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Optimization of the Use of Chinese Teak Seed Powder Coagulant (*Cassia angustifolia*) as a Natural Coagulant in Reducing Turbidity of Dug Well Water Using the Jar Test Method

Wiwit Aditama*, Sofia Sofia, Junaidi Junaidi, Zulfikar Zulfikar

Department of Environmental Health, Polytechnic, Ministry of Health, Aceh, Indonesia

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***Correspondence:** Wiwit Aditama, Department of Environmental Health, Health Polytechnic of the Ministry of Health of Aceh, Banda Aceh, Aceh Besar 23352, Indonesia.
E-mail: widnad78@yahoo.co.id
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Abstract

BACKGROUND: Natural coagulants are used as much as possible to reduce synthetic materials that produce side effects in their use. The use of natural coagulants will be cheaper than synthetic coagulants, which are commonly used for water purification. Chinese tea seeds (Cassia angustifolia) can reduce turbidity, because they contain complex carbohydrates and sugars that can bind particles in the water. Cassia angustifolia plant may also be used as a coagulation agent for conventional drinking water treatment.

AIM: This study aims to determine the optimization of coagulants from Chinese teak seed powder (Cassia angustifolia as a natural coagulant in reducing the turbidity of wells water.

METHODS: This study used *Cassia angustifolia* coagulant for the water treatment coagulation process with turbidity and pH parameters. This was a quasi-experimental study. The Completely Randomized Design (RAL) method was used. The study location was carried out at the Laboratory of the Environmental Health Department, Poltekkes, Ministry of Health, Banda Aceh. The doses used were 10 ppm, 30 ppm, 50 ppm, 70 ppm, and 100 ppm. The data were analyzed by one-way analysis of variance (ANOVA).

RESULTS: There is a difference in turbidity reduction in dug healthy water when *Cassia angustifolia* is added at doses of 10 ppm, 30 ppm, 50 ppm, 70 ppm, or 100 ppm.

CONCLUSION: *Cassia angustifolia* coagulant can be used at low turbidity levels with low doses, but it is necessary to investigate the active compound content and its biocoagulant properties.

Introduction

Water is such an important thing that can't be separated in daily life [1]. There are various water sources such as surface water, groundwater, and rainwater. However, not all water is suitable for consumption and use [2]. Decrease in water quality can also occur due to pesticide spraying limestone [3]. The importance of clean water causes several things to be considered. In general, the standardization of water for sanitation hygiene purposes includes physical, biological, and chemical parameters. The water is usually used to maintain personal hygiene such as bathing, washing equipment, and drinking water [4]. People generally use wells water as a source of clean water if piped water does not flow. However, there are complaints that sometimes the well's water is cloudy, so it cannot be used as a source of clean water [1], [2].

If we want to get clean water, the water must be treated in various ways, both physically and chemically. The water treatment method used in general is physicochemical treatment, namely, coagulation-flocculation, followed by sedimentation. Coagulation is a chemical process, one of which is used in the surface water treatments process. Coagulation is mixing chemicals (coagulants) with raw water to form a homogeneous mixture. The main goal of coagulation is to mix the coagulant more evenly or homogeneously so that floc is formed (floc is a lump of mud produced in the coagulation-flocculation process) [5]. At the same time, flocculation removes water turbidity through the agglomeration of small particles into larger particles. Clumping microflocs into macroflocs formed in the coagulation process [5] occurs in the flocculation process. In the coagulation-flocculation process, alum is usually used as a coagulant. However, the implementation of this method is still experiencing difficulties, because the process is too complex and requires high costs [6].

Natural coagulants are used as much as possible to reduce synthetic materials that produce side effects in their use. The use of natural coagulants will be cheaper than synthetic coagulants, which are commonly used for water purification [6].

Some natural plants used to purify water due to active coagulant substances, namely, mucilage, are cactus [7], Coccinia indica and Okara [8], and dragon fruit stems [6], *Cassia angustifolia* [9]. Sanghi *et al.*

(2002) suggested that *Cassia angustifolia* seed sap is suitable for replacing PAC (Poly Aluminum Chloride) coagulant or using shallow PAC doses to remove Acid Sendula red and Direct Kahi Greendyes in synthetic dye solutions [10]. Farhaoui and Derraz (2016) argue that the plant *Cassia angustifolia* may also be used as a coagulation agent for conventional drinking water treatment [11].

Seed powder is reduced in fat content through maceration with hexane to obtain fat-free seed powder. After the coagulation and stirring treatment of the cloudy water sample, the turbidity value was measured using a turbidimeter so that the percentage reduction could be determined water turbidity (% decrease in turbidity), which indicates its ability as a coagulant [12].

