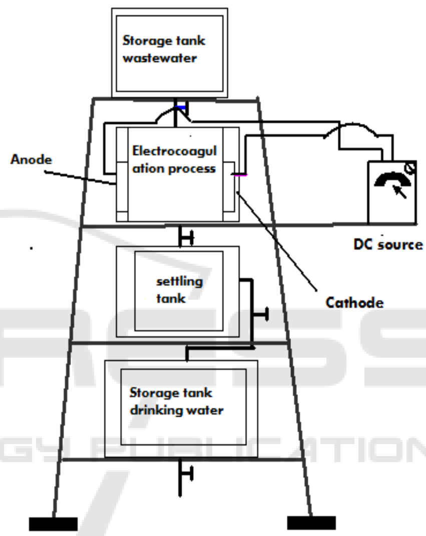

Figure 1: The series of research tools

3 RESULT AND ANALYSIS

The results measurements of changes in bacterial content and water turbidity showed based on the elctrocoagulation process (Elc), elctrocoagulation process with added zeolite (Elc + zeolite) and elctrocoagulation process with added zeolit and NaCl (Elc + zeolite+Nacl)

3.1 The Effect of Electrocoagulation (Elc) Processes on Changes in Bacterial Content and Water Turbidity

The results of measurements of bacterial content and water turbidity from electrocoagulation wastewater treatment processes are shown in table 1. Based on table 1, it can be explained that the electrocoagulation process can reduce bacterial content and water turbidity. Bacterial content can be reduced from 5125 CFU / mL to 2769 CFU / mL or equivalent to 45.97% at 120 minutes of processing time. While with the same time the turbidity can be reduced from 44.10 NTU to 18.24 NTU or equivalent to 58.64%. The electrocoagulation process until to 120 minutes did not produce drinking water standard, because the bacterial content was more than 0 CFU/mL and the turbidity of the water was more than 5 NTU.

The coagulant compound of Al $(OH)_3$ will be generated when the electrocoagulation process is carried out using aluminum as anode. The compounds of $AlOH)_3$ is an adsorbant material that can absorb bacteria and pollutants in the water. Therefore bacterial content and turbidity will be reduced from the wastewater.

Table 1: Results of measurements of bacterial content and water turbidity from the electrocoagulation process (Elc)

Time (minute)	Bacterial content (CFU/mL)	Turbidity (NTU)
0	5125	44.10
10	5000	44.02
20	496 5	43.20
30	4876	42.52
40	4629	40.14
50	4560	38.02
60	4365	36.50
70	4100	34.32
80	3845	31.23
90	3676	28.52
100	3423	25.14
110	3156	22.32
120	2769	18.24

3.2 The Effect of Electrocoagulation Process by Addition of Zeolite (Elc + Zeolite) on Changes in Bacterial Content and Water Turbidity

The results of measurements of bacterial content and turbidity from the treatment wastewater by electrocoagulation process which added zeolite, shown in table 2. Based on table 2, it can be explained that the electrocoagulation process can reduce bacterial content and turbidity in the water. Bacterial content can be reduced from 5125 CFU/mL to 2629 CFU/mL or equivalent to 48.70% with 120 minutes processing time. While with the same time the turbidity of water can be reduced from 44.10 NTU to 16.34 NTU or equivalent to 62.95%. The addition of 100 g zeolite in the electrocoagulation process was able to increase bacterial removal by 2.73% and increase turbidity removal by 4.31%. However, this process also cannot produce drinking water, because the bacterial content was more than 0 CFU/mL and the turbidity of the water was more than 5 NTU.

The reducing of bacterial content and turbidity in the water was accelerated by added of zeolites. Because zeolite has the property of easily absorbing bacterial and pollutants in the wastewater

Table 2: Results of measurements of bacterial content and water turbidity from the electrocoagulation process (Elc) added zeolite (Elc + zeolite)

Time (menit)	Bacterial content (CFU/mL)	Turbidity (NTU)
0	5125	44.10
10	4978	43.82
20	4875	42.40
30	4776	41.52
40	4519	39.74
50	4369	37.42
60	4125	35.90
70	3990	33.22
80	3755	28.83
90	3426	26.52
100	3213	24.34
110	2936	21.52
120	2629	16.34

3.3 The Effect of Electrocoagulation Process by Addition of Zeolite and Sodium Chloride (Elc + zeolite + NaCl) to Changes in Bacterial Content and Water Turbidity

The results of measurements of bacterial content and water turbidity from the treatment wastewater by electrocoagulation process which added zeolite and NaCl, are shown in table 3. Based on table 3, it can be explained that the electrocoagulation process added by zeolite and NaCl can be reduced bacterial content and turbidity in the water. The bacterial content can be reduced from 5125 CFU/mL to 1429 CFU/mL or equivalent to 72.12% with 120 minutes processing time. While with the same time the turbidity of water can be reduced from 44.10 NTU to 1.34 NTU or equivalent to 96.96%. The addition of 100 g zeolite and 0.5 g NaCl in the electrocoagulation process was able to increase bacterial removal by 26.15% and increase turbidity removal by 50.99%. In this treatment the turbidity value is below 5 NTU, but the bacterial content is still more than 0 CFU/mL.Therefore this treatment also has not been able to produce drinking water standard.

