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Effectiveness of *Carica Papaya* Dry Seed as Natural Coagulants in Wastewater Treatment Process

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ABSTRACT

This study aims to assess the efficacy of *Carica papaya*-dried seeds as a natural coagulant in the wastewater treatment process. Using natural coagulants in water treatment provides a safer and more sustainable method. Insufficient research in this field hinders a thorough comprehension of the ideal circumstances, dosage, and potential impacts of *Carica papaya* dry seed coagulation on pollutant elimination in wastewater. Therefore, the investigation of the extraction procedure for coagulants derived from dried *Carica papaya* seeds is essential to establish a reliable and efficient method suitable for use in wastewater treatment facilities. The number of experiments were conducted to accomplish the objective of this study. The experiment utilised textile effluent from an industrial area in Parit Raja, Johor as the wastewater sample. The *Carica papaya* seeds were ground into a powder and then mixed with Sodium Chloride (NaCl) and distilled water to create a coagulant solution. COD, turbidity, pH, and settling depth were measured to assess the effectiveness of *Carica papaya* seeds in treating the effluent sample. At a *Carica papaya* seed coagulant dosage of 2.0 mL with a NaCl concentration of 1.5 M, the optimal COD reduction and turbidity removal efficacy were at 20.95 % and 23.00 %, respectively. This study shows that among 5 different concentration solvent, 1.5M NaCl is most optimum concentration condition demonstrated. Moreover, the research represents the significant potential of *Carica papaya* seed powder as a natural coagulant for treating wastewater that contains textile colouring agents. In conclusion, the research demonstrated that dried *Carica papaya* seeds possess the potential to serve as a natural coagulant in wastewater treatment procedures, thereby presenting a safer and more ecologically sustainable alternative. This study offers insights into the ideal conditions for utilising dried *Carica papaya* seeds as a natural coagulant for treating wastewater that contains textile colouring agents.

Keywords:
Coagulant; water treatment; *Carica Papaya;* textile wastewater

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1. Introduction

Industrial wastewater contains a variety of contaminants, including organic/inorganic chemicals, heavy metals, and non-disintegrating materials. The varieties of industrial effluent vary based on the industry, and they are abundant. Mineral processing, paper, iron and metal shaping, and beer brewing are some sectors that generate wastewater. Cost-effective methods are necessary to treat industrial wastewater in various situations [1].

The textile industry faces environmental challenges in managing its liquid waste due to the presence of various dyes and chemical additives. Dyeing processes are the primary polluters of textile wastewater, resulting in significant levels of chemical oxygen demand, heat, highly suspended solids, and colour. These factors contribute to the complex chemical composition of textile wastewater [2].

Water treatment is the process of eliminating harmful elements from water to ensure its safety for human and domestic use, involving coagulation, flocculation, sedimentation, filtering, and disinfection [3]. The coagulation-flocculation process is a physicochemical method for treating wastewater, involving the addition of coagulants to cloudy water with suspended substances [4]. The coagulation-flocculation process is commonly used in water and wastewater treatment due to its ability to effectively eliminate organic matter, suspended particles, turbidity, and colour. These substances need to be removed because they negatively impact water quality by reducing transparency (resulting in turbidity and TSS), and eventually transport toxic substances and pathogenic organisms [5]. The initial step in the destabilization of colloidal particles in water is the coagulation process, which involves the introduction of positively charged coagulants like poly-aluminium chloride [4,6]. This process often succeeded by flocculation, facilitating particle agglomeration for enhanced removal via sedimentation or filtration [7]. In the flocculation stage, destabilized particles are formed and agglomerated into larger particles, leading to deposition processes as a result of their weight. The effectiveness of this treatment phase depends on the pH, type, and dosage of the coagulant [4,8].

Common coagulants such as aluminium sulphate, Poly-aluminium Chloride (PAC), and iron ions are used to treat drinking water, even though they are often very expensive and dangerous to people's health. Furthermore, the use of these chemicals as coagulants is known to have significant drawbacks from both health and environmental perspectives [9]. Extensive research has been undertaken to analyse the impact of chemical coagulants, including the occurrence of high amounts of chemical residuals and toxic sludge and the potential for long-term health impacts. The cost and limited availability of chemical coagulants and disinfectants pose obstacles to the implementation of conventional water treatment procedures in impoverished nations [10].

Chemicals used for water treatment make up around 20 to 30 percent of the total treatment expenses, and an increase in chemical prices results in a corresponding increase in treatment costs, according to Ishak Hasnan, the head of the Malaysian Water Engineers Action Committee (MyWAC) [11]. These factors can result in financial burdens which lead to consuming a very large expense.

Concerns about the environment, health, and sustainability are raised when chemical coagulants are used to clean water. Hence, natural coagulants are being investigated as a possible replacement. These problems can be resolved with natural coagulants like plant or microbes materials. Substituting natural coagulants with chemicals reduces waste and health risks from leftover chemicals to make water treatment more sustainable. Natural coagulants have a benefit over chemical coagulants in terms of sludge production. This reduces waste and sludge management and disposal expenses, benefiting the environment with improved treatment sustainability. Testing natural coagulants in diverse water treatment scenarios can establish consistent performance and appropriate approaches [12]. Natural coagulants provide the most economical solution because they give numerous benefits like less sludge produced, requiring lower concentration of natural coagulant. Minimal dosage requirements can be attributed to the efficacy of natural coagulants in charge neutralisation and polymer bridging, which are the primary mechanisms for removing contaminants [12]. Thus, using natural coagulants instead of chemical ones may reduce the drawbacks of standard coagulation procedures. Natural coagulants offer an alternative to standard coagulation methods, which rely on inorganic coagulants and organic polymers. These conventional methods have various limitations, including reduced effectiveness at low temperatures, sensitivity to pH changes, instrument corrosion, and the production of non-biodegradable sludge [13].

