

Masthura. The Effect of Applied Voltage in The Electrocoagulation Process of Reducing Pond and River Water Turbidity

THE EFFECT OF APPLIED VOLTAGE IN THE ELECTROCOAGULATION PROCESS OF REDUCING POND AND RIVER WATER TURBIDITY

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Abstract : The study about the effect of the applied voltage to decrease the water turbidity from local pond and river have been conducted. This study aims to investigate the ability of the electrocoagulation process in removing pollutants containing groundwater from the pond and river. The water sample obtained from Dusun I Paya Perupuk Tanjung Pura in Langkat Regency, Indonesia which has been reported having high water turbidity. A copper plate was used as a sacrificial electrode with a specific variation of applied voltage of 6, 9, and 12 Volts. The result showed that applying 9 and 12 volts of voltages were able to reduce 60% and 66% of water turbidity from water pond, respectively. In river water, both optimum applied voltages could reduce approximately 98% of water turbidity. The result indicated that the electrocoagulation process potentially devoted as an alternative way to treat the massive local groundwater.

Keywords : Electrocoagulation, Applied voltage, Groundwater, Pond, River water

Abstrak : Penelitian mengenai pengaruh tegangan listrik terhadap penurunan kekeruhan air sumur dan air sungai pada proses elektrokoagulasi telah dilakukan. Penelitian ini bertujuan untuk mengetahui kemampuan proses elektrokoagulasi dalam menghilangkan polutan yang berada di air yang diperoleh dari air sumur dan air sungai. Sampel air diperoleh dari Dusun I Desa Paya Perupuk Tanjung Pura Kabupaten Langkat. Lapisan plat tembaga (Cu) digunakan sebagai elektroda dengan variasi spesifik voltase sebesar 6, 9, dan 12 volts. Hasil menunjukkan bahwa pemberian voltase 9 dan 12 dapat menurunkan kekeruhan air sumur sebesar 60 dan 66%. Pada sample air sungai, pemberian kedua voltase optimum dapat menurunkan 98% dari kekeruhan air. Hasil penelitian mengindikasikan proses elektrokoagulasi berpotensi sebagai sebuah cara alternative untuk mengolah air.

Kata kunci: Elektrokoagulasi, Tegangan listrik, Air tanah, Air sumur , Air sungai

Introduction

Water is generally classified as clean in terms of its physical form, but the chemical content of water depends on the formation of the lithosphere through which it may be or the presence of pollution from the surrounding environment. In the water flows, minerals can contaminate the water resulting in water pollution. Water often contains metal elements that form brownish-yellow water and patches on clothing and potentially threaten human health such as heath disease, kidney disease, and neurological disease. Consuming the polluted water, especially the

one which contaminated by a specific heavy metal such as Mn, Fe, Mg, and Ca, potentially initiated the disease since it can accumulate to the human body system. Therefore, the water treatment becomes the essential process before consuming the water especially consuming the water collected from the water bodies such as a river, pond, or underground water (Tuti Rahayu, 2004).

Electrocoagulation is the process of collecting and settling fine particles in water using electrical energy. The electrocoagulation process is carried out by inserting electrodes into the electrolyte solution in a chamber. Electrode plates are arranged in parallel at a certain distance and electrified by a DC to flow electrons from the cathode and anode. Electric current initiates the anode to release certain ions which will further react with contaminants. On the other side, hydrogen gas (H₂) is generated in the cathode. This method is part of the green process since it provides high-efficiency process and preventive adding any chemical additives (Moraida, 2011).

Conductivity determines the ability to conduct electric current in a medium. The conductivity level in water indicates the amount of metal content dissolved in the water. Besides, the conductivity is influenced by the electrode material that reacts with ions in water. Thus, there will be an increase in conductivity when the ion concentration increased (Hendrawati et al., 2013).

