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Terminalia catappa (talisay) leaves as coagulant for preliminary surface water treatment

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Abstract

At present, in order to decrease the hazards of using inorganic coagulants for preliminary water treatment, researchers have been studying the possibility of using new methods and materials to treat water. This study aimed to evaluate the performance of turbidity removal in water by using *Terminalia catappa* (Talisay) as natural coagulant. The coagulation active agent in the leaves of *Terminalia catappa* was extracted with 1.0 molar (M) Sodium Chloride (NaCl) solution. Water from Cagayan River, Tuguegarao City, with increased turbidity of 200 Nephelometric Turbidity Units (NTU) was used in this study. This study was done using Completely Randomized Design with loading doses of 2, 3, 4, and 5 ml/L of the stock solution with 5g of *Terminalia catappa* leaf powder in 100 ml 1.0 M NaCl solution as coagulant. The turbidity, pH, and coliform count were determined for all the samples. The turbidity for the samples ranged from $\log_{10}1.81$ to $\log_{10}1.33$ NTU. The 5 ml/L treatment of *Terminalia catappa* showed the lowest residual turbidity where 88% turbidity was removed from the sample. The pH values ranged from 7.27 to 7.46. The total coliform count for all treatments were all equivalent with >6500 cfu/ml. Hence, *Terminalia catappa* leaf extract possesses potential natural coagulant for surface water treatment due to its ability to remove turbidity. However, *Terminalia catappa* leaf extract has no effect on the basicity and acidity of the water sample. Furthermore, it has no observable antibacterial property on water.

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Introduction

The use of plant-based materials as water treatment agents has long history, particularly the wood charcoal as an excellent adsorbent. Several plant-based materials were identified as a natural coagulant such as Moringa (*Malunggay*), Strychnos (Clearing nut tree) and Cactus (Rani and Jadhav, 2012). Recently, tannin-based coagulants have been utilized in coagulation/flocculation process for water purification (Yin, 2010). Tannins are high molecular weight polycyclic aromatic compounds. Tannins are widely distributed in the plant kingdom obtained from natural materials, for example, the organic extracts from bark and wood of trees such as Acacia, Castanea, or Schinopsis (Sanchez-Martin *et.al*, 2010). Interestingly, *Terminalia catappa* leaves, locally known as *Talisay,* contains large amount of tannin. *Terminalia catappa* believed to have originated in Malaysia. It is reaching heights of 15 to 25 m.*Terminalia catappa* shows strong salt-, drought- and wind-tolerance and produces fruit (5- 10 cm long) with a thin flesh surrounding a large fibrous nut (Chen *et.al*, 2000). *Terminalia catappa* leaves have traditionally been used by Betta (Siamese fighting fish) breeders in South East Asia to mimic the natural Betta habitat. They are believed to aid the fish in a number of ways, such as helping fighting fish heal after a battle and inducing spawning in breeding tanks (Gupta and Mishra, 2011).The leaves do contain several flavonoids like kamferol or quercetin and several tannins such as punicalin, punicalagin or tercatin, saponins and phytosterols. Due to this chemical richness, the leaves and also the bark have long been used in different traditional medicines for various purposes. It is also thought that the large leaves (7-10" long) contain agents for prevention of cancers and antioxidant as well as anticlastogenic characteristics (Chyau *et.al*, 2011). In fishkeeping the leaves are also used to lower the pH and heavy metals of the water. It has been utilized in this way by Betta breeders in Thailand for many years. Hobbyists across the world also use them for conditioning the betta's water for breeding and hardening of the scales. Cognizant to the challenges of the continuous pursuit of safe drinking water, this research is deemed beneficial for it yields a practical alternative to inorganic coagulants to save our dependency on these harmful substances in water treatment facilities. The pursuit of this study will lead to meaningful utilization of *Terminalia catappa* leaves. The use of *T. catappa* as a natural coagulant/flocculant for surface water treatment can be a factor to domestic health and safety practices. This study founded on the coagulation-flocculation processes, embarked on eco-friendly approaches which inspire healthy living.

This research was conceptualized to investigate the potential of *Terminalia catappa* leafstock solution as a primary natural coagulant in treating surface water. The effectiveness of the coagulant is measured on the final turbidity, pH level, and coliform count of the water after the treatment.

Materials and methods

Study design

This experimental study used Completely Randomized Design. The experiment investigated the ability of *Terminalia catappa* leaf stock solution of varied concentrations in turbidity removal, its effect to the pH and coliform count of the water. Primarily, Jar test equipment was used for the coagulation-flocculation process. There were replicates for the Jar testing in order to utilize averaging on the turbidity, pH level and coliform count of the water at the end of the treatment.