Protein extraction from plant-based coagulants was carried out using distilled water and NaCl solvents [14]. While distilled water is the primary and cost-effective solvent used for extraction, it is not as effective as a salt solution like sodium chloride (NaCl) in breaking the protein-protein bonds present in coagulant sources [15]. NaCl was chosen because it is considered a natural substance. This salt origin can be found in various natural environments such as salt solutions, seawater, lakes, saline groundwater, and solid rock [16].

In Malaysia, *Carica papaya* seeds are advised as natural coagulants for water treatment because they are cheap and available resources with non-seasonable fruit. As a result of Malaysia's abundant agricultural resources, the seeds in issue are widely available and reasonably priced. Chemical coagulants, which have to be shipped or made, cost more than natural coagulants. Plant-based natural coagulants derived from different plant wastes offer a cost-effective alternative [17]. Malaysia has a large supply of *Carica papaya* seeds, making them a reliable source for water treatment. Indigenous natural coagulants also support domestic businesses, economic growth, and resource independence.

This research aims to take advantage of a natural coagulant obtained from dried *Carica papaya* seeds as a substitute for a chemical coagulant, specifically Aluminium Sulphate (alum). In this study, water samples are collected from the effluent of textile industrial wastewater. The significance of this study is found in its contribution to the development of alternative approaches to water treatment. Additionally, it has the potential to facilitate the advancement of innovative methods or materials for the purpose of water purification.

1.1 Literature Value

The process of coagulation serves as an effective treatment approach for water contaminated with pollutants [18]. During coagulation, microscopic particles stick together to form larger groups (flocs) and dissolved organic matter sticks to the aggregates of particles so that it can be removed later during a solid or liquid separation process [19]. The process involves the introduction of chemical agents or natural substances into water, resulting in the modification of the physical characteristics of solid particles that are dissolved or suspended in the water. This alteration facilitates the sedimentation or flocculation process [18].

The schematic diagram of the mechanism of coagulation by Owodunni and Ismail, as shown in Figure 1 below [12]. As part of the charge neutralisation process, ions with opposite charges are used to attract colloidal particles. Also, when coagulants are added to the wastewater, the electrical load is neutralised even more until the zeta potential hits zero. Therefore, colloidal particles' electric charge is neutralised, reducing or eliminating electrostatic repulsion [20].