In this study, the coagulant *Cassia angustifolia* was used for the coagulation process in water treatment with turbidity and pH parameters. The study aims to determine the optimal use of the coagulant from powder china teak seeds (*Cassia angustifolia*) as a natural coagulant in reducing wells water turbidity. This study wanted to see whether *Cassia angustifolia* seed powder can be used as a natural coagulant and what optimizing the dose of Chinese teak seed powder (*Cassia angustifolia*) as a natural coagulant can reduce the turbidity of dug wells water.

Materials and Methods

The materials used are wells water, *Cassia angustifolia*, aquades, filter paper and tissue, and alum (PAC).

Instrumentation

The tools used in this research are Beaker glass 1,000 ml five pieces, Beaker glass 500 ml one piece, Beaker glass 200 ml two pieces, Spatula, Jerry can, Floculator, Turbidimeter, pH meter, and litmus paper, Analytical balance, Cup, spoon and stationery, blender, sieve, jar, test jar, and oven.

Procedure

This was a quasi-experimental research, a *pre-post-test only with control group design*, with a completely randomized design (RAL) method. This study used three groups, which were treatment group, positive control group, and negative control group. Observations were only conducted during the post-test, by comparing the results of observations between the treatment group, the negative, and positive control groups. The study location was carried out at the Laboratory of the Department of Environmental Health Poltekkes, Ministry of Health, Aceh. The research object was the Chinese teak seed powder obtained from the Chinese teak plant (*Cassia angustifolia*) originating from the cities of Banda Aceh and Aceh Besar. The research subject is dug wells water belonging to the Aceh Besar resident area. The number of samples needed is based on the number of repetitions, namely, according to Supranto J (2000) [13], the control group and the treatment group each received replication to produce a more precise measure of the effect of treatments on the experiment, the equation used to calculate the number of replications was using the formula Fereder (1991) as follows: $(t-1)(r-1) \geq 15$

Information: t = number of treatments, r = number of replications, the calculation of the number of repetitions in the four treatments that will be used in the study is as follows:

$(t-1)(r-1) \geq 15$
$(4-1)(r-1) \geq 15$
$4(r-1) \geq 15$
$4r-4 \geq 15$
$4r \geq 15+4$
$4r \geq 19$
$R \geq 19/4$
$R \geq 4.75 \approx 5$

The research procedure was: K1 -> C1; K2 -> C2

Sub procedure

The data obtained from the calculation of the simplex lattice design (prediction) were compared with the data from the actual test results and analyzed using one-way analysis of variance (ANOVA) to determine whether there was a significant difference between the treatments. If the ANOVA test result is significant, namely, $p < \alpha$, it continues with the Last Significant Difference (LSD) test.

Results

This study used *Cassia angustifolia* powder as a coagulant with a predetermined dose. The jar test results with turbidity, pH, and temperature parameters (Table 1).

The percentage rate of turbidity reduction is depicted in Figure 1 – the higher the coagulant dose, the more significant the percentage reduction in turbidity.

In Figure 2, the percentage rate of decrease in turbidity level after the jar test process, it can be concluded that the higher the dose of coagulant, the greater the decrease in turbidity.

As shown in Table 2, the one-way ANOVA test yielded Sig = <0,001 < 0.05. It can be concluded that because Ho is rejected and Ha is accepted, there is a difference in the decrease in turbidity of dug healthy water when Chinese teak seed powder (*Cassia*

Table 1: Results of measurement of turbidity, PH, and water temperature of dug wells before and after treatment

Chinese teak seed coagulant dosage (ppm)	Initial turbidity (NTU)	Turbidity (NTU)	Turbidity reduction efficiency (%)	pH	Temperature (°C)
Control (+)/alum	110.5	4.33	96.08	7.4	24
Control (−)/water		107	3.17	7.4	24
10		98.6	10.77	7.1	24
30		35.5	67.87	7	24
50		30	72.85	7	24
70		21.3	80.72	7	26
100		14.5	86.88	7	26
Control (+)/alum	109	3.3	96.97	7	24
Control (−)/water		99	9.17	7	24
10		94.3	13.49	7	24
30		94.4	13.39	7	24
50		62.8	42.39	7	24
70		35.1	67.8	7	26
100		24.5	77.5	7	26
Control (+)/alum	108.9	3.7	96.6	7	25
Control (−)/water		98.9	9.18	7	25
10		95	12.76	7	24
30		94.2	13.5	7	24
50		61.4	43.62	7	25
70		35.7	67.22	7	26
100		16.4	84.94	7	26
Control (+)/alum	108.9	4	96.33	7	24
Control (−)/water		97	10.93	7	24
10		96.3	11.57	7	24
30		94.2	13.5	7	25
50		55.9	48.67	7	24
70		33.8	68.96	7	25
100		15	85.94	7	25
Control (+)/alum	106.7	2.9	97.28	7	24
Control (−)/water		97	9.09	7	24
10		95	10.97	7	25
30		88.8	16.78	7	25
50		56.7	46.86	7	24
70		33.9	68.23	7	25
100		17	84.07	7	25

angustifolia) is added at concentrations of 10 ppm, 30 ppm, 50 ppm, 70 ppm, and 100 ppm.

