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Utilization of Tamarind Seed Biocoagulant as Learning Material for Water Purification Practicum in Colloidal System

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Abstract

Discharging wastewater directly into the environment can harm nearby organisms. Efforts to increase environmental awareness, especially about sewage, can be started with educational activities. The study investigates the correlation between chemistry material and water purification using tamarind seed bio coagulant, assessing its feasibility for chemistry experiment design in schools. This research uses descriptive qualitative research. This study described data from observations of water purification using tamarind seed coagulant, literature studies on chemistry practicum, and interviews with two chemistry teachers and two high school students.The results showed that the relationship between colloidal material and the experiment was to determine the types of products that contain colloidal systems in daily life and the properties of colloids. The results of the chemical parameter test revealed significant changes in the pH levels of river, laundry, and batik wastewater samples, with batik coloring waste showing the most significant changes. The organoleptic test results revealed significant changes in the color, odor, and sediment of batik dyeing wastewater. The protein in tamarind seeds can destabilize substances that cause turbidity. Based on literature studies and interviews, tamarind seed bio coagulant is feasible as a teaching material for chemistry practicum on colloidal system.

Keywords: Biocoagulant, Colloid, Practicum, Tamarind Seeds,Water Purification

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INTRODUCTION

Water polluted with sewage is unsuitable for daily use because it contains hazardous materials and pathogens that can cause skin irritation digestive disorders, and is carcinogenic (Raju et al., 2018). Water quality in Indonesia has declined due to population activities, especially in the industrial and household sectors. Indonesia has not yet reached the Indeks Kualitas Air (IKA) score in 2022 because the points recorded were 53.88 of the Kementerian Lingkungan Hidup dan Kehutanan (KLHK) targeted points of 55.03 points (Kementerian Lingkungan Hidup dan Kehutanan, 2022). It can occur because the waste produced is not treated and discharged directly into the waters, causing a decrease in water quality (Zainol et al., 2021).

One of the efforts that can be made to reduce deteriorating water quality is adding coagulants derived from natural materials (bio coagulants) and coagulants derived from chemicals or synthetic coagulants (Kristianto et al., 2020). Previous research covered the opportunities of bio coagulant application for drinking water and wastewater treatment recovery, that bio coagulants are eco-friendly, biodegradable, and do not produce chemical residue in the effluent (Kurniawan et al., 2020). Meanwhile, synthetic coagulants can harm the environment if they are used continuously (Martini et al., 2020). Using synthetic coagulants to purify wastewater is considered less environmentally friendly because it still contains high aluminum sulfate compounds, which are more than 0.2 mg/L (Saputroh et al., 2020). Therefore, natural coagulants were developed from animal extracts, microorganisms, and plants (Saputroh et al., 2020).

Plants that can be used as alternative coagulants (natural coagulants) are tamarind seeds (Tamarindus Indica L.). The seeds of tamarind still need to be well utilized and are just thrown away (Ulwia & Soumena, 2017). The tannin content in tamarind seeds (Tamarindus indica L) is considered to be used as a biocoagulant in the coagulation process (Riyandini & Iqbal, 2020). In addition, the protein in tamarind seeds serves as a natural polyelectrolyte that functions similarly to synthetic coagulants (Martina et al., 2018). Previous research results also stated that tamarind seeds, as a natural coagulant, could reduce turbidity and COD in liquid waste from the detergent industry (Ronke et al., 2016). Amino groups in tamarind seeds can bind negatively charged colloidal particles. These particles will then be destabilized and form large particles, eventually settling (Afrianisa & Ningsih, 2021). Tamarind seeds (Tamarindus Indica L) contain tannins, which can function as a biocoagulant in coagulation (Thakur & Choubey, 2014). Tannins are widely used in water treatment because they contain anionic phenolic groups. Phenolic groups in tannins will be deprotonated and form resonances that are stabilized with phenoxides, thus allowing coagulation (Nimesha et al., 2022).