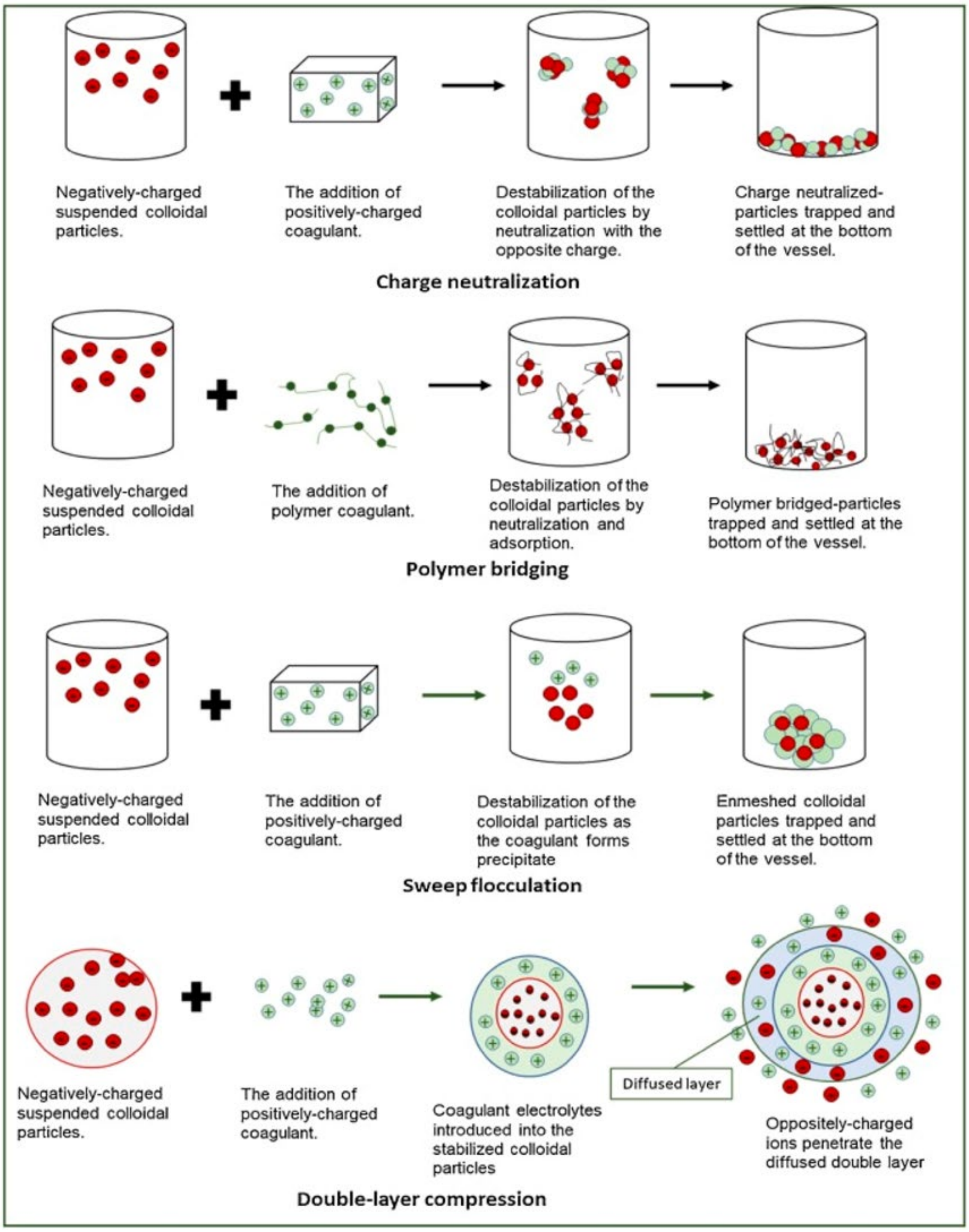

Fig. 1. The figure illustrates schematic diagram representing mechanism of coagulation [12]

In the context of water treatment, the addition of a chemical coagulant typically initiates a hydrolysis process, leading to the formation of cationic species that undergo colloidal reactions. The phenomenon of polymer bridging occurs when a polymer or polyelectrolyte coagulant possessing an elongated molecular structure induces the destabilisation of colloidal particles by creating interparticle bridges that establish connections between them. The polymer coagulant exhibits the ability to adsorb numerous particles onto the surface of the polymer molecule [21]. Consequently, the formation of cohesive aggregates, known as macro flocs, occurs, which are further interconnected through the presence of bridges. The flocs resulting from polymer bridging exhibit a flaky morphology characterised by irregular void spaces. The sweep flocculation coagulant allows the entrapment of colloidal particles, compelling their sedimentation to the lower area. The precipitation of amorphous metal hydroxide involves the formation of a net-like structure through the process of hydrolysis. The process of double-layer compression involves the utilisation of a coagulant to facilitate the reduction of repulsive forces between colloidal particles, thereby enabling their assembly. This mechanism operates through the existence of a substantial concentration of electrolyte ions in the vicinity of the colloidal particles. Consequently, an opposing charge is introduced into the diffused double layer encompassing the colloids, leading to an augmentation in density [22].

The best way to make strong flocs is through polymer bridge, following charge neutralisation and sweep flocculation. The flocs resulting from charge neutralisation exhibit a compact yet fragile structure due to their greater dependence on physical bonding rather than chemical bonding. Analysis of the flocculation index, starting floc aggregation, and relative settling factor shows that sweep flocculated flocs show strong settling behaviour but form at a slower rate. The higher aggregation rate leads to larger flocs formed through double-layer compression however, the excessive friction force of these flocs impacts their settling behaviour. Furthermore, the ionic charge of the coagulant plays a crucial role in determining the effectiveness of floc formation. Divalent ions exhibit enhanced floc stability and accelerated settling compared to monovalent ions. Charge neutralisation is commonly the primary mechanism of coagulation for natural coagulants [20].

1.2 Natural Coagulant

In recent times, there has been increasing interest in using natural coagulants for water and wastewater treatment. This is primarily due to their ability to effectively treat water without depleting alkalinity or disrupting pH levels. Furthermore, it should be noted that natural coagulants do not introduce any metallic substances into the effluent, unlike chemical coagulants. This characteristic results in a reduced sludge volume produced [12].

The classification of natural coagulants includes two main categories: plant-based coagulants and non-plant-based coagulants. Plant-based coagulants can be produced using coagulants derived from various botanical sources, including leaves, seeds, fruit wastes, and tree bark. Plant-based coagulants have been prioritised in research over non-plant-based coagulants because of their superior cost-effectiveness [23]. Non-plant-based coagulants are coagulants derived from substances other than plants and microorganisms. These polymer-based coagulants can be anionic, cationic, or non-ionic, but they can also be polyelectrolytes with a dual ionic nature [24].

1.2.1 Plant-based coagulant

Water treatment often involves the utilisation of natural coagulants. Nevertheless, their application in industrial wastewater treatment is limited due to their comparatively higher costs in comparison to chemical coagulants. In general, natural coagulants have been found to be effective in the treatment of water or wastewater exhibiting low turbidity levels within the range of 50 to 500 NTU (Nephelometric Turbidity Units). There are several functional and charged groups, such as carboxylic (-COOH) and hydroxyl (-OH) groups, are present in natural coagulants. In general, the mechanism of action of natural polymeric coagulants involves a combination of polymer bridging and charge neutralisation [25].