In addition, to ascertain the difference in the reduction in turbidity, the *Bonferroni* test was used to compare the concentration groups of Chinese teak seed powder (*Cassia angustifolia*) with various dosage variations and controls. The results of the *Bonferroni* test are summarized in Table 3.

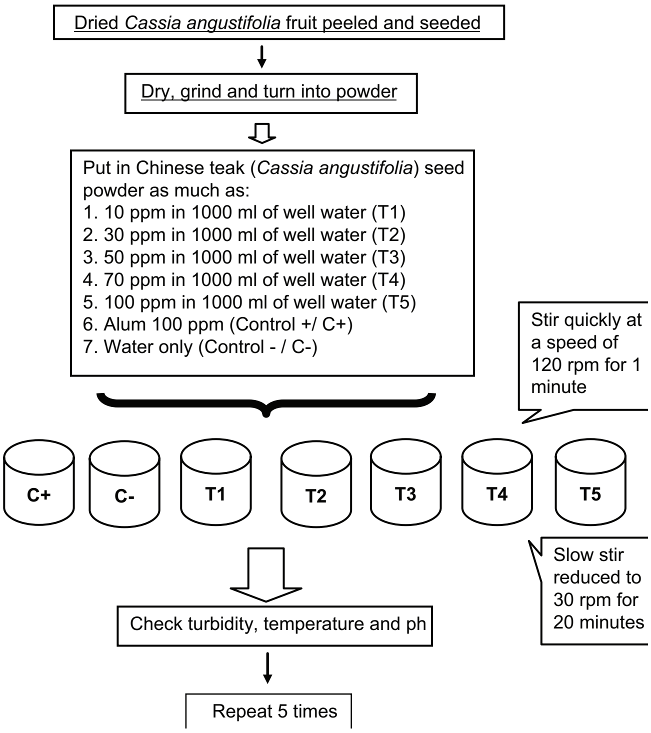

Figure 1: The research procedure

As shown in Table 3, the difference of turbidity difference average reduction at 10 ppm, 70 ppm, and 100 ppm is significant (0.001) and to compare the average turbidity reduction across all doses, as shown in Table 4.

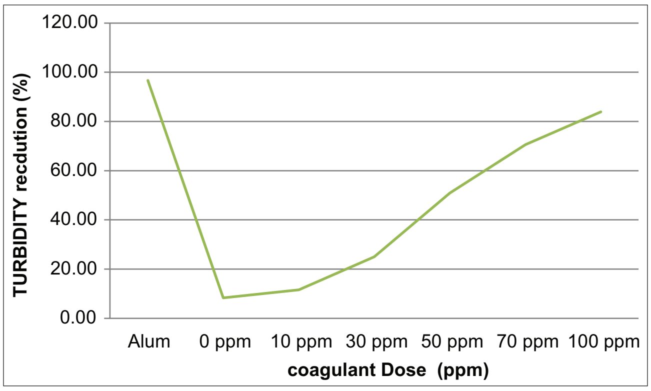

Figure 2: Percentage rate of decrease in turbidity level after the jar test process

As shown in Table 4, subset 1 contains turbidity values of 100 ppm and 70 ppm, indicating that the average turbidity of the two doses is not significantly different. In other words, the average decrease is identical between the two doses. Turbidity values of 70 ppm and 50 ppm are found in subset 2, indicating that the average turbidity of the two doses is not significantly different. In other words, the average decrease in turbidity between the two doses is the same, and the turbidity values in subset 3 are 30 ppm and 10 ppm, respectively, indicating that the average turbidity between the two doses is not significantly different. In other words, the average decrease is identical between the two doses.

Table 2: The one-way ANOVA analysis test resulted the significance effect of Chinese steak power on decreasing turbidity.

Doses	Mean	SD	SE	95% CI	*P*
10.00	95.18	1.47	0.65	94.35–98.00	<0.001
30.00	81.42	25.77	11.52	49.41–113.42	
50.00	53.36	13.38	5.98	36.73–69.98	
70.00	31.96	6.01	2.68	24.49–39.42	
100.00	17.48	4.05	1.81	12.44–22.51	

SD: Standard deviation, SE: Standard error, CI: Confidence interval.