The results of an interview conducted with one of the chemistry teachers suggested that chemistry learning is more dominated by teachers than students (Anggreani, 2019). The results of the literature study also found that practicum activities still need to be carried out (Rahmawati & Khamidinal, 2019). This is different from the essential competencies of the curriculum on colloidal material, which should introduce students not only to theoretical concepts but also to direct experience to hone science process skills (Ghozali, 2017). However, the limited knowledge of educators regarding the potential of local resources in the surrounding environment, facilities and infrastructure, human resources, costs, time, and other non-technical constraints cause practicum to be rarely carried out (Candra & Hidayati, 2020). School activities generally produce waste from using chemicals that, if not appropriately handled, endanger living things and damage the environment (Rizkiana et al., 2020).

Efforts to increase environmental awareness can also be made by educating about the importance of environmental care attitudes by presenting a learning atmosphere based on an environmental approach (Sitti Hasnidar, 2019). Practical activities with a contextual approach can increase students' concern for the environment because the problems come from daily life (Nugroho & Puspitasari, 2019). When practicum activities are carried out with a contextual approach, there will be an interaction of knowledge that students already have with the learning environment so that the meaningfulness and interest in the material increases. Students' science process skills will also increase (Ting & Siew, 2014). Practical activities can also increase interest, curiosity, critical thinking, openness, creativity, and environmental sensitivity (Puspita Sari & Sudiana, 2019).

Water purification by utilizing tamarind seeds can be implemented in high school chemistry learning, namely in the material of colloidal coagulation properties. Colloidal material is one of the chemical materials connected with daily life (Novilia et al., 2017). Learning material connected to real life will become more meaningful and stored long in the memory of students so that it is not easily forgotten (Jumalia & Suryelita, 2022). The potential of tamarind seeds as a water purification bio coagulant has not been studied, and its utilization in chemistry learning has not been researched, so this research is essential to utilize the potential of tamarind seeds from food or beverage processing (Nur Fahima et al., 2022).

Utilizing local natural materials can be integrated with practicum activities to support learning, such as research by Wijayadi in making indicators for acid-base titration practicum from Telang flowers (Wijayadi et al., 2020). This study has not shown the discovery results if applied in the lessons. Therefore, researchers conducted similar research utilizing natural materials like tamarind seeds as a biocoagulant in colloidal systems because the material is intimately related to everyday life. It is essential for students to be interested in learning this material and knowing the scientific process that occurs so that they can apply concepts for problem-solving in the future, one of which is through a chemical practicum based on natural materials around them.

METHOD

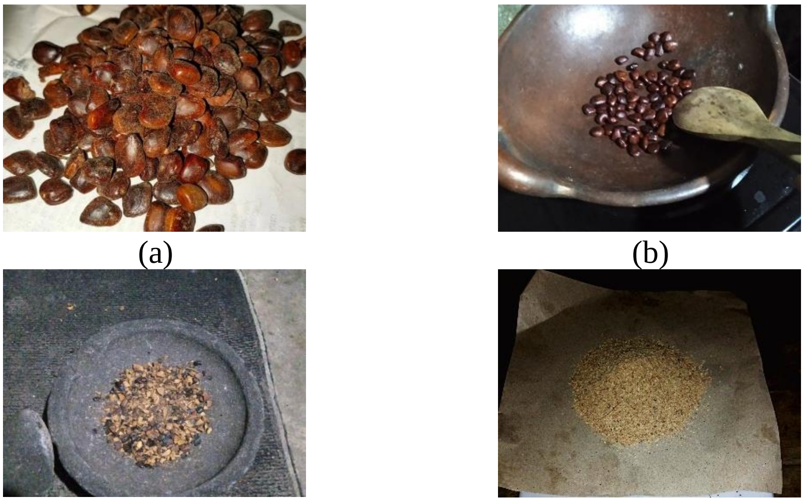
The study uses qualitative research methods, which will be subjected to descriptive analysis. Sugiyono (2013), posits that qualitative research is conducted under natural conditions, directly studying data sources with researchers serving as key informants. Such research methods entail experiments, observation, and semi-structured interviews (Salim, 2019). Experiments and observations aim to evaluate the potential of tamarind seeds as a biocoagulant. Interviews were given to two teachers and two students from SMAN 2 Ungaran that aimed to gather data on the feasibility of biocoagulants as teaching materials for colloidal system.

Subject Relevance of Colloid Materials with Practicum Design

A literature study analyzes the relationship between colloidal material and water purification practicum. This involves using curriculum texts to conduct the study. This study aims to analyze the chemistry curriculum for schools (Fitri & Fikroh, 2021).