1.3 Carica Papaya

Carica papaya is an herbaceous plant that is classified within the Caricaceae family. The vegetation grows in tropical regions and exhibits a maximum height of 10 metres [26]. The seeds of

Carica papaya fruit contain around 20% of its entire weight. The therapeutic value of *Carica papaya* seeds is often overlooked, and they are typically discarded during fruit processing [27]. The seeds contain a high concentration of unsaturated lipids, making them a potential substitute for essential oil. The *Carica papaya* seeds and leaves are both rich sources of protein, dietary fibres, phytochemicals, antioxidants, and minerals. The *Carica papaya* leaves contain a significant amount of protein, making them suitable for improving high-carbohydrate foods [26].

Several studies have investigated different plant-based natural coagulants like Moringa Oleifera and date seed to assess their effectiveness in removing the turbidity and total coliform count from water as well as wastewater [28]. The utilisation of plant extracts that possess coagulating and antimicrobial properties while ensuring human safety is clearly apparent. The *Carica papaya* seed contains substantial protein content, and certain authors have suggested that the proteins present in the plant extract serve as active coagulating agents [28].

The coagulant properties of *Carica papaya* seeds can be linked to the presence of proteins with positive charges [29]. These proteins can stick to things like silt, clay, bacteria, and toxins that have a negative charge. This process of sticking together makes it easier for flocs to form, which then settle and clear the water. This process includes both binding and neutralisation of charges. Additionally, *Carica papaya* seed powder can bind to solid particles in water solutions, making them sink to the bottom. Papain, also referred to as *Carica papaya* proteinase, is a significant protein with 345 amino acid residues. It comprises a singular sequence of peptides that are both mature and specific [29]. *Carica papaya* seeds have been used to remove faecal microorganisms in the contaminated water [30].

Existing research on the effectiveness of *Carica papaya* dried seed as a coagulant in wastewater treatment is insufficient. The lack of study in this area makes it hard to know the best conditions, dosage, and possible effects of *Carica papaya* dry seed coagulation on removing pollutants from wastewater. In addition, it is necessary to conduct research on the coagulation mechanisms of *Carica papaya* dry seed and its interaction with the various pollutants present in wastewater. Studying the mechanisms of using *Carica papaya* dry seeds as a natural coagulant can aid in the development of effective and environmentally beneficial wastewater treatment methods. Also, the process of extracting coagulants from dried *Carica papaya* seeds must be investigated to find a reliable and simple method that can be readily implemented in wastewater treatment facilities. *Carica papaya* dry seed will be used more often as a natural coagulant in large-scale wastewater cleaning processes.

1.4 Objective

This study's objectives are to determine the efficacy of *Carica papaya* seeds as a natural coagulant in water treatment processes. The study concentrates on three specific aspects: its ability to reduce Chemical Oxygen Demand (COD), turbidity, and its effectiveness as a coagulant based on pH levels and settling depth. This study seeks to shed light on the potential use of *Carica papaya* seeds as an eco-friendly alternative for water treatment and purification by analysing these parameters.

2. Methodology

2.1 Research Flow

The project methodology shown in Figure 2 involves conducting research in order to accomplish the overarching aims and objectives of the project, which aim is to figure out whether *Carica papaya* seeds function effectively as a coagulant in the context of wastewater treatment.

