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REMOVAL OF COD, BOD, AMMONIA AND TSS USING ELECTROCOAGULATION METHOD WITH A COMBINATION OF ALUMINUM (AL) AND IRON (FE) ELECTRODES IN FISH PROCESSING WASTEWATER

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ABSTRACT

The Wastewater from fish processing contains highly organic pollutants, causing pollution to water bodies. Electrocoagulation method is utilised in fisheries wastewater treatment because of its simple and easier to do and also effective in removing pollutants. This research uses an experimental method with a quantitative approach by using dependent variables such as COD, BOD, ammonia, TSS and pH and independent variables such as electrical voltage of 3, 5 volts and contact time of 60, 90 and 120 minutes. The results of the electrocoagulation process using Al and Fe electrodes showed the effectiveness of reducing the concentration of COD, BOD and TSS values by 96.34%, 95.2% and 73.22% with the maximum voltage of 5 volts and a contact time of 120 minutes. The effectiveness of reducing ammonia concentration occured at the optimum voltage of 3 with a contact time of 60 minutes, which was 98.75%. The pH concentration increased from acidic to alkaline. Based on the results of this study, the amount of voltage in the electrocoagulation method can affect the concentration of COD, BOD, ammonia and TSS contained in wastewater from fish processing. The results obtained show the quality of wastewater in accordance with predetermined quality standards.

Keywords : Fishery Wastewater, Electrocoagulation Method, Voltage.

ABSTRAK

Air limbah hasil pengolahan ikan mengandung polutan organik yang sangat tinggi sehingga menyebabkan pencemaran bagi badan air. Metode elektrokoagulasi digunakan dalam pengolahan air limbah perikanan karena sederhana dan mudah untuk dilakukan serta efektif dalam penyisihan polutan. Tujuan dari penelitian ini adalah untuk mengetahui efektivitas penurunan polutan dan pengaruh dari variasi tegangan listrik serta waktu kontak dengan metode elektrokoagulasi yang menggunakan elektroda aluminium (Al) silinder sebagai anoda dan besi (Fe) spiral sebagai katoda dalam penyisihan COD, BOD, amonia, TSS, pH pada air limbah hasil pengolahan ikan. Penelitian ini menggunakan metode eksperimental dengan pendekatan kuantitatif melalui variabel terikat yaitu COD, BOD, amonia, TSS serta pH dan variabel bebas yaitu tegangan listrik 3, dan 5 volt, serta waktu kontak 60, 90 dan 120 menit. Hasil dari proses elektrokoagulasi menggunakan elektroda Al dan Fe menunjukkan efektivitas penurunan konsentrasi nilai COD, BOD dan TSS sebesar 96,34%, 95,2%, dan 73,22% dengan kemampuan optimum tegangan sebesar 5V dan waktu kontak 120 menit. Efektivitas penurunan konsentrasi amonia terjadi pada kemampuan optimum tegangan 3V dengan waktu kontak 60 menit yaitu sebesar 98,75%. Konsentrasi pH meningkat dari asam menjadi basa. Berdasarkan hasil penelitian ini, besar tegangan pada metode elektrokoagulasi dapat mempengaruhi konsentrasi

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COD, BOD, amonia serta TSS yang terdapat pada air limbah hasil dari pengolahan ikan. Hasil yang diperoleh menunjukkan kualitas air limbah sesuai dengan baku mutu yang telah ditentukan.

Kata kunci: *Air Limbah Perikanan, Metode Elektrokoagulasi, Tegangan*

Introduction

Based on data from The Central Bureau of Statistics (BPS) Banda Aceh City in 2023, the city of Banda Aceh produced 17,736 tons of fish in 2021 and increased production to 23,548 tons in 2022. The impact of increased production produces a significant quantity of wastewater. This fisheries wastewater tends to contain very high levels of organic pollutants. Therefore, processing is required to meet the specified quality standards (Yuliasni et al., 2019). The resulting wastewater can cause a decrease in the dissolved oxygen content in water, thereby reducing the availability of oxygen for organisms in the environment and producing an unpleasant odours (Marta and Nursyam, 2021).The characteristics of fish processing wastewater at one of the frozen fish processing and storage companies in the Lampulo Fish Auction Site (TPI) area, Banda Aceh City are above the quality standard with a COD value of 520 mg/L, BOD of 354.5 mg/L, Ammonia of 20 mg/L and pH of 6.1.

