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THE USE OF CHITOSAN AS A WATER CLEARANT FOR DUG WELLS IN GAMPONG JAVA BANDA ACEH

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Abstract

Pollution of dug well water in Gampong Jawa Banda Aceh is caused by an imbalance in the ecosystem of organic and inorganic pollutants. The purpose of this study was to determine the effect of chitosan biocoagulant as a dug-well water purifier. The stages of this research were making chitosan from shrimp shells, making chitosan biocoagulant with the addition of 1% CH_3COOH, and coagulation and flocculation with various biocoagulants (0.1%, 0.2%, and 0.5%) using the jar test method with fast stirring at 150 rpm and slow stirring at 50 rpm. The results of FTIR research on chitosan were characterized by the loss of the C=O group in the deacetylation process to change the acetyl amino group in chitin to amino, with a degree of deacetylation of 93.27%. The optimum performance of biocoagulants at a concentration of 0.5% can reduce pH from 7.1 to 6.9, the turbidity level to 99.99% (NTU), and E. coli to 0 jml/mL. The conclusion from this study is that chitosan biocoagulants are able to reduce turbidity levels (NTU), pH, and Escherichia coli bacteria.

Keywords: *chitosan coagulant, Gampong Jawa, water purification*

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1. Introduction

Gampong Jawa's well water, which is located in the landfill area, is one of the needs of the surrounding population. Gampong Jawa Banda Aceh is located in Kuta Raja sub-district, which has a landfill with an area of 21 hectares that has been

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operating on a sanitary landfill basis since January 2009 (DLHK3 2018). Some of the well water has experienced environmental pollution, which is influenced by the imbalance of the ecosystem contained in the soil or around it (Fadhillah et al. 2016). The main cause of this pollution is the surrounding garbage waste, and garbage waste contains organic materials that have decomposed (Irhamni et al. 2017). So that it has the potential to adversely affect the environment and well water around local residents' housing (Hasibuan 2019), clean water parameters must be adjusted to the Indonesian Minister of Health Regulation No. 32 of 2017.

Several studies have been conducted as a countermeasure for polluted water to become clean and suitable for daily use, such as using chlorine (Zubir 2020), poly aluminum cloride (Putra et al. 2019), chitosan from clam shells (Sari and Mini 2017), chitosan from crab shells (Alawiyah and Hadi 2016), or shrimp shells (Manurung 2011), and others.

Chitosan in shrimp shell content is around 90%, and it would be detrimental if shrimp shell waste was just thrown away without knowing its benefits (Cahyono 2018). Chitosan can be used as a natural coagulant that is biodegradable, biocompatible, bioactive, and non-toxic, so chitosan has been widely studied and researched for use in the fields of biotechnology and water treatment (Sartika, 2016). Research by Ainurrofiq et al. (2017) using waste from shrimp shells and alum was able to reduce TSS by 89.55%, or 555 mg/L, where the dose of 150 mg/L was the optimum dose for TSS reduction. Manurung's (2011) research, by varying chitosan from shrimp shell (0.1%, 0.20%, and 0.5%), was able to reduce the turbidity value of water by 90.37% at a concentration of 0.5%. According to research by Ihsani and Widyastuti (2015), the addition of chitosan from shrimp skin at a concentration of 0.4% was able to reduce water turbidity to 86.074%, where the chitosan variations used were (0.1; 0.4; 1; 1.5; and 2%). Based on the above background, it is important to conduct research on the effect of chitosan biocoagulant as a water clearant for dug well water in the Gampong Jawa area of Banda Aceh.

2. Research Methodology

In this study, the tools used were: Erlenmeyer (Duran), Spatula, Stirring Rod, Porcelain Cup, Measuring Cup (Duran), Drip Pipette, Blender (Philips), Analytical Balance, Oven (Modena), Funnel, Filter Paper (Whatman 41), Universal Indicator, Beaker Glass (Duran), Magnetic Stirrer, Turbidimeter, and FT-IR Instrument Two Universal ATR (Single Reflection Diamond) - L1600107 and AAS Instrument SP AA-7000, ASC-7000 and GFA.