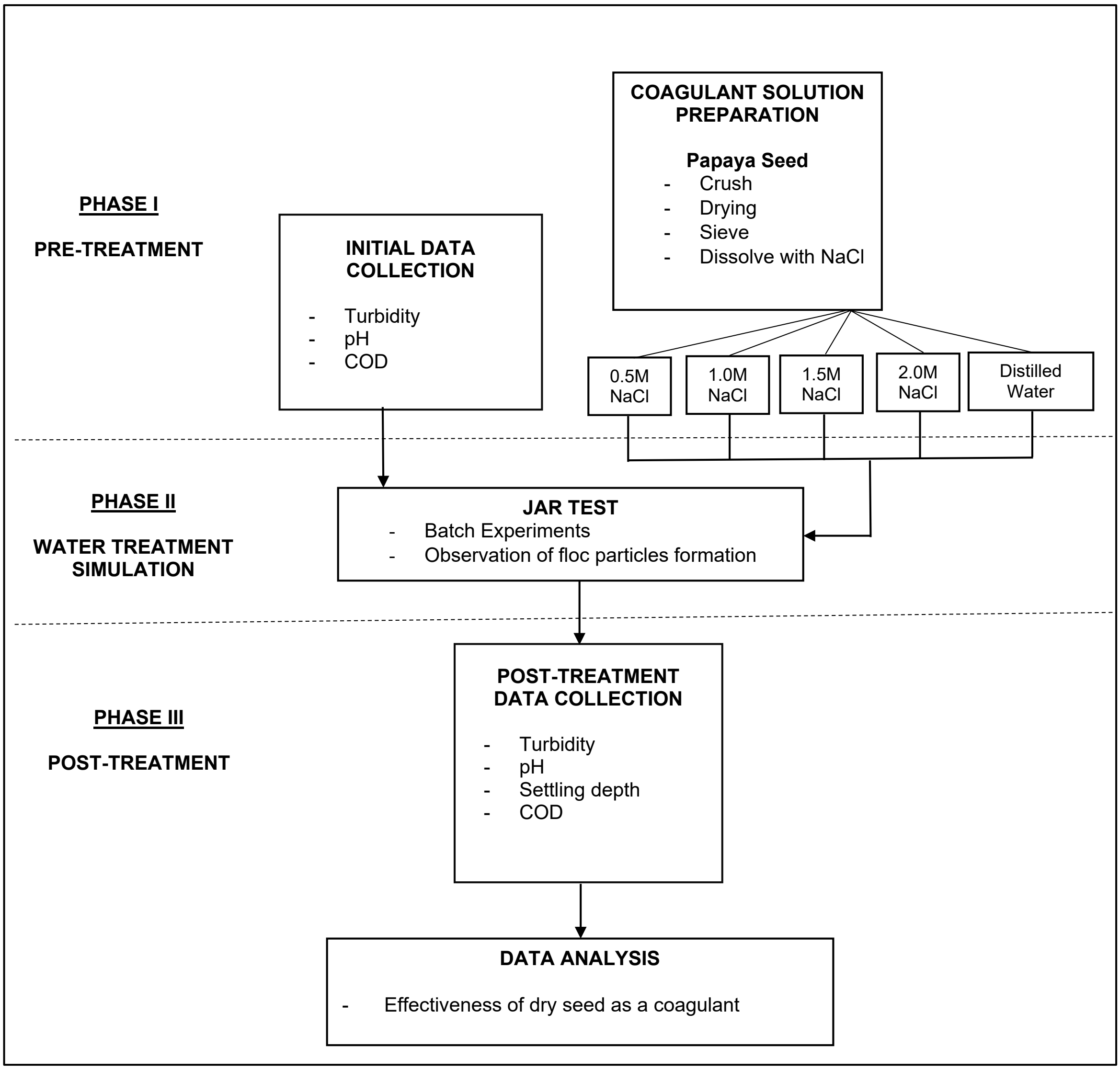

Fig. 2. The flowchart illustrating the project methodology

This research is composed of three different phases: pre-treatment, simulation of the wastewater treatment process, and post-treatment. Phase 1 pre-treatment involves the collection of preliminary data from wastewater samples and the implementation of a procedure to produce a coagulant solution. The main ingredient of the material preparation involves the utilisation of dried seeds from the *Carica papaya* fruit, which are later pulverised into a fine powder. These powdered seeds were dissolved in a NaCl solution with five different concentrations.

Phase 2 is a laboratory-scale simulation of water treatment using the Jar Test method. In the Jar Test experiments, dried *Carica papaya* seeds are dissolved in various concentrations of NaCl to generate a coagulant solution. Lastly, for Phase 3 post-treatment, data collection of COD, turbidity and ph occurred after completion of the Jar Test. Then, the data will be analysed to determine the effectiveness of dry seed as a coagulant.

2.2 Preparation of Textile Wastewater

This study used a sample of wastewater from an industrial area in Parit Raja, Johor. The industrial processes in the area that produce textile effluent were the source of this wastewater sample. The effluent utilised in this study was analysed to determine its initial properties.

2.3 Material Preparation

Figure 3 shows the fresh *Carica papaya* seed washed with distilled water and dried for 6 hours at 50 degrees Celsius in an oven. Following that, the *Carica papaya* seeds would undergo a process of crushing, pulverization, and sieving, resulting in the production of finely powdered particles of uniform size, as shown in Figure 4.

Fig. 3. Raw *Carica papaya* seed used

Fig. 4. Dry *Carica papaya* seed powder used

Mixing 5g of dried *Carica papaya* seed powder with 100 mL of pure water or sodium chloride (NaCl) to make a coagulant solution with distilled water and different amounts of NaCl. This experiment used NaCl concentrations of 0.5M, 1M, 1.5M, and 2.0M.

2.4 Jar Test

The ASTM D2035 was utilised to perform the Coagulation-Flocculation Jar Test for water. ASTM D2035 outlines the application of jar testing as a means to evaluate the effectiveness of coagulation and flocculation methods in the treatment of water and wastewater. This method involves treating samples with different chemical dosages in jars and observing settling and clarity. It aims to optimise the treatment process for the effective removal of particles and turbidity, resulting in enhanced water quality and cost efficiency. Before the stirring process started, the initial data was taken from wastewater samples which are pH, turbidity, and COD. As shown in Figure 5, six 0.5L beakers were used in this jar test method. After completion of the jar test, a retention time of 15 minutes may be necessary to achieve full reaction completion.

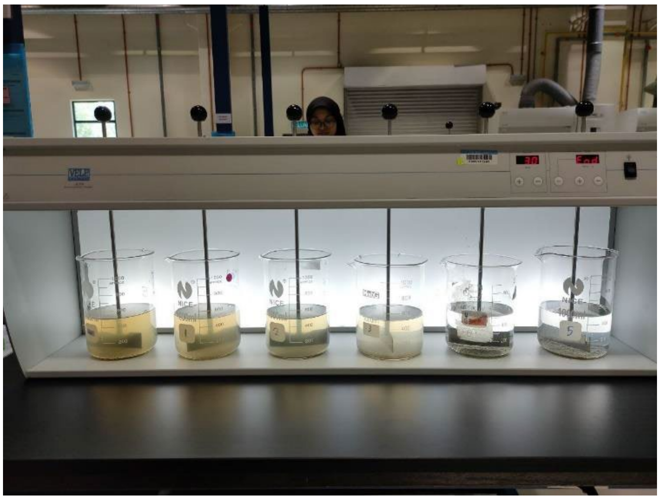

Fig. 5. Jar test process

2.5 Data Analysis
2.5.1 Chemical oxygen demand (COD)

The data analysis of COD reduction percentages includes the investigation of how wastewater treatment procedures can effectively reduce COD levels over a period of time. This analysis incorporates the utilisation of statistical methods to enhance treatment effectiveness and expand the fundamentals of sustainable water management. Using Eq. (1), the effectiveness of the *Carica papaya* seed and alum coagulant in reducing the COD of the water was determined.