Experimental of Tamarind Seeds as Water Purification Biocoagulant

The tamarind seeds used in this study were obtained from the remaining tamarind used for herbal medicine production in the local area. Furthermore, tamarind seeds are cleaned and then roasted to separate the tamarind seed skin (Hermida et al., 2021). The tamarind seeds are ground into powder and sieved to homogenize and enhance the surface area of the coagulant, facilitating the process of forming flocs when mixed into liquid waste (Poerwanto et al., 2015). The powder is then dried for sixty minutes, approximately at 100°C. It should be noted that exposure to high temperatures exceeding 100°C can result in the loss of active substances in tamarind seeds, thus affecting their efficacy as coagulants (Ferreira Junior et al., 2020). The Tamarind seed powder in Figure 1 is obtained by calculating the initial weight of tamarind seeds, which is 108 grams. After being dried, the weight decreased by 60 grams, so according to the mathematical calculation, the content of tamarind seeds was 44.5%.



(a) (b) (c) (d)

Figure 1. (a) tamarind seeds, (b) roasting tamarind seeds, (c) grinding tamarind seeds, (d) tamarind seed powder after sieving

To begin the observation process, 3 grams of biocoagulant adding into each 200 mL wastewater sample, then stir quickly and manually for 3 minutes, and stir slowly for 12 minutes. Rapid stirring can cause destabilization of colloids and fine suspended solids, leading to the formation of microflocs (Hambali et al., 2017). As part of the coagulation process, the slow stirring process during sample flocculation results in micro flocs that can fuse and grow in size to form larger (Nurhidayah & Solikha, 2017). As a result, these flocs can be effectively deposited through the sedimentation process (Ashari et al., 2021).

The Feasibility of a Water Purification Practicum Using Tamarind Seed Bio Coagulant as Teaching Material

A literature study and an interview method were conducted to determine the significance of practicum design for chemistry topics, including pedagogical and human resource aspects (Arianton et al., 2019). The interview was conducted with two chemistry teachers and three students. We interviewed one of chemistry teachers and two students for reviewed a high school chemistry practicum and research on implementing natural materials in school chemistry practicum activities. The questions intended for the respondents were six questions for teachers and four questions for students. The interview technique used in analyzing the potential of tamarind seed biocoagulant as a learning material and alternative simple practicum is a semi-structured interview with an open-ended question interview model.

RESULTS AND DISCUSSION

Experimental of Tamarind Seeds as Water Purification Biocoagulant

Observations were made using chemical and physical characteristics. Chemical characteristics include the value of acidity or pH. The results of chemical parameters can be seen in **Table 1**

Table 1. Chemical Observation Results of Wastewater Samples Before and After The Application of Tamarind Seed Biocoagulant

No	Wastewater Sample	Before coagulant addition	After coagulant addition
1	River	6.8	6.6
2	Laundry	7.8	7.3
3	Batik coloring	7.3	6.8

Chemical Parameters

Based on Table 1. the coagulation process is affected by acidity. When the water is more alkaline, the amount of organic matter absorbed by the tamarind seed coagulant decreases (Hayati et al., 2016). In river water waste, laundry, and batik coloring, the pH decreases by 3%, 6.4%, and 7%. At low pH, the amine group in the tamarind seed protein gets protonated to $NH3^{+}$, which serves as the active site of the coagulant. The protonation process enhances the coagulation properties of tamarind seed extract, resulting in heightened effectiveness in reducing water turbidity (Zainol & Nasuha Mohd Fadli, 2020).

Physical parameters

Physical characteristics include color, odor, and sediment determined by the organoleptic method. The organoleptic method was chosen so that students could observe the coagulation process with color, odor, and sediment parameters (Rosariawari & Khasanah, 2022). This method was chosen because testing tools such as jar tests and turbidimeters were limited to measuring water turbidity. The regimentation process for two hours is shown in Table 2.

Table 2. Organoleptic Observation of Wastewater Before and After Adding Biocoagulant.