Electrocoagulation is a method of water treatment that involves an electrochemical reactions with the release of active coagulants in the form of metal ions into the solution at the anode and at the cathode there will be an electrolysis reaction that results in the release of hydrogen gas (Takwanto et al., 2018). Based on Sarif's research (2022), which has tested fish freezing wastewater using the electrocoagulation method with aluminum (Al) electrodes and has compared the efficiency of variations in current density and variations in contact time in reducing pollutant contaminants. The results obtained were that using aluminum (Al) electrodes can remove COD pollutant levels of 62.74% with a current density of 15 A/m2 and a contact time of 180 minutes. However, no one has done wastewater treatment from fish processing by the electrocoagulation method with aluminum (Al) and iron (Fe) electrodes. Therefore, this study was conducted with a combination of cylindrical and spiral electrode designs and varying the electric voltage and contact time.

Methods

This research uses an experimental method with a quantitative approach in the laboratory. This method starts from collecting literature studies, formulating problems, collecting data in the form of primary and secondary data, analysing data, determining results and discussing also drawing conclusions.

Samples were taken from the sewerage at PT. X, which is located at TPI Lampulo, Kuta Alam District, Banda Aceh by referring to SNI 6989.59:2008 as much as 15 L which was put into a jerry can. The characteristic test fish processing wastewater was conducted at UIN Ar-Raniry Multifunctional Building Laboratory and at UPTD Center for Health and Medical Devices Laboratory in Aceh. The parameters measured were COD, BOD, ammonia, TSS and pH in accordance with the Minister of Environment Regulation No. 5 of 2014 concerning Wastewater Quality Standards Appendix XIV.

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The tools used in this research were a glass tub measuring 30 cm x 15 cm x 15 cm, cylindrical aluminum electrodes measuring 10 cm with a diameter of 2 cm and spiral-shaped iron with dimensions of 10 cm and a height of 10 cm each as many as 2 pieces and Power Supplies.