$$\text{COD Reduction (\%)} = \frac{pre-post}{pre}\ x\ 100\% \quad (1)$$

2.5.2 Turbidity removal

The method of examining turbidity removal data involves determining the effectiveness of natural coagulants in reducing turbidity levels in wastewater as well as establishing connections between turbidity and various environmental factors. The efficacy of the *Carica papaya* seed and alum coagulant in reducing the water's turbidity was determined using Equation (2). Where T_1 is initial turbidity (NTU) and T_2 is final turbidity (NTU).

$$\text{Turbidity Reduction (\%)} = \frac{T_1-T_2}{T_1}\ x\ 100\% \quad (2)$$

3. Result and Discussion
3.1 Carica papaya Seed Coagulant Turbidity Removal Efficiency

Figure 6 shows a line graph of six different solutions with varying coagulant dosages. All *Carica papaya* seed coagulant solutions demonstrated an increase in turbidity removal with an increase in NaCl concentration. 2 mL *Carica papaya* seed coagulant at 1.5M of NaCl concentration reduces higher turbidity due to active component solubility. It shows that removing turbidity from surface water requires fewer powder *Carica papaya* seed coagulants. The more turbidity removed, the more *Carica papaya* seed coagulants are used. Furthermore, the graph illustrates that the *Carica papaya* seed coagulant solution with the highest NaCl concentration, specifically 2.0M NaCl, exhibits the greatest average turbidity removal. Salts, such as NaCl, can impact the coagulation process by modifying the electrical double layer surrounding particles and influencing charge neutralisation and particle destabilisation [31]. The NaCl concentration in wastewater affects the coagulation efficiency of *Carica papaya* dry seed because the salting effect extracts protein out from *Carica papaya* seed, which is a coagulant agent.

Coagulant proteins play a crucial role in promoting the coagulation of colloids, which in turn facilitates their removal. This is primarily due to the adsorption and bridging phenomena that occur when proteins interact with colloidal particles. Proteins are characterized by their long chain length and high molecular weight, which are the key factors responsible for the formation of bridges between colloidal particles that improve the elimination of turbidity in wastewater [32,33]. The composition of *Carica papaya* seeds can be considered to justify the requirement of a smaller quantity for effective coagulation. Sugiharto (2020) found that the *Carica papaya* seed meal has a crude protein content of 24–30%, an in vitro protein digestion of 80%, and a 47% amount of important amino acids [33]. The existence of amino acids which are positively charged can enhance the coagulation and flocculation process with the mechanism of charge neutralization.

