Removal of Water Turbidity Using Tamarind Seed

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Abstract

Tamarind seed is a valuable source of protein, essential fatty acids, and minerals which can be used as an additive to perfect balanced functional foods. In this study, the amount of protein was found to be 11.692 mg/g of water extract of tamarind seed. The objective of this investigation was tamarind seed as a coagulant to remove water turbidity and total dissolved solids (TDS) of four water samples (S I, S II, S III and S IV) for the three different seasons. These raw water samples were collected from lakes and streams used by rural people in nearby Pathein township. The optimum turbidity removal efficiency (% TRE) and TDS removal efficiency(% TDS) of tamarind seed were observed for all selected water samples to be in the range of 77.07% - 81.71% and 83.07% - 90.17% at pH range 6.37 – 6.97 of 0.6 g doses at a settling time of 60 minutes.

Keywords: Tamarind seed, protein, turbidity, total dissolve solids, pH

Introduction

In many developing countries, access to clean and surface water is a major problem. According to UN, 1.1 billion people still do not have access to an adequate supply of safety water and these people are among the world poorest. Surface water either from rivers or rain fed ponds has becoming one of the main sources of water supply. The quality and quantity of water available to humans have been vital factors in determining their well-being. The chemical reactions that occur in water and the chemical species found in it are strongly influenced by the environment in which the water is found (Manahan, 2000).

Coagulation is a physical-chemical process to remove turbidity of drinking water and waste water, is a common process used for removing suspended matter from water. Coagulation and flocculation followed by clarification are some of the main processes used for water treatment. The physical phenomenon of destabilization of colloids is induced by several agents. The most commonly used coagulants are lime, aluminium sulphate (alum), ferric chloride, and ferrous sulphate etc. However, this process is normally very slow, so some chemical products like polyacrylamides are added to water in order to accelerate the coagulation process by increasing floc size. This is known as flocculation(Sanchez-Martin, *et al*., 2012). Aluminium can be used for efficient coagulation but overdose of aluminium cause Alzheimer's diseases. Proteins are also known as flocculant-inducing agents (Santiago, *et al*., 2002).

Natural plant extracts have been used for water purification for many countries. In many rural communities of developing countries water clarification methods like flocculation, coagulation, and sedimentation, and natural coagulants have been used as effective coagulants. Coagulants are biodegradable, safe to human and cost-effective since they are locally cultivated, and various effective dosage range can be used for flocculation and coagulation (Unnisa, 2018). There are few problems that cost large seasonal variations in raw water and increase its turbidity. The naturally occurring coagulants are presumed safe for human health. The turbidity can cause block light to aquatic plants, smother aquatic organism, and carry

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contaminants and pathogen. The main objective of this study is to evaluate the coagulation potentials of waste or non-useful materials such as tamarind seeds powder for the treatment of turbid water. Study also focus on the determination of optimum dosage and contact time for using tamarind as natural coagulant in household water treatment.

Figure 1. Photograph of plant, fruits and seeds of *Tamarindus indica* L.

Scientific name of tamarind is *Tamarindus indica* L. and belongs to Caesalpiniaceae. Myanmar name is ma-gyii. The tamarind is a long-lived, medium-growth tree, massive tree reaches, under favorable conditions, a height of 80 or even 100 feet. The tamarind is indigenous to Africa and typical of wooded savanna ecosystems. In Asia (India, Myanmar, Thailand, Sri Lanka and Indonesia) and South America. Tamarind has played an important role in traditional medicine. In beverage form, it was commonly used to treat sore throats, diarrhea, constipation, fever and peptic ulcers. The bark and leaves were also used to promote wounding healing. The polyphenols in tamarind have antioxidant and anti-inflammatory properties. These can protect against diseases such as heart disease, cancer and diabetes. The seed extract may also help lower blood sugar, while the pulp extract may help you lose body weight and reverse fatty liver disease..