The materials used were shrimp shells (*Paneus monodon*) identified at the Biology Laboratory of UIN Ar-Raniry Banda Aceh, Gampong Jawa dug well water, NaOH, distilled water, HCl, Acetone, CH_3COOH, Sodium hypochlorite (NaOCl), Eosin Methylen Blue Agar (EMBA), and NaCl.

2.1. Procedure

2.1.1. Preparation of Tiger Shrimp Skin Samples

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The shrimp shell is separated from the skin and meat; the shrimp shell that has been separated from the meat is washed and drained, then put into the oven at a temperature of 110–120 °C for ± 1 hour until browned. Next, mashed shrimp shell that has been in the oven using a blender is sieved using a 100mesh sieve.

2.1.2. Preparation of Chitosan from Shrimp Shell

Deproteinization (Dompeipen et al., 2016)

Protein removal in shrimp shell can be done by reacting shrimp shell powder obtained from the sample preparation process with the addition of NaOH in a ratio of 1:10 (b/v). Then the solution was reacted at 65°C for 2 hours until reddish white clumps were formed. The results obtained were then filtered and the residue was washed using distilled water until neutral. The residue was dried in an oven at 60°C for ± 3 hours.

Decalcification (Dompeipen et al., 2016)

Decalcification was carried out by dissolving the deproteinized sample in HCl in a ratio of 1:15 (b/v) and stirring for 30 minutes at 60°C. Then decantation was carried out so that no bubbles appeared, then the solution was filtered and the residue was washed using distilled water until neutral. The residue was dried in the oven for ± 3 hours at 60°C.

Decolorization (Dompeipen et al., 2016)

The results of decalcification were added to acetone until wet. Then it was stirred and allowed to dry. After that, it was dissolved with NaOCl in a ratio of 1:10 (b/v) until then stirred for ± 2 hours at 40°C and allowed to stand. The solution was filtered and washed with distilled water until neutral. The filtered residue was dried in an oven at 60°C for ± 3 hours. Then the results of this process were weighed and characterized using FT-IR to see the chitin groups that formed.

Deacetylation (Ihsani and Widyaastuti, 2015)

The results of the decolorization process in the form of chitin were dissolved using NaOH in a ratio of 1:15 (b/v). The mixture was reacted at 80°C for ± 1 hour. Then it was filtered and washed with distilled water until neutral (pH 7). Next, the residue was put into the oven at 60°C for ± 3 hours. The chitosan obtained was weighed and then characterized in FT-IR to see the groups contained in chitosan and calculated the yield and the formula for determining the degree of deacetylation of chitosan (Dompeipen et al., 2016).

$$\%\ DD = 100 - 1\left(\frac{A1655}{A3450}\right) \times 100/1{,}33$$

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Description:
A1655 = Absorbance found at wave number 1655 cm^{-1}.
A3450 = Absorbance found at wave number 3450 cm^{-1}.
1.33 = Determination obtained from the comparison of A1655/A3450 for chitosan in full deacetylation

2.1.3. Preparation of Chitosan Solution (Manurung, 2011)

A total of 1g chitosan was dissolved into 100 mL of 1% CH_3COOH, this solution is the stock solution which is then used for the preparation of working solutions (0.1%, 0.2% and 0.5%).

Formula for Making Chitosan Solution: $= \frac{grams\ of\ dissolved\ substance}{mL\ Solution} \times 100\%$

2.1.4. Initial Measurement of Dug Well Water

Sampling of Dug Well Water

Sampling of dug well water in Gampong Jawa Banda Aceh refers to SNI 6989.58.2008 concerning well water collection methods. Samples of dug well water in Gampong Jawa Banda Aceh were taken from as many as three different wells consisting of local residents' houses. Well water sampling is done at a distance of 100 m.