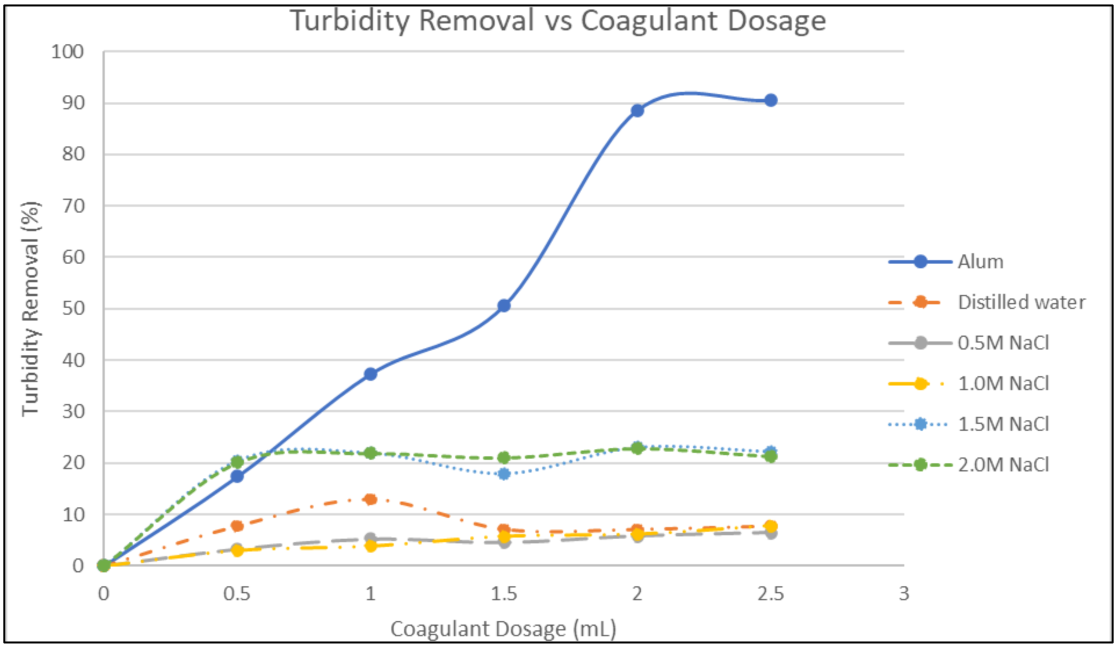

Fig. 6. Percentage of turbidity removal vs coagulant dosage

3.2 The Efficacy of Carica Papaya Seed Coagulant in the Reduction of Chemical Oxygen Demand (COD)

The efficiency of COD reduction increased with higher dosages of *Carica papaya* seed coagulant. As shown in Figure 7, the second-highest dose of *Carica papaya* seeds at a concentration of 1.5 M NaCl reduced COD by 20.95%, while a dose of 0.5 mL at a concentration of 0.5 M had the least effect, removing only 0.42%. *Carica papaya* seed can reduce COD value because *Carica papaya* seed contains glutathione (GSH) [34,35]. GSH has been associated with the defense response to biotic stress [36]. GSH can work synergistically with superoxide dismutase (SOD) which is an antioxidant enzyme to neutralise reactive oxygen species (ROS) [37]. Therefore, *Carica papaya* seeds can indirectly reduce COD by removing pollutants that can cause oxidative stress and ROS production.

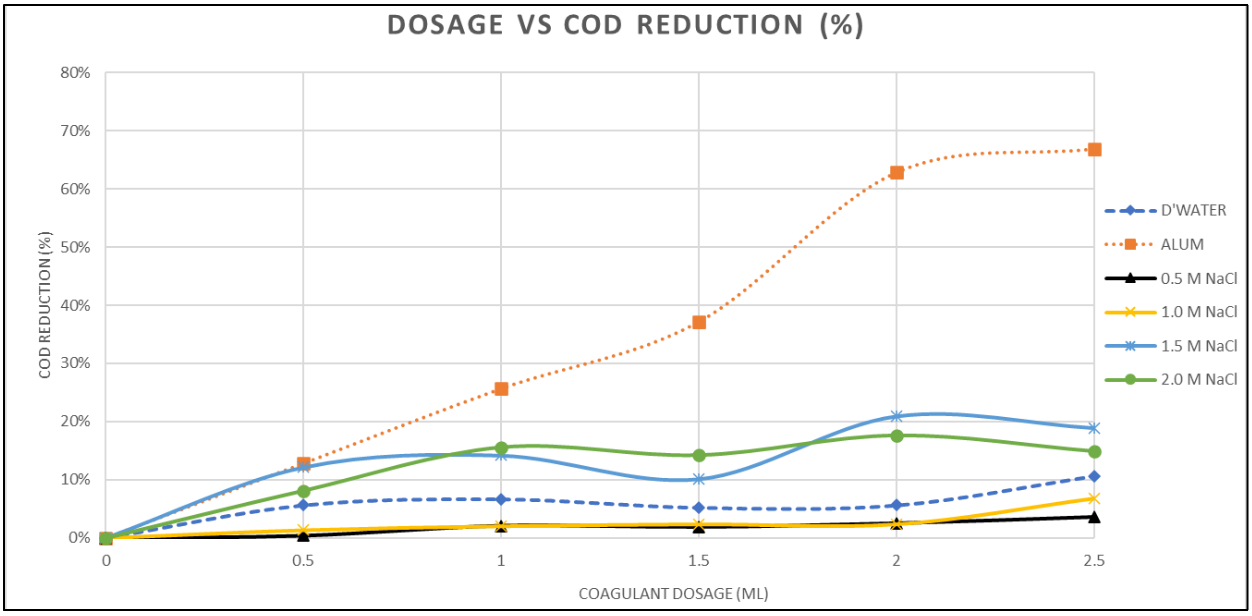

Fig. 7. Percentage of COD removal vs coagulant dosage

3.3 Efficacy of Carica Papaya Seed Coagulant As Measured By pH

As shown in Figure 8, using 0.5mL and 2.5mL of 2.0M NaCl, the solution of NaCl and *Carica papaya* seed marginally raises the alkalinity of the water to a maximum of 7.6. In the meantime, the solution of distilled water and *Carica papaya* seeds reduces the pH. As the control sample has a neutral pH of 7.18, a blank sample is used. The concentration of distilled water and alum decreases the pH in the meantime. It shows that 1.0M NaCl at a dose of 2.0mL was the best solution for the natural coagulant in *Carica papaya* seeds because the result is closest to 7.29, which is blank. Consequently, it was determined that *Carica papaya* seed powder has no measurable capacity to neutralise surface water samples [39]. This conclusion was supported by George and Chandrn (2018), no significant pH changes were observed in the water sample treated with *Carica papaya* seed as a coagulant [29].