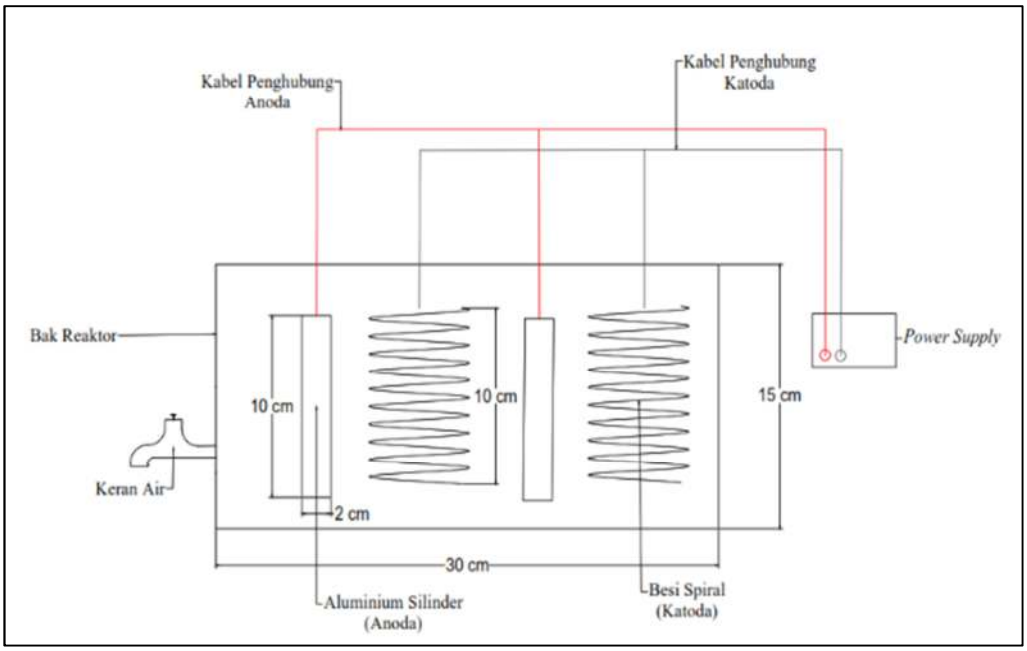

Figure 1. Electrocoagulation Reactor Design

Figure 1 shows the design of the glass bath of the electrocoagulation reactor filled with 1.5 cm electrode array and attached with alligator clips connected to the power supply. Two anode electrodes are connected to the positive lid and two cathode electrodes are connected to the negative lid. The variables reviewed in this study used 3 variations for voltage (3, 4, 5 volts) and 3 variations for contact time (60, 90, 120 minutes) in wastewater treatment of the fishing industry.

This study analyses the percentage of pollutant reduction in fish processing wastewater using the following effectiveness formula:

$$\text{Effectiveness (\%)} = \frac{Initial\ Level - End\ Level}{Initial\ Level} 100\% \quad \text{.....(1)}$$

The analysis used in this study is a correlation test analysis using Statistical Program and Social Science Software or SPSS version 2.7. Correlation test analysis aims to show the direction and strength of the influence of a relationship between two or more independent variables simultaneously on one dependent variable (Rachmadani and Abidin, 2019).

Results and Discussion

The measurement results of fish processing wastewater characteristics in Table 1 show that the parameters of COD, BOD, ammonia, TSS and pH exceed the quality

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standards of the Minister of Environment Regulation No. 5 of 2014 concerning Wastewater Quality Standards.

Table 1. Characteristics of Wastewater from Fish Processing

Parameter	Unit	Results	Quality standards
COD	mg/L	520	200
BOD	mg/L	354.5	100
Ammonia	mg/L	20	10
TSS	mg/L	262	100
pH	-	6.1	6-9

The results of the decrease in concentration and the percentage removal of COD parameter concentrations can be seen in Figure 2 which shows an increase in efficiency in removing COD concentration in wastewater by 96.34%. The highest COD level reduction was 19 mg/L with the electrocoagulation process using a voltage of 5 V and an optimum contact time of 120 minutes. The decrease in COD parameters levels in wastewater treatment is due to the cylindrical aluminum (Al) electrode which act as an anode has a larger surface area so that it produces a lot of Al(OH)3 coagulant which will bind organic compounds. The spiral-shaped iron electrode which acts as a cathode will form hydrogen gas bubbles that will raise the suspended flocs.

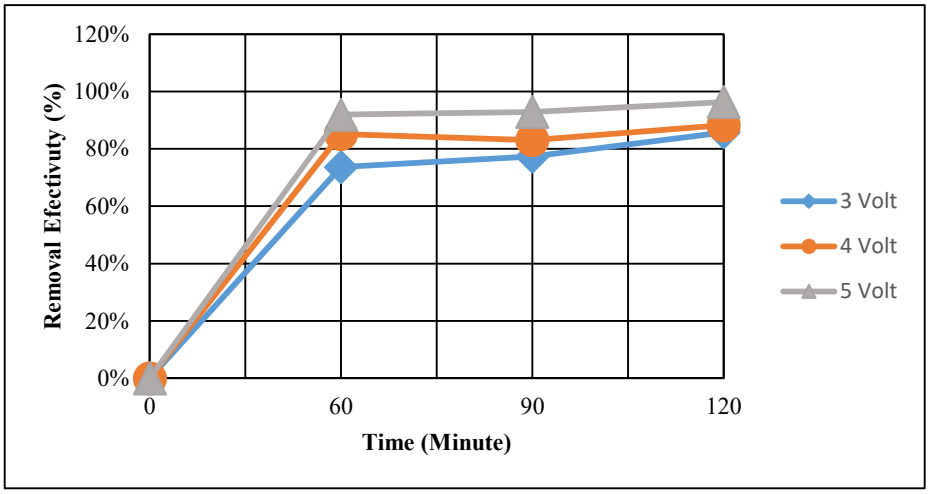

Figure 2. Effectiveness of Reducing COD Levels Using the Electrocoagulation Method Process