Wastewater Sample	Physical Parameters	Before	After
River	Color	Sloppy brownish	Sloppy
	Smell	Ammonia	No smell
	Sediment	None	Available

Wastewater Sample	Physical Parameters	Before	After
			
Laundry	Color Smell Sediment	Greyish Soapy None 	Less greyish No smell Available 
Batik coloring	Color Smell Sediment	Deep red No smell None 	Cherry red No smell Available 

Based on Table 2, n the color parameter, laundry water samples and batik dyeing waste show a more intense color after coagulating and precipitating. It can be caused by starch contained in tamarind seeds because one of the properties of starch is insoluble in water (Chen et al., 2020). However, the river water samples showed an increase in color. This is supported by research (Kriswandana et al., 2020) that tamarind seed protein dissolved in water turns into a positive electrolyte that can destabilize negatively charged turbidity-causing substances so that the light barrier that enters the water decreases, which causes the water to become more apparent. Organic matter in water/waste can bind with positive ions in coagulants (Lafiyah, 2018). The coagulation-flocculation process in bio coagulants can be seen in the following Figure 2.

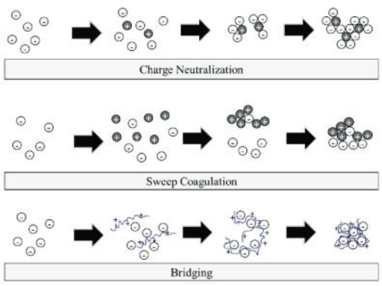


Figure 2. Coagulation Process

Based on Figure 2, the chemical mechanism of coagulation using natural coagulants involves charge neutralization and particle agglomeration. When these coagulants are added to the water, they neutralize the negative charge of the wastewater so that they agglomerate and form larger clumps that can remove the damaging substances in the wastewater (Alazaiza et al., 2022). After being added with bio coagulants, the three samples did not produce an odor in the odor parameter. The initial condition in river water smelled a slight ammonia odor due to household waste, while in laundry water, there was a detergent odor. The decrease in the odor of wastewater from pungent to odorless occurs because tamarind seed husks contain volatile aroma compounds, natural polysaccharides with antibacterial activity, and odor-masking substances (Sofiavizhimalar et al., 2022). Previous research also revealed that the ethanol extract of tamarind seed skin has been tested for antibacterial activity against Staphylococcus aureus (Rahim et al., 2023).

The results of sediment observation showed that all wastewater samples formed sediment. The best sediment results were obtained in batik coloring wastewater, which is thought to be due to its impurities. The precipitate formed can occur due to the tannin of tamarind seeds, which helps the coagulation process. The tannin content in tamarind seed bio coagulant can bind organic compounds as proteins to form aggregates that are easy to precipitate (Badawi et al., 2023**.** In tamarind seed powder, carboxyl, hydroxyl, and amine groups in tamarind seed powder facilitate suspension attachment and expand the attachment area of previously formed flocs to create larger flocs (Kurniawan et al., 2022)**.** In addition, Mikro bubbles appear on the water's surface, indicating that the coagulant has agglomerated dissolved particles in the wastewater. These bubbles are flocs formed due to the coagulation process (Iwuozor, 2019). In wastewater, organic matter can be removed through microbubbles due to suspended material adhering to the charged surface or oxidation as the microbubbles agglomerate, producing hydroxyl radicals (Poh et al., 2014).

Relevances of Colloid Materials with Practicum Design

Identifying material linkages starts with analyzing the chemistry curriculum in SMA/MA to determine students' skills. After analyzing the curriculum, indicators of competency achievement in class XI colloid material were analyzed. The results of curriculum identification with competency achievement indicators for the experimental design are listed in Table 3.

Table 3. Analysis of The Relationship of The Experimental Design to The Chemistry Subtopic.

No	Experiment Phase	Learning Materials
1.	Preparation of tamarind seed coagulant.	Determine the types of products that belong to the colloidal system in daily life.
2.	Physical observation of wastewater after being added with tamarind seed coagulant.	Determine the type of colloidal system based on its dispersed and dispersing phases. Describe the types of colloids. Determine the factors that affect coagulation precess.

The experimental design can be related to the subject matter of chemistry, specifically the selection of the type of product that includes a colloidal system in the form of a natural coagulant from tamarind seeds. The coagulant is made as a powder, which, if dissolved in a wastewater sample, will produce sediment after the flocculation process. Adding tamarind seed biocoagulant in wastewater samples can also be integrated with colloidal properties, including coagulation. In chemical observations of wastewater, the pH parameter is measured. This measurement can be related to determining factors that affect coagulation, one of which is acidity.