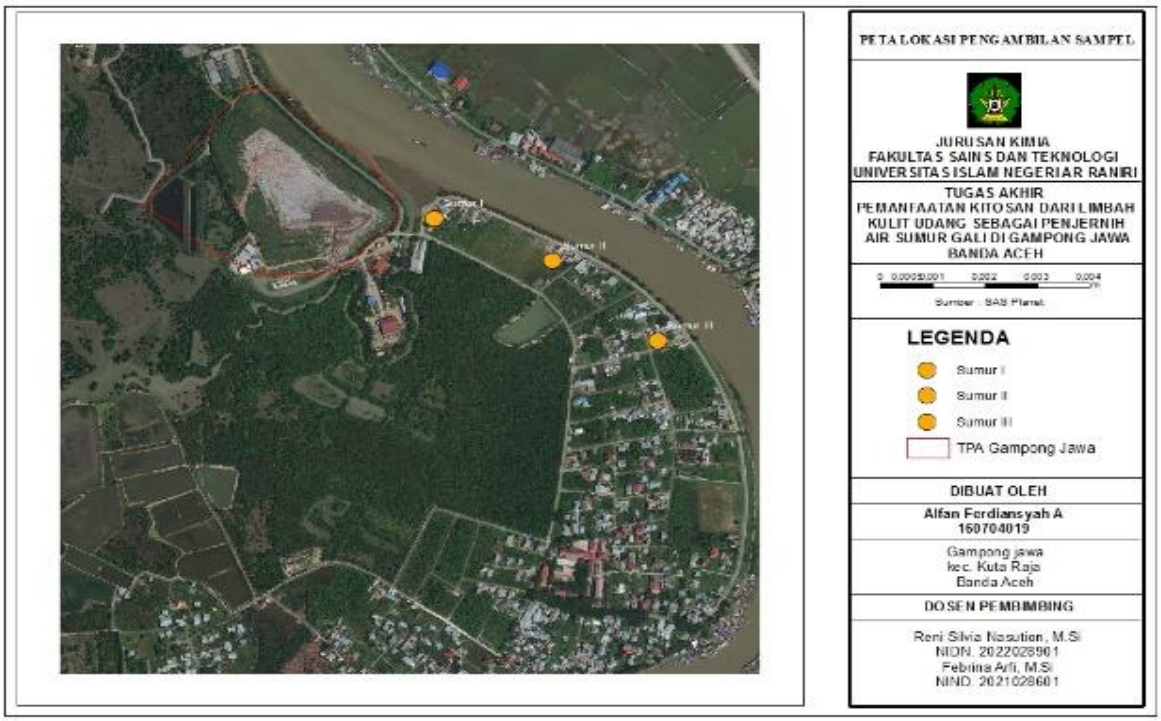

Figure 1: Gampong Jawa landfill, Banda Aceh

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Measurement of pH and Turbidity (NTU)

Dip the pH meter electrode in the dug well water sample of Gampong Jawa Banda Aceh before the addition of shrimp shell chitosan biocoagulant and use a turbidimeter tool to analyze turbidity levels.

Escherichia coli Bacteria Test (jml/mL) (Fauzia, 2021)

Test with the Total Plate Count (TPC) method using the Spread Plate method, which is a method of adding 1 mL of sample dilution to sterilized EMBA media. After adding the sample, the media is carried out by the scratch method. Then the Petri dish was rotated near the fire on the Bunsen and then covered with plastic wrap. Then the media was incubated for 24-48 hours at 37^{o}C. Colonies that grew on EMBA media were then counted with a tool called a colony counter.

Iron Level Measurement (Suryadirja et al., 2021)

Enter the well water test sample that has been prepared by injecting it into the SSA and then measuring the absorption at a wavelength of 283.3 nm. The measurement results were recorded and then analyzed.

2.1.6. Chitosan Coagulation Power Test (Manurung, 2011)

Dug well water from 3 different sources as much as 500 mL was put into 9 beakers, then the well water samples were added with chitosan coagulant as much as 0.1%, 0.2%, and 0.5%, respectively, then a jar test was carried out with rapid mixing at 150 rpm and slow mixing at 50 rpm, then let stand for 30 minutes and filtered using filter paper to separate the flocs formed, measured pH, followed by analyzing turbidity, and *E. coli.*