Biochemical Oxygen Demand (BOD) is the oxygen required by microorganisms to destroy organic matter aerobically(Daroini and Arisandi, 2020). The decrease in BOD value after the electrocoagulation process was carried out to 17 mg/L with a reduction efficiency of 95.20% which occurred in the electrocoagulation process using the optimum voltage and time of 5V with 120 minutes which can be seen in Figure 3. This event was caused by a decrease in BOD concentration so that causes a reduction in the amount of organic compounds in wastewater.

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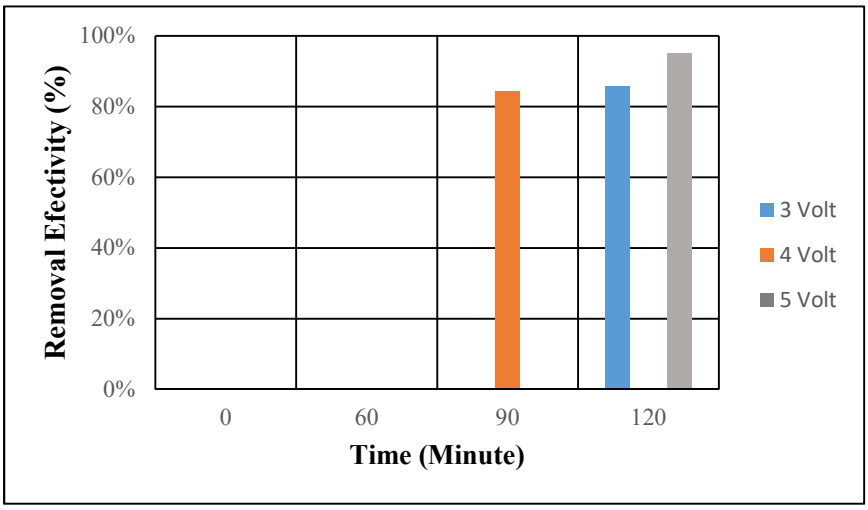

Figure 3. Effectiveness of Reducing BOD Levels Using the Electrocoagulation Method Process

The results of the efficiency of reducing ammonia parameters in fish processing wastewater after the electrocoagulation process can be seen in Figure 4. There is an increase in effectiveness in ammonia parameters by 98.75%. The optimum ability of the electrocoagulation process in reducing ammonia occurs at a voltage variation of 3V with a contact time of 60 minutes, which is 0.25 mg/L. Although the ammonia parameter value has met the quality standards, the value of each treatment tend to fluctuate. According toNur et al., (2020)The efficiency of the decrease that occurs fluctuates due to saturation of the electrode plate used, causing the electrode's ability to attract pollutants in wastewater to decrease. This happens because many pollutants stick to the electrode so that the electrochemical process becomes minimum and affects the electrocoagulation process.