Materials and Methods

Collection of Sample for Natural Coagulant and Preparation

The scientific name of tarmarind was confirmed as *Tamarindus indica* L. according to the authorized botanist of Department of Botany, Pathein University. The fruit of *Tamarindus indica* L.was collected from nearby market Pathein Township. The seeds were removed form fruits and were dried under sunlight for ten days. The pulverized seed material to obtain as powder was made using grinding machine.

Chemical requirements

Sodium carbonate, sodium hydroxide, potassium sodium tartarate, copper sulphate, Folin-phenol reagent

Apparatus requirements

UV-Vis spectrophotometer (PD-303) pH, DO, CD/TDS Meter (Lovinbond 150, Germany), oven (LDO-030E,Korea, digital balance (Shimadzu), turbidity meter (MI 415 Milwaukee), pipette (10 mL), conical flasks (150 mL), beaker (250 mL), volumetric flasks (1000 mL and 100 mL), measuring cylinders (10 mL and 100 mL), a digital balance, magnetic stirrer (IKA C-MAG HS4), vortex mixer(Thermo Scientific)

Determination of protein contents in tarmarind seed

The protein contents in tarmarind seed was determined by Lowry' method with slight modification (Lowry,1951). Bovine serium albumin (BSA) was used as a standard protein.

Preparation of crude extract

Dried powder tamarind seed was weighed for 100 mg and added 5.0 mL distilled water. Then the sample was centrifuged for 10 minutes and taken the supernatant to use for protein estimation.

Reagents

Reagent A (2% sodium carbonate in 0.1 N sodium hydroxide),
Reagent B (1% potassium sodium tartarate),
Reagent C (0.5% copper sulphate),
Reagent D (Folin-phenol Reagent, 1.9 mL of Folin-phenol was added in 8.1mL of distilled water)

Lowary's method

In this experiment, the standard curve was constructed using various concentrations of BSA solution against with absorbance at 660 nm in UV-Vis spectrophotometer. A 50 mg of BSA was accurately weighted and dissolved in distilled water and the volume was made up to 50 mL volumetric flask to obtain 1000 ppm solution. 0.2, 0.4, 0.6, 0.8, and 1.0 mL of BSA solution were added to five test tubes, respectively, and made up to 1.0 mL using distilled water. In another test tube 1.0 mL of distilled water was added as a blank. 4.5 mL of mixture (48 mL of reagent A, 1 mL of reagent B, and 1 mL of reagent C) solution was added to all the test tubes including blank and incubated for 10 minutes. After incubation 0.5 mL of reagent D was added and incubated for 30 minutes. The absorbance was measured at 660 nm in spectrophotometer.

Volumes of 0.1 mL, 0.2 mL, and 1.0 mL of the water extract of tamarind seed (100 mg/mL) solution were used in the above procedure. Protein content was calculated using linear regression excel program with standard curve of BSA. All tests were done in triplicate. The absorbance values were presented with standard deviation (SD).

Water Sample Collection and Sites

Four water samples were collected from different locations in the middle of the lakes and streams. All water samples were collected from 15 cm (6 in) from surface water for SI (shan- ywar lake, Lat: 16.7286802 Long: 94.7712411), S II (pay-pin- kyee stream, Lat: 16.7264794 Long: 94.7740119), S III (ohmmar-dane lake, Lat: 16.769296, Long: 94.742905) and S IV (myoe- kyaung stream, Lat; 16.794981, Long: 94.799342) by low density polyethylene bottles and immediately labeled in the field. Sample bottles were sealed and stored in clean and dry environment at room temperature (Unnisa, 2018).

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

Figure 2. Location of sampling site for water samples (a) Shan Ywar lake, (b) Pay Pin Kyee stream (c) Ohmmar Dane lake and (d) Myoe Kyaung stream

Examination of pH, Turbidity and Total Dissolved Solids in Raw Water Samples

The collected raw water samples were examined pH by pH meter , turbidity by tubidity meter and total dissolved solid (TDS) by gravimetric method (EPA,1983).