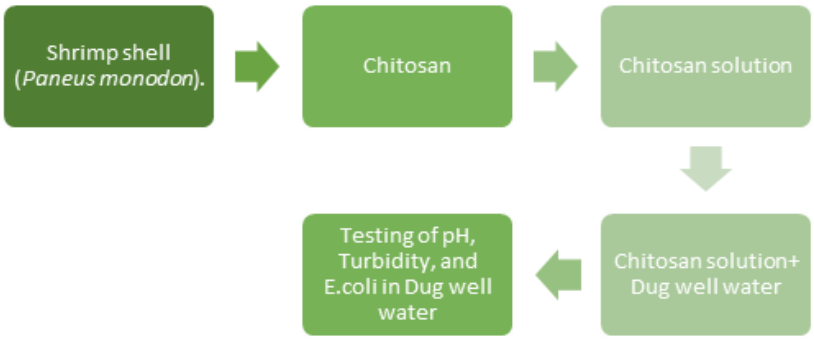

Figure 2: Flowchart of research

3. Results and Discussion

3.1. FTIR Characterization of Chitin and Chitosan

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Chitin and chitosan were analyzed using FTIR spectrophotometry to determine the functional groups formed. This analysis is needed to determine the success of the synthesis of shrimp shell waste chitosan (*Paneus monodon*). FTIR spectra of chitin, in the absorption band wave number 3446 cm^{-1} which indicates the presence of OH groups and N-H amide groups in chitin, appear at wave number 3267 cm^{-1}. This shows that there has been a release of acetyl groups. The wave number of 2961 cm^{-1} indicates the presence of the CH(-CH_3) group. The absorption band at a wave number of 2889 cm^{-1} is an aliphatic CH group. In the chitin spectra, there is a C=O group at a wave number of 1659 cm^{-1}, which indicates the difference between chitin and chitosan. At a wave number of 1421 cm^{-1} there is an O-H bending group. The chitin spectra contained a C-N amine group at a wave number of 1624 cm^{-1}. At a wave number of 1118 cm^{-1} which indicates the presence of C-O (-C-O-C-) stretching. The alkane C-H group that appears in the chitin spectra appears at a wave number of 955 cm^{-1}.

Chitosan powder was analyzed using FTIR in the 3373 cm^{-1} wave number absorption band, which shows the presence of OH and NH groups at 3297 cm^{-1} wavelength. Aliphatic C-H groups that appear at a wave number of 2878 cm^{-1}. An absorption band at wave number 1650 cm^{-1} indicates the presence of NH primary amine. The deacetylation process changes the acetylamino groups found in chitin into amino groups. This can be characterized by the disappearance or reduction of C=O group absorption from the molecule in the FTIR spectrum **(Fitriani, 2010).**

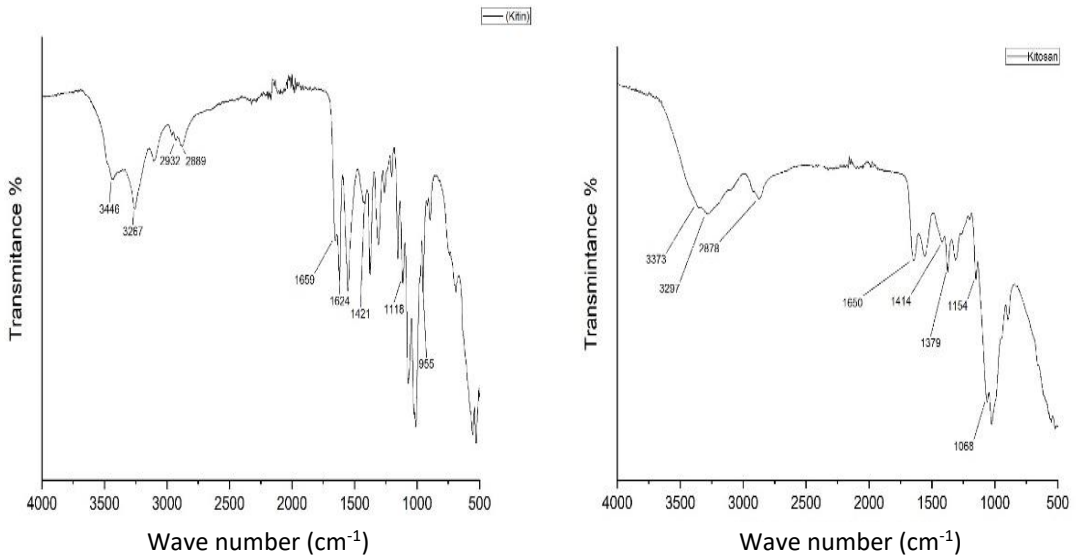

Figure 3: FTIR (a) chitin from shrimp shell (b) chitosan from shrimp shell

In this study, the deacetylation degree result was 93.2783%. This shows that the chitosan has been deacetylated perfectly. According to Rahayu and Purnavita (2007),

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which state that the degree of deacetylation for chitosan in general is around 60% and around 90–100% for fully deacetylated chitosan.