In the present study, Copper plate (Cu) was used as the electrode since it had a high conductivity compared to the other metal-based electrode such as aluminium. The high conductivity of the Cu electrode possibly provides a better electrocoagulation process. The electrocoagulation process using Cu electrode potentially becomes an alternative way to produce clean water which can be daily used based on specific parameters regulated by the Ministry of Health of Republic Indonesia.

Groundwater

Groundwater is water located below the ground level in the saturated zone with hydrostatic pressure equal to or greater than atmospheric pressure. The groundwater is divided into shallow groundwater and deep groundwater. To be more specific, the shallow groundwater was generated by the adsorbing process from the land surface. Normally, the shallow groundwater located at a depth of 15 m² and is used as a source of clean water through shallow wells or ponds. The shallow groundwater has quite good quality and limited sources depending on the season. The second type of groundwater is deep groundwater. The deep groundwater located after the first water-dense layer. Collecting the deep groundwater is not as easy as collecting the shallow groundwater because it has to use a drill and insert the pipe to reach the water. The deep groundwater normally located in depth between 100 - 300 m². Comparing to shallow groundwater, the deep groundwater has better quality and quantity which is not depending on the season (Fety and Yogi, 2011).

Groundwater mainly comes from rainwater that falls on the surface of the earth/earth and most of the water seeps into the soil and fills cavities or pores in the soil. The groundwater content in the soil depends on the structure of the soil, whether the soil is water seepage or has a waterproof layer (Asmadi, 2011).

River water

The river as one of the natural resources has a versatile function for the life and livelihood of living things. The function of the river is as a source of drinking water, transportation facilities, irrigation sources, fisheries, etc. The anthropogenic activities often pollute the water bodies in the river resulting in the decrease of environmental quality (Soemarwoto, 2003).

The river has three parts of environmental conditions namely upstream, downstream, and river estuary. All three conditions have different water quality. In upstream, the water quality is the best one indicated by clear color, having a small amount of pollution or chemical/biological components. In downstream, most of the water has been contaminated by human activity. It is indicated by the presence of high chemical and biological components. Most of the water collected in downstream needs further treatment before consuming by the local people. In river estuary, the water quality is influenced by seawater. The water flow is relatively slow but having a high volume. Most of the water in the estuary contains a high number of dissolved components, sludge, and dissolved soil showed by the high turbidity which potentially forms a delta channel (Soemarwoto, 2003).

Clean water quality

The clean water must have a good quality which refers to water quality standards. Water quality is the condition and quality of water that is tested by certain parameters and methods based on applicable regulations. While the water quality standard is a measure of the limits or levels of living things, substances, energy, or components that exist or must be present or pollutants that are tolerated containing in the water. The quality of raw water will determine the amount of investment in the water purification plant and the costs of operation and maintenance. The worse water quality cost a higher price of clean water. The good water requirements are viewed in terms of water quality which includes physical, chemical, and microbiological quality so that when consumed it does not cause side effects (Permenkes No. 416/Menkes/PER/IX/1990).

Table 1. Clean water quality requirement based on the regulation of health ministry of Republic Indonesia No. 416/1990

No	Parameter	Unit	Maximum allowance parameter level	Evidence
A.	Physical			
	1. Odor	-	-	Odorless

Masthura: The Effect of Applied Voltage in The Electrocoagulation Process of Reducing Pond and River Water Turbidity