The reducing of bacterial content and turbidity in the water was accelerated by added of zeolites and NaCl. Because zeolite has the property of easily absorbing bacterial and pollutants in the wastewater and NaCl easily killing of bacterial.

The addition of NaCl can also increase the electrical conductivity of wastewater, so that the current in the electrocoagulation process becomes even greater. The greater of electric current will be accelerated the formation of Al $(OH)_3$ coagulant. The compounds of Al $(OH)_3$ easily to absorb bacterial and pollutants in the water, so that the bacterial content and water turbidity was decreased from the water.

Table 3: Results of measurements of bacterial content and water turbidity from the electrocoagulation process (Elc) added zeolite (Elc + zeolite +NaCl)

Time (menit)	Bacterial content (CFU/mL)	Turbidity NTU
0	5125	44.10
10	4888	41.22
20	4665	38.20
30	4446	36.52
40	4129	32.54
50	3869	27.92
60	3575	25.70
70	3196	21.26
80	2765	18.93
90	2526	15.52
100	2018	11.34
110	1836	6.52
120	1429	1.34

3.4 Comparison Curves of Wastewater Treatment

Figure 2 is curve for result of measurement of bacterial content based on the results of the electrocoagulation process (Elc), the electrocoagulation process added zeolite (Elc + zeolite) and the electrocoagulation process added zeolite and NaCl (Elc + zeolite + NaCl) based on tables 1, 2 and 3.

Based on figure 2, shows that the electrocoagulation process (Elc) is able to reduce bacterial content in water. Zeolite 100 g added to the electrocoagulation process (Elc + zeolite) is able to accelerate of reduce bacterial content in water compared to the electrocoagulation process only. If the electrocoagulation proses was added zeolite 100 g and NaCl 0.5 g, then the decrease in bacterial content is faster than the only electrocoagulation process or the electrocoagulation process which is added zeolite. In be concluded that the most rapid to reduce bacterial content in the water was found in the electrocoagulation process which was added 100 g zeolite and 0.5 g NaCl.

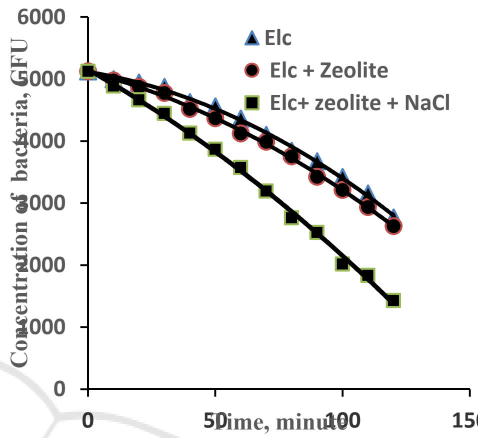

Figure 2: Curve changes of bacterial content in water

Figure 3 is curve for result of measurement of turbidity based on the results of the electrocoagulation process (Elc), the electrocoagulation process added zeolite (Elc + zeolite) and the electrocoagulation process added zeolite and NaCl (Elc + zeolite + NaCl) based on tables 1, 2 and 3.

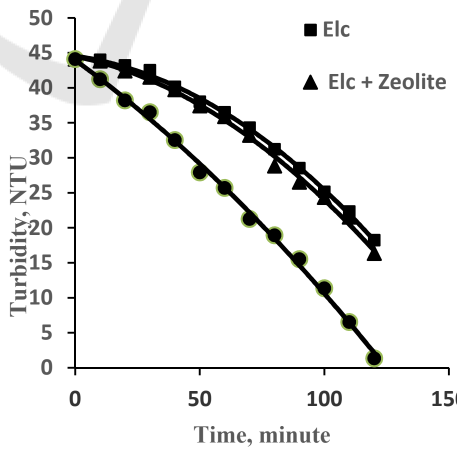

Figure 3: Curve changes of turbidity in water

Based on figure 3, shows that the electrocoagulation process (Elc) is able to reduce turbidity in water. Zeolite 100 g added to the electrocoagulation process (Elc + zeolite) is able to accelerate of reduce turbidity in water compared to the only electrocoagulation process. If the electrocoagulation proses was added zeolite 100 g and NaCl 0.5 g, then the decrease in turbidity is faster than the only electrocoagulation process or the electrocoagulation process which is added zeolite. In be concluded that the most rapid to reduce turbidity in the water was found in the electrocoagulation process which was added 100 g zeolite and 0.5 g NaCl

4 CONCLUSION

The addition of zeolites and NaCl to the electrocoagulation process can be reduced bacterial content and turbidity in the water. Electrocoagulation process at 12 V for 120 minutes by adding zeolite 100 g and NaCl 0.5 can be reduced bacterial content from 5125 CFU/mL to 1429 CFU / mL or equivalent to 72.12% and turbidity from 44.10 NTU to 1.34 NTU or equivalent to 96.96%.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Ministry of Research and Technology Directorate General of Higher Education of the Republic of Indonesia for the financial support awarded to carry out this research for the third year, also Afiliation-Laboratory FMIPA University of Indonesia UI those have helped a lot in the data collection required.

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