3.2. Dug Well Water Analysis of Residents of Gampong Jawa Banda Aceh

Parameter measurements for monitoring dug well water were carried out at several locations, and sampling points were determined by considering aspects of the designation of dug wells in Gampong Jawa Banda Aceh. Monitoring of dug well water quality was carried out at three sampling point locations in Kuta Raja Subdistrict, each of which is 100 meters from the well. Based on the description above, it is necessary to conduct a physical and chemical examination of dug well water, which is a source of water in Gampong Jawa Banda Aceh. Based on the results obtained from the examination of the physical condition of well water, namely, Well I is cloudy and smells, Well II is slightly cloudy and smells, and Well III is slightly cloudy and smells. Conditions in terms of parameters stipulated in Permenkes RI No. 23 of 2017 in Well I, Well II, and Well III can be seen in Table 1.

Table 1. Results of Initial Measurement of Water Quality of Dug Wells in Gampong Jawa, Banda Aceh

The Well	Parameters Permenkes RI No.23 Year 2017			
	pH	Turbidity (NTU)	Fe Analysis	*E. coli* (amount/mL)
	6,5-8,5	25	1	0
The Well I	7,2	25,0	0,0698	225
The Well II	7,1	18,7	0,0899	125
TheWell III	7,1	8,11	-	45

3.3. Application of Chitosan Biocoagulant as a Purifier of Dug Well Water in Gampong Jawa Banda Aceh

Application of chitosan from shrimp shells (*Paneus monodon*) as a coagulant using the Jar Test Flocculator SW1 (Stuart Scientific) method on dug well water in Gampong Jawa, Banda Aceh. The research was conducted on a laboratory scale using a jartest, which is a simulation of conventional treatment process operations (coagulation, flocculation, and settling). The jar test was conducted at room temperature. Chitosan that has been dissolved in 1% acetic acid was then subjected to dose variation. The dose variation refers to the research of Dompeipen et al. (2016).

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Table 2. Measurement Results of Dug Well Water Quality with the Addition of Chitosan Coagulant from Shrimp Shells Waste

The Well	% Coagulants	Parameters		
		pH	Turbidity (NTU)	*E. Coli* (amount/mL)
The Well I	0,1	7,0	20,1	70×10^2
	0,2	7,0	10,69	30×10^2
	0,5	6,9	0,01	0×10^2
The Well II	0,1	7,0	12,89	40×10^2
	0,2	7,0	8,35	20×10^2
	0,5	6,9	0,01	0×10^2
The Well III	0,1	7,0	5,27	15×10^2
	0,2	7,0	2,01	0×10^2
	0,5	6,9	0,0	0×10^2

The dose variations used in this study were 0.1%, 0.2%, and 0.5%. As for the stirring speed of 150 rpm and the slow stirring of 50 rpm, it refers to the research of Ainurrofiq et al. (2017).

3.3.1. Turbidity Analysis (NTU)

Turbidity measured using a turbidimeter tool on dug well water in Gampong Jawa Banda Aceh before the coagulation process can be seen in Table 1, with Well I at 25 NTU, Well II at 18.7 NTU, and Well III at 8.11 NTU. So it can be stated that the three wells are classified as suitable for use in accordance with the parameters set by Permenkes RI No. 23 of 2017, namely with a value of 25 NTU, but in terms of the color observed, the three wells are classified as cloudy. According to research by Valentina et al. (2013), turbidity can be caused by organic substances, colloids, mud, and clay. Turbidity in well water can also be caused by the presence of organic and inorganic materials. Water can be said to be turbid if it contains particles of suspended material that give a cloudy and dirty color or appearance when observed. In addition, the presence of fine particles of Fe $(OH)_3$.n H_2O in the water that precipitate and colloidal compounds cause the water to become cloudy (Kurniawati et al. 2017).