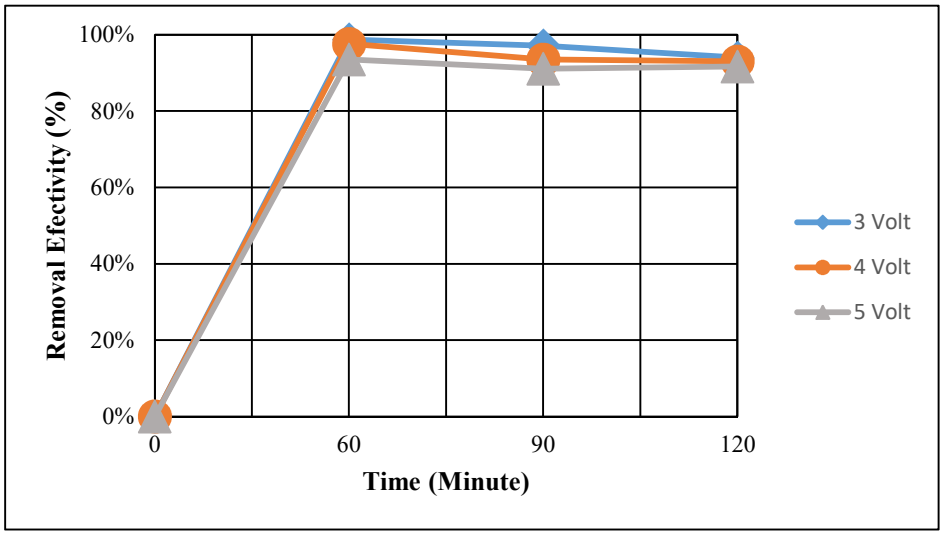

Figure 4. Effectiveness of Reducing Ammonia Levels Using the Electrocoagulation Method

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Based on Figure 5, it can be seen that the increase in effectiveness occurred by 73.22% which occurred in 120 minutes with a voltage of 5V, namely 70 mg/L. This also happened in researchFauzi et al., (2019)using aluminum and iron electrodes where the effectiveness of reducing ammonia concentration occured at a contact time of 150 minutes with a voltage of 12V of 76.08%.

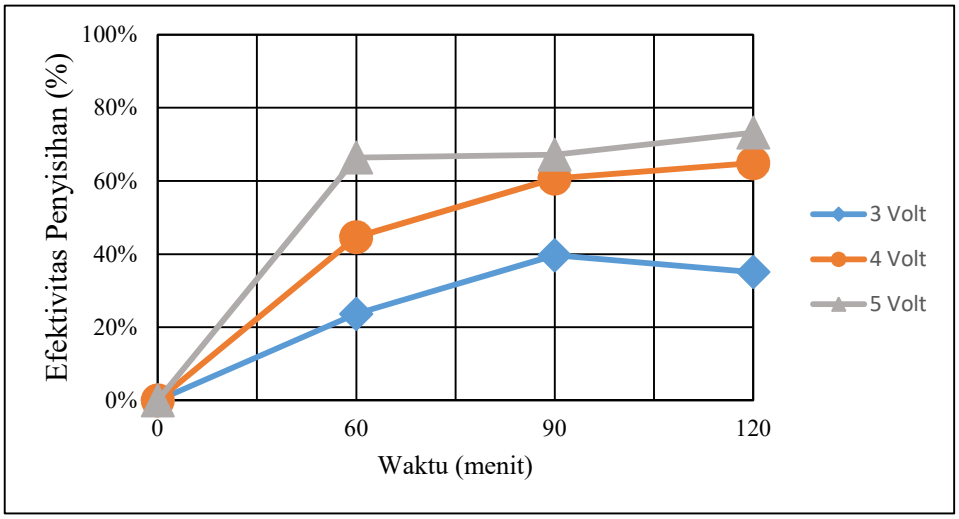

Figure 5. Effectiveness of Reducing TSS Levels Using the Electrocoagulation Method Process

The reduction in pollutants occurs because the particles formed during the electrocoagulation process have the ability to float to the surface. This is also due to the particles becoming larger and eventually settling to the bottom of the reactor tank. However, these particles may not have settled completely, hence the particles were carried away during the TSS test sampling.

This situation is reinforced by the statement ofNur et al., (2020)that the deposition of AI(OH)3 in the reactor tank occurs due to an oxidation reaction that occurs at the anode resulting in the growth of floc mass and precipitation. However, with stirring and hydrogen gas, some of the flocs formed stick to the reactor walls. The release of hydrogen gas in the electrocoagulation process causes a flotation process in the sample. Hydrogen gas will attach to pollutant particles that have a lower density compared to the density of water, so they will float to the surface. Floc formation in the electrocoagulation process is closely related to the intensity of the applied electrical voltage. The higher the voltage intensity, the more flocs are produced to capture contaminants in the waste.