Collection of Water Sample

Twenty liters of water was collected from Cagayan River located at Buntun, Tuguegarao City. Based on the water collection procedure set by Philippine National Standards for Drinking Water (2007), the water samples used in this study were taken in the middle of the river and at mid-depth. The turbidity of the water was further increased to 200 NTU by mixing clay particles in the water. The clay was mixed vigorously in the water. The mixture was then left overnight to allow complete hydration of the clay particles. The supernatant was collected carefully and transferred in a water jar. The collected water was then transferred to 18 beakers of 1 L volume.

Preparation of Plant Stock Solution

Fallen leaves of *Terminalia catappa* were obtained from Cagayan State University, Carig Campus. The leaf samples have an average length of 17.78 cm. The *T. catappa* leaves with dark to light red in color were chosen. The leaves were air-dried then cut into small pieces and dried in the oven at 90 °C for 12 hours to remove the remaining moisture. The leaves were ground to fine powder by using a dry miller. The powdered leaves were kept in shelled container under ambient temperature. The extraction of coagulation active agent was carried out by mixing 5.0 g *Terminalia catappa* leaves, 100 mL of extraction solution and blended for 2 minutes. The extraction solution consisted of 1.0 M NaCl was used to extract the coagulation active agent. The slurry from extraction process was filtered through filter paper and the filtratewas utilized as a 50g/L *Terminalia catappa* leaf stock solution. The stock solution of the coagulant was only used in a day.

Measuring Water Quality Parameters

The jar test was performed to evaluate the effect of coagulant dosage on turbidity removal efficiency in surface water. The equipment used for the jar test was an improvisation of the actual unit. The experiment was carried out using different concentrations of the Talisay stock solution which was extracted with 1.0 M NaCl. All four 1000 mL beakers were initially filled with water samples and were placed in the slots of jar tester and were subsequently agitated at 150 rpm for two minutes. Different amount of coagulant ranging between 2.00 - 5.00 ml/L were added into each of the beaker during agitation and the process was left for 5 minutes. The mixing was reduced to 30 rpm and continued to agitate for 45 minutes. After agitation process all samples were placed in ambient room temperature for approximately one hour. A pH Meter Quality Probe was used to measure the acidity and basicity of the water making sure the electrode did not touch the beaker. Twenty mL was obtained from the supernatant and was placed in two test tubes for spectrophotometric measurement of turbidity and coliform count. Turbidity was then measured by pouring the supernatant to the turbidity tube until turbidity measure is read (Myre and Shaw, 2006). From the turbidity measure, percent transmittance was calculated.

Statistical Analysis

Analysis of Variance (ANOVA, General Linear Model Procedure) was done to assess whether significant ($p < 0.05$) variations existed among the treatments given to assess their efficacy as water coagulants. Multiple mean comparisons using Least Significant Difference (LSD) were computed to ascertain where the differences existed. Analysis of data was computed using IBM SPSS Statistics v.20, 2011.

Results and discussion

Turbidity

Table 1 shows the mean values of the turbidity and transmittance of the water after each treatment. The data suggests that the untreated water has still the highest turbidity as expected.

Table 1. Mean Turbidity Levels in NTU and % Transmittance of the Water After the Treatments.

MeanTurbidity Values		Mean Transmittance Values	
Control	2.3000	Control	54.6000
A5	.9900	A5	83.3000
T2	1.8133	T2	54.9000
T3	1.7333	T3	58.9667
T4	1.6500	T4	67.9333
T5	1.3333	T5	72.4000

It is observable that there was a decrease in turbidity respective to the treatments of *Terminalia catappa* leaf stock solution ranging from $_{\log10}$1.81 NTU to $_{\log10}$1.33 NTU. A concentration of 5 ml/L of *Terminalia catappa* worked best in terms of turbidity removal among the four treatments of the stock solution at $\log_{10}1.33$ NTU. Consequently, transmittance values show also the same data pattern vis-à-vis turbidity as shown in the same table. 72.4% transmittance was observed at 5 ml/L concentration, considerably lower than 83.3% transmittance for 5ml/L of Alum.The results of the previous table is supported by the data shown in Table 2. It was observed that as the amount of coagulant dose increases its capacity to remove turbidity also increases. Best result was observed at optimum dose of 5 ml/L at which 88% turbidity was removed from the water sample. This suggests that the extract of *Terminalia catappa* leaves has potential to remove turbidity of the raw water sample.