Analysis of turbidity levels was carried out using a turbidimeter tool, and then the jartest method was carried out, which had been added to the tiger shrimp chitosan coagulant. In the flocculation coagulation process, there was a decrease in turbidity. As can be seen in Table 2, it is known that turbidity levels have decreased with the addition of various doses of coagulants. The results of this study show the most optimum turbidity parameter value for reducing turbidity levels at a dose of 0.5% chitosan coagulant with a fast stirring speed of 150 rpm and a slow stirring speed of 50

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rpm so as to produce a turbidity value of no more than 25 NTU in accordance with the parameters set.

According to research by Alawiyah and Hadi (2016), the utilization of chitosan as a water purification biocoagulant is due to the presence of amine groups in chitosan, which can increase its activity, so that chitosan becomes a polycationic compound. The stirring process during the jar test will determine the success of the coagulation process. Coagulation or rapid stirring functions by creating turbulence in water so that it can disperse fine particles that occur during coagulation to form microflocs. Then flocculation is carried out, namely slow stirring, which aims to combine microflocs to become larger flocs (macroflocs). According to Ratnawulan and Noor (2018), the most likely mechanisms in the coagulation process are adsorption and unstable inter-particle bonds, or adsorption and stress neutralization of the two mechanisms. To determine which mechanism occurs is a difficult matter because both mechanisms may occur simultaneously, so in general, the chitosan coagulant mechanism occurs with the mechanisms of particle bridges and adsorption.

3.3.2. pH Analysis

Dug well water, according to Permenkes RI No. 23 of 2017, has a pH of 6.5–8.5 in Table 1. The higher the concentration of chitosan coagulant that is added, the lower the pH value will be because the chitosan solution is already acidic with a pH of 4.00. The decrease can also occur due to the presence of polyelectrolytes and cationics contained in chitosan. The decrease occurred to 6.9 from 7.1. In this condition, the optimum coagulant occurred at a dose of 0.5%. According to Ariani et al. (2018), the main factor that can affect water quality is acidity (pH), so this causes most aquatic biota to be very sensitive to changes in pH. The pH limit value for well water in Permenkes RI No. 23 of 2017 ranges from 6.5 to 8.5, so from the measurement results, it can be stated that the pH of the dug well water in Gampong Jawa Banda Aceh is included in the normal level.

3.3.3. E.coli Bacterial Analysis

The analysis was carried out by taking a 10-2 suspension using cutton buds and using the scratch method on EMBA media that had been sterilized using an autoclave. Then the petri dish was rotated near the fire on the bunsen and then covered with plastic wrap. then the media was incubated for 24-48 hours at 37 ^{o}C. Colonies that grew on EMBA media were then counted with a tool called a colony counter. In this study, *E. coli* bacteria can be identified using EMBA media. According to N.W. and Sumarya (2021), EMBA media can distinguish groups of bacteria that ferment lactose where EMBA media contains lactose. One of the bacteria that can ferment lactose is the *E. coli* bacteria. Positive results on EMBA media will show a metallic green color because *E. coli* bacteria ferment lactose and produce acid. Table 1 indicates that wells I, II, and III cannot be used for daily purposes because the bacteria contained exceed the established Permenkes.

According to research by N.W. and Sumarya, (2021), *E. coli* in dug well water is caused by construction factors and the location of dug wells adjacent to toilets and

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septic tanks. This can cause *E. coli* pollution in dug well water through water seepage on the well wall. Surface soil containing pollutants will carry microbiological pathogens to the soil layer around shallow dug wells with the help of gravity and water **(Ariani et al., 2018).** It must be remembered that the water in the environment will affect the well flowing opposite to it (from a sanitary point of view). So it is necessary to pay attention to the maximum displacement distance of pollutants and the fact that the displacement is always in the direction of groundwater flow. So it is not allowed in chemically or bacteriologically contaminated areas within the scope of the well. Distance is one of the factors that influences the distribution pattern of microbial growth and reproduction. The distance between wells is at least 15 meters from polluting sources such as toilets, cattle drums, final disposal, and so on **(Amyati, 2019).** Based on the results of research on residents' wells I to III, it can be concluded that the well water has been contaminated with pathogenic E. coli bacteria that cause gastrointestinal tract infections (diarrhea) and infections in the urinary tract **(Sutiknowati, 2016).** Water that has been polluted by pathogenic bacteria and cannot meet the quality standards of Permenkes RI No. 23 of 2017 will affect human health if consumed and used for daily purposes.