No	Parameter	Unit	Maximum allowance parameter level	Evidence
2.	Total dissolved solid	mg/L	1.500	-
3.	Turbidity	NTU	25	-
4.	Taste	-	-	Tasteless
5.	Temperature	°C	±3°C	-
6.	Color	TCU	50	
B.	Chemical			
1.	Hg	mg/L	0,001	
2.	Ar	mg/L	0,05	
3.	Fe	mg/L	1,0	
4.	F	mg/L	1,5	
5.	Cd	mg/L	0,005	
6.	CaCO ₃ / Hardness	mg/L	500	
7.	Cl ⁻ ion	mg/L	600	
8.	Cr (IV)	mg/L	0,05	
9.	Mn	mg/L	0,5	
10.	NO ₃ ⁻ as N source	mg/L	10	
11.	NO ₂ ⁻ as N source	mg/L	1,0	
12.	pH	-	6,5 – 9,0	As the trace of minimum and maximum level except for rainwater which has pH 5.5 as the minimum pH level
13.	Se	mg/L	0,01	
14.	Zn	mg/L	15	
15.	CN ⁻	mg/L	0,1	
16.	SO ₄ ²⁻	mg/L	400	
17.	Pb	mg/L	0,05	
C.	Mikro biologic	Amount per 100 ml	50	Not piped water
	Total coliform (MPN)	Amount per 100 ml	10	Piped water

Source : Permenkes No. 416/Menkes/PER/IX/1990

Materials and Method

Sample preparation

The study used an experimental method design. The sample used was collected from the local pond and river water in Desa Dusun I Paya Perupuk Tanjung Pura Kabupaten Langkat, Indonesia. The sample was taken twice on the surface and bottom of the pond. In river water, the sample was collected in the upstream dan downstream area. The samples were then mixed to homogenize the sample.

Electrocoagulation Procedure

Figure 1 showed the experimental equipment schematically. An aquarium used as the chamber for conducting the study. With a dimension of 30 cm x 25 cm x 15 cm. A copper electrode plate that has a dimension of 12 cm height x 10 cm width x 0.5 mm thickness was used for the sacrificial electrode arranged in monopolar configurations. There were three plates were constructed in the reactor system and the distances of each plate were set in a similar length. The current was maintained by a precision DC power supply with a specific characterization by the ranges of 0-12 voltage. In this study, there were three levels of the voltage applied in the system to investigate the effect of applied voltage in the water electrocoagulation process. In the beginning, 6 voltage was introduced to the system for a certain time until the clear water achieved. The processes were repeated with a specific 9 and 12 voltages with similar procedures. As a control, the untreated sample was kept without any voltage applied. Furthermore, all the control and the treated sample were analyzed at the Clinical Laboratory of Medan.

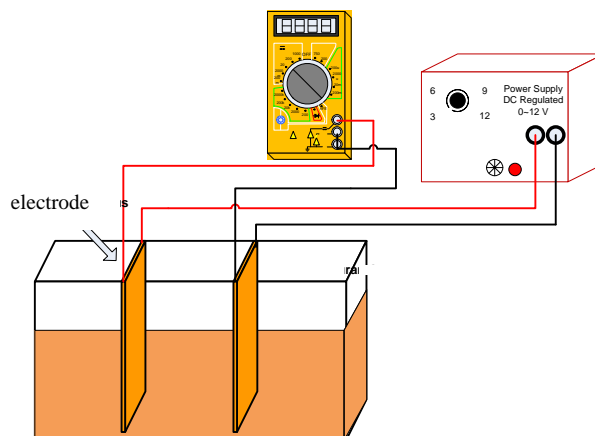


Figure 1. Experimental system of electrocoagulation using Cu electrode

Result and Discussion

Turbidity is one of the physical contaminant parameters which determines the water quality. There is formed by the suspended solids generated by the suspended soil or the other moist inorganic particles originating from rainwater runoff (erosion). Turbidity does not directly affect health, but turbid water needs to be treated in order to meet clean water requirements. The level of turbidity indicates the presence of dissolved and suspended components which both sourced from the results of erosion and the fractions of plant remnants.

In the present study, Table 2 represented the result as the function of the applied voltage to reduce the turbidity of pond and river water. Before the treatment, both samples were categorized as turbid water since their turbidity had the excess the minimum requirement of clean water standard. The pond water had

higher turbidity compared to river water. However, applying 6 voltage on the electrocoagulation system did not turn both samples to be clean water since the turbidity had only reduced to 28 NTU and 26 NTU for pond water and river water, respectively. Therefore, the electrocoagulation seemed potentially applied since it could reduce approximately 40-50 % turbidity in low applied voltage.