The Feasibility of a Water Purification Practicum Using Tamarind Seed Bio Coagulant as Teaching Material

According to the interview data based on ten questions addressed to teachers and students there are five important points were obtained on Table 4.

Table 4. Data Result From Interviews

Sources	Main Interview Topics	Responses
Teachers	Obstacles that result in chemistry practicum activities not being maximized.	“Less lesson time because in one learning cycle the time is only 45 minutes, while during the practicum the teacher also has to condition the participants in the lab which sometimes takes a lot of time”
	The use of natural materials in chemistry practicum activities.	“Some materials such as acid-base have used natural materials. For example, the use of turmeric juice, hibiscus flowers, and purple cabbage in acid-base practicum”
	Relevance of water purification practicum using tamarind seed bio coagulant with chemistry content.	"Based on how the product works, it has presented the nature of coagulation in colloidal systems, so I think it is relevant to the content"
Students	Attractiveness to developing and experimenting using tamarind seed biocoagulant for water purification.	"I am interested in doing this experiment because I just found out the potential of natural materials used in practicum besides, it is also easy to work"
	Understanding colloidal material, especially the coagulation process after practicum.	"With this practicum, I know the way of water purification with the coagulation process"

The results of interviews with two chemistry teachers obtained the results of this experiment and can be used as teaching materials for students. This practicum can explain the theory of colloidal coagulation in real terms so that students become more familiar with the material (Hardeli et al., 2021). Based on the readiness and ability of teachers to carry out the experimental design, it was found that the practicum design made it easier for teachers and students to carry out the practicum. The teacher mentioned that the frequency of chemistry practicum in class XI is more frequent, requiring more practicum preparation. The teacher also plays a role in supervising the practicum because there are still many hazardous chemicals in the laboratory. Therefore, the practicum design for tamarind seeds as a water purification coagulant can be carried out as an alternative experiment at school because the tools are not too complex, the manufacturing materials are not too dangerous, and the work methods are simple. They can be accomplished outside the laboratory (Sofia et al., 2022). Conducted to research by Fanesa et al. on using green chemistry in chemistry materials, practicum activities using natural materials can be carried out independently by students at home with safer work safety risks than in the laboratory (Fanesa et al., 2021).

The data results also indicate that the tamarind seed bio coagulant is suitable for teaching and is relevant to colloidal system material. Incorporating the environment in the practicum allows teachers to develop the scientific thinking process of students during learning. Observing the environment as inspiration can be an effective way to teach in the classroom (Suryadi et al., 2017). Colloidal material is often presented in a narrative form. Thus, this practicum allows students to observe firsthand the practical application of colloidal material, specifically in coagulation material. Research by Richard Mayer’s Cognitive Theory of Multimedia Learning has shown that learning materials can significantly impact a person's understanding and sensory perception. Individuals who only receive auditory input tend to have a lower understanding level than those who receive visual and auditory information (Ponticorvo et al., 2019).

Based on interviews with two students about the ease of understanding and the ability to stimulate interest in learning, the results showed that students were interested in this practicum design because it was easy and could increase their understanding of the nature of colloidal coagulation. Using appropriate media for the material being taught effectively stimulates student interest, increases participation in the teaching and learning process, and enables students to easily grasp the material, thus increasing student achievement (Rasanzani et al., 2017).

CONCLUSION

The research results can conclude that tamarind seeds, as a biocoagulant, can purify river, laundry, and batik dyeing wastewater. The most significant effects were seen in the laundry wastewater sample because it had the best pH reduction of 7% in the batik coloring wastewater sample. Organoleptic observations show that the most significant changes occur in batik wastewater samples. This experimental design using biocoagulants can be used as teaching material and by the characteristics of experiments in high school. This is supported by the response of teachers and students that the practicum of water purification using tamarind seed bio coagulant is relevant to coagulation material and helps students understand the material.

RECOMMENDATION

In order to follow up on the findings of this study, it is recommended to pay attention to coagulation factors, especially the determination of the amount of coagulant in the sample, as well as the time and speed of stirring.

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