The results of the analysis of *E. coli* bacteria testing can be seen in Table 2. It states that the addition of 0.5% coagulant in wells I, II, and III was able to reduce the levels of *E. coli* bacteria with a colony count of 0 amount/mL. Based on RI Minister of Health Regulation No. 23 of 2017, the number of bacteria in well water must reach 0. According to research by Zulfikar and R. Putri (2017), pollutant sources such as rubbish and animal waste can contaminate dug well water because of the close distance to the dug well. This happens because the absorption of bacteria in the soil from rubbish and feces will contaminate groundwater, so that the water source from the dug well is also contaminated by *E. coli* or other bacteria. The results of the researcher's observations regarding the dug wells of the Javanese village of Banda Aceh reached an average depth of 5 meters. Although all of the dug wells used watertight concrete rings, in some of the residents' dug wells, there were cracks or gaps in the walls, so they had the potential to be contaminated. by the absorption of groundwater containing bacteria. Amyati., (2019) research on the identification of *E. coli* bacteria in dug well water states that the condition of the well for a long time will allow cracks or leaks from the well walls. This condition allows the seepage of water coming from rivers or septic tanks, so that it is very easily contaminated. Knowing the possibility of water seepage from rivers or sewage tanks into dug wells requires an in-depth groundwater flow analysis.

According to research by Asni et al. (2014), chitosan to be used as an adsorbent must have a degree of deacetylation value of > 60% so that absorption occurs perfectly. Research by Ratnawulan et al. (2018) regarding the use of chitosan in water recycling as an application for clean water production techniques stated that chitosan molecules have the ability to interact to reduce total bacteria on the surface of microbial cells so that chitosan is able to adsorb to form defense cells. Research by Mahatmanti et al., (2001) shows that the mechanism by which chitosan acts as an antibacterial can damage cells' main constituent structures, namely: cell walls,

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cytoplasm, ribosomes, and ribosome membranes. This means that chitosan is in an acidic atmosphere, causing protein denaturation and enzyme inactivation. Chitosan has enzymes that can stimulate the inhibition of bacterial growth, namely the lysozyme enzyme and the aminopolysaccharide group **(Sahara et al., 2020).**

3.3.4. Fe Metal Content Analysis

Measurement of the levels of the standard solution of iron metal (Fe) that has been included in each Fe standard solution that has been made with a concentration of 0 ppm, 0.5 ppm, 1 ppm, 2 ppm, 3 ppm, and 4 ppm by injecting SSA depth and then measuring the absorption at wavelength 248.3 nm. The results of these measurements are made into a calibration curve to obtain a linear equation. Test samples of dug well water that have been prepared by injecting them into the SSA, then measure their absorption at a wavelength of 248.3 nm. Then the measurement results are recorded for analysis. Based on the results of measuring the Fe metal content in dug well water before adding the chitosan biocoagulant using atomic absorption spectrophotometry (SSA), the result in well I was 0.069 mg/L, and in well II, the result was 0.0899 mg/L. According to the quality standards stipulated in the Republic of Indonesia Minister of Health Regulation No. 23 of 2017, the iron metal content determined is 1 mg/L, so that the water from the dug wells of the residents of Gampong Jawa Banda Aceh meets the specified requirements and no further treatment with the addition of biocoagulants is carried out. Research by Indah and Hendrawani, (2019) shows that small amounts of iron compounds found in the human body function to form erythrocyte cells. According to research by Ergantara et al. (2018), based on toxicology, if excess Fe is present in the human body, it will cause health problems such as disorders of the intestinal walls and death. Putra and Mairizki's research (2020) shows that the main causes of increasing metal levels in dug well water are industrial activities, domestic agriculture, and others.

4. Conclusion

The addition of chitosan as a biocoagulant at a concentration of 0.5% was able to reduce turbidity levels to 0.01 NTU, pH to 6.9, and *E. coli* to 0 amount/mL. In comparison, concentrations of 0.1% and 0.2% resulted in less effective outcomes.

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