Table 2. Residual Turbidity of the Water Treated with *Terminalia catappa*LeafStock Solution.

Treatment	Residual Turbidity (NTU)	% of Residual Turbidity
2 ml/L	67.35	34
3 ml/L	57.17	28
4 ml/L	45.73	23
5 ml/L	23.26	12
Blank	200.71	100

Moreover, statistical tests affirm that there is a significant difference among the final turbidity of the water treated with different concentrations of *Terminalia catappa* leaf stock solution. At p-value<0.05, there is also a statistically significant difference among the transmittance values.

Table 3. Mean pH Levels of the Water After the Treatments.

Treatments	Mean
Control	7.1100
A5	7.0600
T2	7.4633
T3	7.3367
T4	7.2433
T5	7.2767
Total	7.2483

This confirms that *Terminalia catappa* leaves have indeed a coagulation property and has a potential to be a coagulant.

This observation could be attributed to the tannins in the leaves destabilizing the suspended particles' charges in the water of *Terminalia catappa* supported by the study of Ozacar and Sengil in 2001 using tannins extracted from Turkish Corns as coagulant and coagulant aid.

pH

Table 3 reveals the mean pH of the water after the treatment of Terminalia catappa at different concentrations and when alum is added. It is observable to all treatments of *Terminalia catappa* that the pH increases as compared to the control groups (C and A5).

Although there is small discrepancy between T4 and T5, a decreasing pH is observed as the concentration of *Terminalia catappa* increases to 5 ml/L. Water treated with alum has the lowest pH among groups.

This result can be supported by the fact that *Terminalia catappa* leaves contain tannins which lowers the pH of water; hence used in aquaria as water conditioners especially to Beta-Siamese fishing (http://aquariadise.com/indian-almond-leaves/).

Test of difference will show moreover that there was no significant difference among the pH of the water after treating with different concentrations of *Terminalia catappa* (p=0.167).

Coliform Count

Based on the equivalent coliform counts of >6500 from all the treatments, it can be said that there was no observable antibacterial property of Terminalia catapppa to water (Table 4). Consequently, with equivalent means, there is no significant difference among the treatments.

This sameness of coliform counts among treatments could be explained by the fact that the source of water may have been highly contained with many forms of bacteria where the concentration of Terminalia catappa coagulant and Alum may not be sufficient.

Accordingly, after coagulation and flocculation processes the water still has to be subjected for disinfection by chlorination to completely kill pathogens and other microbes in the water during water treatment.

Table 4. Mean Coliform Counts of the Water.

Treatment	Mean
Control	6500.00
A5	6500.00
T2	6500.00
T3	6500.00
T4	6500.00
T5	6500.00
Total	6500.00

Alum compared to Terminalia catappa

One of the aims of this study is to compare the performance of alum and *Terminalia catappa* as coagulant. It can be deduced in Table 5 that there is a significant difference between the mean turbidity values of the water treated with 5ml/L of Alum and 5ml/L of *Terminalia catappa* leaf stock solution.

It further shows that Alum works better as coagulant than *Terminalia catappa*.

Table 5. Significant ANOVA between Alum and *Terminalia catappa* coagulant of equal concentration.

Dependent Variable			Mean Difference (I-J)	Sig.
Turbidity	A5	T5	-.3433*	.008
Transmittance	A5	T5	10.9000	.083
pH	A5	T5	-.2167	.090

There is, however, no significant difference between the mean transmittance values (p=0.245) and pH levels (p=0.251) of the water treated with Alum and *Terminalia catappa*. An Independent Sample T-test was run to support this conclusion. It is interesting to note that a p- value of greater than 0.005 from p=0.045 is needed to show that Alum and *Terminalia catappa* have no significant difference in terms of its performance in turbidity removal.

Conclusions

Terminalia catappa leaf extract possesses potential natural coagulant for surface water treatment due to its ability to remove turbidity. However, *Terminalia catappa* leaf extract has no effect on the basicity and acidity of the water sample. Furthermore, it has no observable antibacterial property on water. To determine the relationship between the tannins or protein content to turbidity removal, the isolation and characterization of coagulation active agent in *Terminalia catappa*'s leaves through Fourier Transform Infrared Spectroscopy (FTIR) analysis is recommended. Furthermore, to strengthen the results of this study, using other techniques and experimental design in probing the potential of *Terminalia catappa* as coagulant is encouraged.

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