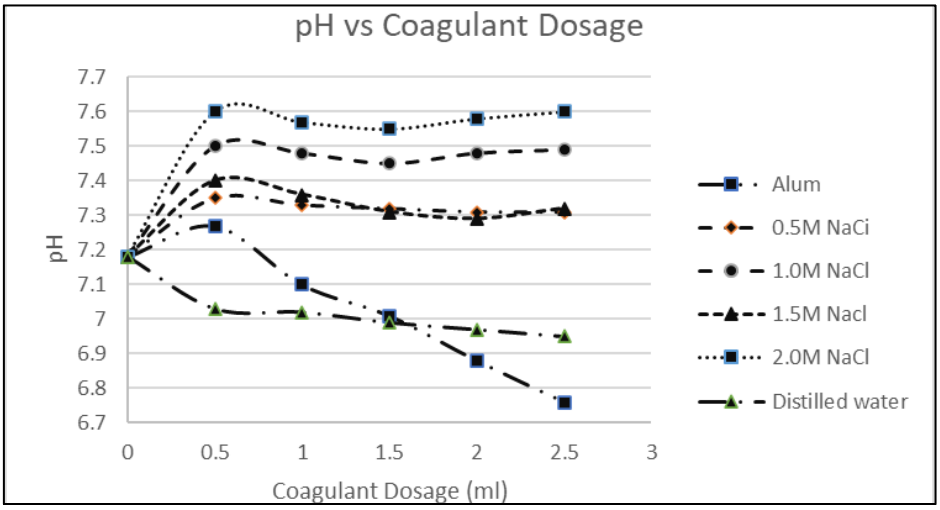

Fig. 8. pH vs Coagulant dosage

3.4 Efficacy of Carica Papaya Seed Coagulant as Measured by Floc Formation

According to Table 1, the most floc formation was shown for each concentration. Most of the floc formation for the alum solution coagulant was fine in size particles. Meanwhile, all the *Carica papaya* seed coagulant solutions produce very fine-sized floc formation except for distilled water, which is moderately fine. A settling rate assessment is conducted to evaluate the compactness and size of flocs. Flocs with slower settling rates may indicate larger and less compact structures, whereas flocs with faster settling rates may suggest smaller and denser flocs. Based on the Data of particle size analysis from particle size analysis and coagulation experiments, floc formation can be classified as moderately fine, fine, or very fine.

Table 1
Analysis of Coagulant Concentration and Floc Formation

Coagulant Dosage	Floc Formation
Alum	Fine
0.5M NaCl	Very Fine
1.0M NaCl	Very Fine
1.5M NaCl	Very Fine
2.0M NaCl	Very Fine
Distilled Water	Moderately Fine

3.5 Comparison of Results Obtained from the Current Study with Existing Literature.

The tabulated data in Table 2 presents a comparison between the findings of this study and the existing literature. In this study, textile industrial wastewater has been utilized for the experiment and a natural coagulant with five concentrations of solvent also has been used. The table presents an exploration of the effectiveness of different natural coagulants in reducing turbidity and chemical oxygen demand (COD) in wastewater. Extensive research has been conducted on the seeds of *Carica papaya* to date. When compared to pigeon peas and date stones, *Carica papaya* was found to be slightly less successful at reducing turbidity except in carwash wastewater treatment. Date seed and *Carica papaya* seed performed better, but it's important to remember that they were tested in different wastewater circumstances. Also, a different type of wastewater was used in a separate study on *Carica papaya*, which led to better results. The finding showed that *Carica papaya* could be a good alternative to chemical coagulants. It also showed that the seeds of *Carica papaya*, which are easy to find, have other benefits.

Table 2
Comparison of Results Obtained from Existing Literature

Type of wastewater	Natural coagulant	Turbidity removal (%)	COD removal (%)	Ref.
Sewage treatment plant wastewater	*Carica papaya* seed	41.89	66.67	[31]
Carwash wastewater	*Carica papaya* seed	97.00	35.91	[35]
Raw river water sample	*Carica papaya* seed	89.14	-	[29]
Kaolin synthetic wastewater	Pigeon Pea (*Cajanus cajan*)	94.62	-	[38]
Iron and steel industrial wastewater	Date stone	-	96.50	[39]
Textile industrial wastewater	*Carica papaya* Seed	23.00	20.95	This study

4. Conclusions

The present study uses *Carica papaya* seeds as a natural coagulant for treating textile wastewater. *Carica papaya* seed powder was used as a natural coagulant to remediate textile-dyed effluent in this study. *Carica papaya* seeds replaced artificial coagulants with surprising success. At 2.0 mL *Carica papaya* seed coagulant and 1.5 M NaCl, COD reduction and turbidity removal efficacy were 23.00% and 20.95%, respectively. This study shows that among 5 different concentration solvents, 1.5M NaCl is the most optimum concentration condition demonstrated. According to the analysis, NaCl affects *Carica papaya* seed coagulation. This impact happens because the electrical double layer around the particles is changing, which affects the neutralisation of charges and the destabilisation of the particles. *Carica papaya* seeds can also lower Chemical Oxygen Demand (COD) in wastewater treatment. This is because *Carica papaya* seeds may remove contaminants that cause oxidative stress and ROS generation. This study enhances *Carica papaya* merchants' sales revenue, which benefits society because businesses and communities love papayas. *Carica papaya* seed benefits can also help introduce more indigenous fruits. Additionally, recycling *Carica papaya* seeds reduces the production of organic waste. Reducing landfill waste could reduce environmental contamination. As a natural coagulant used to treat water, *Carica papaya* seeds didn't leave behind many pollutants. *Carica papaya* seeds cleanse water without harmful consequences like chemical coagulants. This minor residual component improves drinking water sustainability and environmental health. This wastewater treatment coagulant is an environmentally beneficial alternative to chemical coagulants.

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