Based on the characteristics of fish processing wastewater, it has a pH value of 6.1 and is classified as a acidic. The results of changes in pH concentration in fish processing wastewater after the electrocoagulation process with voltage variations of 3, 4 and 5V with contact times of 60, 90 and 120 minutes can be seen in Figure 6.

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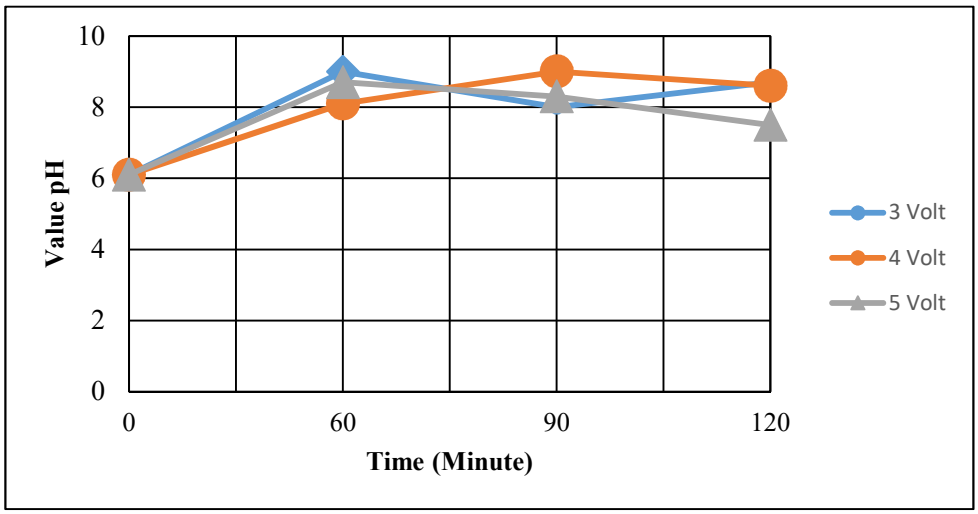

Figure 6. Changes in pH Levels in Liquid Waste Resulting from Fish Processing Using The Electrocoagulation Method

The pH value increased after the electrocoagulation process which can be seen in Figure 6. The increase in pH value tends to fluctuate in the treatment, in line with the increasing length of time and increasing voltage. Based on the data from research, it can be seen that the pH value for fish processing wastewater has met the quality standards of The Minister of Environment Regulation Number 5 of 2014 Appendix XIV with a value of 6-9.

Increasing the pH value will result in a decrease in the content of pollutants in wastewater. According to research conducted byFendriani et al., (2020)The increase in value occurs because in the electrocoagulation process there is a buildup of hydroxide ions (OH-). This large accumulation of hydroxide ions results in a reduction in the energy required to produce hydrogen or oxygen gas, resulting in more abundant gas bubbles. This increased number of air bubbles also contributes to the increased efficiency of the flotation process.

To determine the effect of voltage and contact time on reducing the concentration of COD, ammonia, TSS and pH, a correlation test was conducted using the Statistical Program and Social Science (SPSS) version 2.7 application. The results of the correlation test can be seen in Table 2.

Table2. Correlation Test Results

Dependent variable	Independent Variable	Correlation Value	Significance
COD	Voltage	-0.873**	0.002
	Time	-0.385	0.306
Ammonia	Voltage	0.726*	0.027
	Time	0.596	0.090
TSS	Voltage	-0.900**	<0.001
	Time	-0.320	0.401
pH	Voltage	-0.346	0.361
	Time	-0.289	0.451

Note: * = Significant at 1% level
** = Significant at 5% Level

The correlation test results in Table 2 show that the voltage value has a correlation value of -0.873 and time value of -0.385. The voltage and time values has a negative correlation (-) which indicates an inverse relationship, meaning that the increasing time and voltage will reduce the concentration of COD values. Meanwhile, the r table value with N = 9 for an error rate of 5% is obtained at 0.666. The analysis shows that the voltage correlation value of 0.873 > r table 0.666 and the time correlation value < r table 0.666. This shows that voltage has a very high influence on decreasing COD values, but the time variable has a low correlation coefficient on decreasing COD values. This study found a significant correlation between voltage and COD reduction with a value of 0.002 < 0.05, but contact time has an insignificant correlation coefficient with COD reduction with a value of 0.306 > 0.05. The decrease in COD concentration in fish processing wastewater occurred by 19 mg/L at a voltage variation of 5V with a contact time of 120 minutes.