The study was continued by applying a higher voltage to 9 and 12 voltages. The result showed that the higher applied voltages reduce higher turbidity since 9 and 12 voltages could reduce the turbidity of river water to 20 and 17 NTU, respectively. Both treated water samples met the minimum required standard of clean water which now could be categorized as clean water. It has also happened to the river water sample were applying 9 and 12 voltages reduced 31 NTU samples to 1 NTU for both treated systems. According to Siringo-ringo (2013), the decrease in turbidity level in electrocoagulation process depended on the contact time and applied voltage where both parameters determined the number of ions released by the electrodes to produce copper hydroxide which further binds the organic materials to form flocks which could clump the suspended solids in water, resulting in the decrease of water turbidity level.

Table 2. The result of electrocoagulation treatment

Sample	Applied voltage (Volt)	Turbidity (NTU)	Minimum requirement of clean water standard based on Permenkes No. 416/1990
Pond water	0	50	25 NTU
	6	28	
	9	20	
	12	17	
River water	0	31	25 NTU
	6	26	
	9	1	
	12	1	

The effect of the applied voltage to contact time on the electrocoagulation process

The voltage and electric current played the main role in electrocoagulation since both determined the formation of electron transfer reactions and reaction rates. In the basic process, electrocoagulation and electrochemistry had a similar process where the applied current in anode initiated the oxidation process for anion ions. In the present study, the series of applied voltage had 5 Ampere as the maximum of electric current. The choosing of the electric current was because of the availability of equipment. It could be seen that the combination of applied current and voltage could effectively reduce the turbidity of both samples. The result proved that both voltage and current were important in the

electrocoagulation process because initiating the system with voltage and currently facilitated the reduction reaction of colloid or small particle in the cathode. This combination of oxidation and reduction reaction becomes the main core in the electrocoagulation process.

Table 3. The effect of the applied voltage to the contact time on the electrocoagulation process

No	Applied voltage (Volt)	Pond water		River water	
		Current (mA)	Time (Minutes)	Current (mA)	Time (Minutes)
1	6	1,4	100	1,55	75
2	9	5,5	86	3,3	60
3	12	8,2	80	5,8	54

In table 3, the applied voltage differentiated the contact time on the electrocoagulation process. In pond water, applying 9 and 12 volts generated 86 and 80 minutes of contact time, respectively. Moreover, river water needed a shorter time which only required 60 and 54 minutes to reduce the turbidity for 9 and 12 volts, respectively. The difference of contact time depended on the turbidity itself, where the higher turbidity generated the higher contact time. Additionally, the higher voltage applied to the system resulted in less contact time of the electrocoagulation process. It was because the higher applied voltage generated the higher generated current which facilitated more generated ions. The number of generated ions correlated the number of conversions in the electrocoagulation system which initiated the shorter process. The other reason was because of the number of copper conductivity which was higher compared to the other common sacrificial electrode. Higher conductivity means the efficiency of electron transfer between electrodes.

Moraidah (2011) reported that the applied current initiated the chemical transformation in the medium of electrolyte solution and metal (electrode). The higher voltage and current flowed to the medium would generate a higher number of electron shifted in the system. The electron could form OH^- and make a bond with Cu^{2+} from anode resulting in the formulation of complex $\text{Cu}(\text{OH})_2$ which further used to absorb contaminant in the sample.

Conclusions

The applied voltage differentiated the efficiency of the electrocoagulation process in which applying 9 and 12 volts provided the highest reducing turbidity in both pond and river water samples. All the treated samples have fulfilled the minimum requirement of clean water based on the regulation of health minister of Republic Indonesia No 416/MENKES/PER/IX/1990. Furthermore, the applied voltage generated the different contact times as the result of different current generated to the system. The study proved that the electrocoagulation could be an alternative way to reduce the turbidity of local water to fulfill the minimum requirement of clean water.

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