Discussion

The results indicated that increasing the dose of Chinese teak seed powder (*Cassia angustifolia*) used as a coagulant resulted in a more significant reduction in turbidity during the jar test process using Chinese teak seed extract. This result is consistent with the previous research showing that colloidal particles in water naturally have the same charge [11]. As a result, colloidal particles repel one another, preventing large particles from forming in the water. Coagulation reduces the repulsion and attraction between colloidal particles by introducing ions of opposite charges [14], [15].

Table 3: Turbidity reduction test results for various doses of coagulant powder of Chinese teak seed powder (*Cassia angustifolia*)

Coagulant dosage (I)	Coagulant dosage (J)	Mean difference (I−J)	SE	Significant	95% CI	
					Lower bound	Upper bound
10	30	14.42	8.48	0.46	−10.96	39.80
	50	42.48*	8.48	0.00	17.10	67.86
	70	63.88*	8.48	0.00	38.50	89.26
	100	78.36*	8.48	0.00	52.98	103.74
30	50	28.06*	8.48	0.03	2.68	53.44
	70	49.46*	8.48	0.00	24.08	74.84
	100	63.94*	8.48	0.00	38.56	89.32
50	70	21.40	8.48	0.13	−3.98	46.78
	100	35.88*	8.48	0.00	10.50	61.26
70	100	14.48	8.48	0.45	−10.90	39.86

CI: Confidence interval, SE: Standard error. *alpha: 0.05

The increasing attractive force between colloidal particles causes the particles to grow in size and sink to the water's bottom [16]. The precipitate forms flocs from the colloidal particles that remain in the water [17]. This interparticle collision occurs through a flocculation process [18], as the plants used to purify water due to an active coagulant (i.e., mucilage) are cactus, *Coccinia indica*, Okara, dragon fruit stems, and *Cassia angustifolia*. Sanghi *et al*. (2002) suggested using the sap seeds of *Cassia angustifolia* in place of the coagulant PAC (*Poly Aluminum Chloride*) or in combination with PAC at a low concentration to remove the red dye *Acid Sendula* and the green dye *Direct Kahi*, a solution of synthetic dyes. Farhani and Deraz (2016) argue that the *Cassia angustifolia* plant may also be used as a coagulation material for conventional drinking water treatment [7], [8], [9], [10], [19], [20].

Table 4: Congruence the average reduction in turbidity caused by all doses of coagulant Chinese teak seed powder (*Cassia angustifolia*)

Tukey HSD[a]				
Chinese teak seed coagulant dosage (ppm)	*n*	Turbidity (subset for alpha=0.05)		
		1	2	3
100	5	17.48		
70	5	31.96	31.96	
50	5		53.36	
30	5			81.42
10	5			95.84
Significant		0.452	0.125	0.456

*alpha: 0.05

Through maceration with hexane, the fat content of the Chinese teak seed powder was reduced to obtain fat-free Chinese teak seed powder. After coagulation and stirring, the turbidity value of the cloudy water sample was determined using a turbidimeter, and the percentage decrease in turbidity of the water (percentage decrease in turbidity) demonstrated its coagulant ability [21].

A flocculation process is a sophisticated form of coagulation. Typically, an efficient coagulation process initiates the formation of good flocs. The flocs' quality affects how quickly or slowly the particles settle in the sedimentation tank. At this stage, the flocculation efficiency level and sedimentation time required will be determined following the raw water characteristics entered in the previous stage. Stable particles combine to form larger flocs, separated more quickly during the flocculation process [22].

The results of further statistical tests showed that different turbidity between the use of Chinese teak (*Cassia angustifolia*) seed powder at doses of 100 ppm, 50 ppm, and 10 ppm, where the average decrease was significantly different. The higher the dose the higher the turbidity level which decreased until it reached an average of an average of 17.48 NTU at a dose of 100 ppm. While at dose of 30 ppm, it has decreased to an average of 62.58 NTU. Other previous studies resulted that the optimum dose obtained was 35 ppm aluminum sulfate with an efficiency of 66.1% reducing turbidity. So that, this extract can be applied as an appropriate technology to provide clean air in the community. Various studies have applied natural coagulants in the provision of clean water on a larger scale [23].

Conclusion

There is a difference in turbidity reduction in dug healthy water when Chinese teak seed powder (*Cassia angustifolia*) is added at doses of 10 ppm, 30 ppm, 50 ppm, 70 ppm, or 100 ppm. Because the average turbidity is significantly different at doses of 10 ppm, 50 ppm, and 100 ppm, it can be used at low turbidity levels with low doses, but it is necessary to investigate the active compound content and its bio-coagulant properties.

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