COD measurements are carried out with the aim of seeing the amount of oxygen content needed to oxidise organic compounds in water. The decrease in COD concentration indicates that the higher the voltage variation applied to the wastewater, the lower the COD concentration. This is reinforced bySugito et al, (2022)Voltage and time will affect the formation of oxygen and hydrogen gas through oxidation reactions on the electrode, so that the ability to reduce organic matter causes COD concentration to decrease.

The results of measuring the reduction in ammonia show that for a contact time of 60 minutes with a voltage of 3V, the ammonia concentration experienced the highest reduction of 0.25 mg/L from the characteristic value of wastewater resulting from fish processing, namely 20 mg/L. Voltage has a strong influence on reducing ammonia concentration as shown in Table 4.3 with a correlation value of 0.726 > r table 0.666 with a significance value of 0.027 < 0.05. So, it can be concluded that voltage has a strong correlation with decreasing ammonia values and has a significant correlation between voltage and decreasing ammonia values. Table 4.3 shows that contact time has a correlation value of 0.596 < r table 0.666 with a significance value of 0.090 > 0.05. This shows that contact time has a moderate correlation and has an insignificant correlation with the decrease in ammonia values. The correlation value produced in the correlation value of voltage and contact time shows a positive relationship so that the effect between voltage and time on the ammonia value is

unindirectional, meaning that if the smaller the voltage and time, the ammonia value will decrease.

The results of measurements at 5V voltage with a contact time of 120 minutes can reduce the TSS concentration from the initial value of 262 mg/L to 70 mg/L which meets the quality standards stipulated in Minister of the Environment Regulation Number 5 of 2014 Appendix XIV, namely 100 mg/ L. Based on the correlation test analysis, the correlation value for voltage is -0.900 > 0.666 with a significance value of <0.001 < 0.05. This shows that there is a positive and significant correlation between voltage and the decrease in TSS values. The correlation value at time obtained was -0.320 > 0.666 with a significance value of 0.401 > 0.05. So, it can be concluded that time has a low correlation and an insignificant correlation with decreasing TSS values. The decrease in TSS is related to the amount of voltage and length of contact time given during the electrocoagulation process, so that it will increase the flocs produced which can bind contaminants in waste water.(Radityani et al., 2020)

To determine the effect of voltage and contact time in the electrocoagulation process in influencing the pH value, a correlation test was also conducted. The voltage obtained a correlation value of -0.346 < 0.666 with a significance value of 0.361 > 0.05 and the contact time obtained a correlation value of -0.289 < 0.666 with a significance value of 0.451 > 0.05. It can be concluded that voltage and contact time have a low correlation and an insignificant correlation with the pH value. The value of the independent variable shows a small value of the dependent variable, so it can be said that the independent variable has a low correlation with the dependent variable.

Conclusion

Based on the results of the research that has been conducted, the following conclusions can be drawn:

1. The optimum removal efficiency for COD, BOD and TSS was 96.34%, 95.2%, 73.22% respectively with a voltage variation of 5V and a contact time of 120 minutes. The optimum ability to reduce ammonia values occurs at a voltage variation of 3V and a contact time of 60 minutes with an effectiveness of 98.75%. As for neutralising the pH concentration, it increased from acidic to alkaline.
2. The amount of voltage used in the electrocoagulation method has a significant influence and correlation on reducing the concentrations of COD, BOD, ammonia and TSS found in wastewater from fish processing. This is proven by the correlation test using the Statistical Program and Social Science (SPSS) application version 2.7

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