Removing of Turbidities and Total Dissolved Solids by Tarmarind Seed

Preparation of Synthetic turbid water

Hydrazine sulphate (1g) and hexamine (10g) were separately made up to 100 mL with using distilled water by 100 mL volumetric flasks. Mixture of 50mL of hydrazine sulphate solution and 50 mL of hexamine solution were made up to 1000 mL with distilled water, stand and allowed the mixture for 24 hours for the development of turbidity. After 24 hours, the developed solution was of 400 NTU (APHA, 1999). The initial concentrations of 20 NTU, 40 NTU, 60 NTU, 80 NTU and 100 NTU were separately prepared from 400 NTU stock solution with distilled water. The initial pH in the synthetic turbid water was adjusted to 0.01M NaOH and 0.01M HCl (Unnisa, 2018).


(a)


(b)


(c)


(d)

Figure 3. Photographs of water samples collection sites; (a) shan-ywar lake, (b) pay-pin-kyee stream (c) ohmmar- dane lake and (d) myoe- kyaung stream

Preparation of coagulant solution

Each 0.2 g, 0.4 g, and 0.6 g powdered of seed were made into a paste using a small amount of water mixed into 50 mL of sample water and shaken in order to activate the coagulant properties of the seed to form a solution.

Removing of Turbidity and Total Dissolved Solid from Synthetic and Raw Water Samples

The removal of turbidity and TDS were was conducted by coagulation method according to the Unnisa, 2018 with slight modification The solutions each contained 0.2 g, 0.4 g and 0.6 g of water extract of seed were mixed with 1000 mL of synthetic and raw water samples into the beaker. The mixture solution was mixed with 100 rpm for 1 minute, followed by 10 minutes of 40 rpm mixing using magnetic stirrer and then let it stand for various settling time (30 min, 60 min, 90 min). All the suspensions were then left for sedimentation; the clarified samples were collected from the top of the beaker and filtered using filter paper to remove any remaining sediment. After filtration, the water samples were recorded pH, turbidity and total dissolved solid were recorded after treating the samples. The results were reported in Tables 4, 6 and 7. All tests were performed in triplicate and described with standard deviation.

The turbidity of each clarified sample was then measured using turbidity meter and followed by determining the pH and TDS of treated water sample. The turbidity removal efficiency of tamarind seeds powdered was calculated by construction of standard curve (plotted concentration against turbidity) of synthetic turbid water using linear regression excel program see in Figure 5 and Table 3.

The percentage of turbidity removal efficiency (%TRE) was calculated using by following equation [12];

$$TRE\ \% = (T_0\text{-}T/T_o\ )100\%$$

Where as ,T_0 = Initial turbidity (NTU) of raw water and T = Final turbidity (NTU) of treated water.

Percentage of TDS removal efficiency of tamarind seed after treated on raw water samples was calculated by the gravimetric method (EPA, 1983).

Results and Discussion

Estimation of Protein Contents of Natural Coagulants

Protein content of tamarind seeds was estimated by standard curve of Bovine serum albumin see in Table 1 and Figure 4. Protein content of tamarind seeds was found to be 11.692 mg/g of water extract while reported value was in the range of 13.3–26.9% (Morad et al. 1978). The advantages of natural organic polymers coagulants, polyelectrolytes are more than 50% reduction in sludge volume, no effects on water pH, no increase in total dissolved solids of finished water, no dissolution of any substances in the treated water.

Table 1. Absorbance Values of Standard BSA and Tamarind Seed and Protein Contents of Tamarind Seed at 660 nm

Volume of BSA (mL)	Abs. at 660nm	Volume of coagulant (mL)	Abs. At 660 nm	Concentration	
				mg/L	mg/g
0.2	0.097±0.00				
0.4	0.132±0.00	0.1	1.124	7514.2	7.514
0.6	0.157±0.01	0.2	1.539	10478.5	10.478
0.8	0.182±0.01	1.0	1.709	11692.8	11.692
1.0	0.212±0.00				

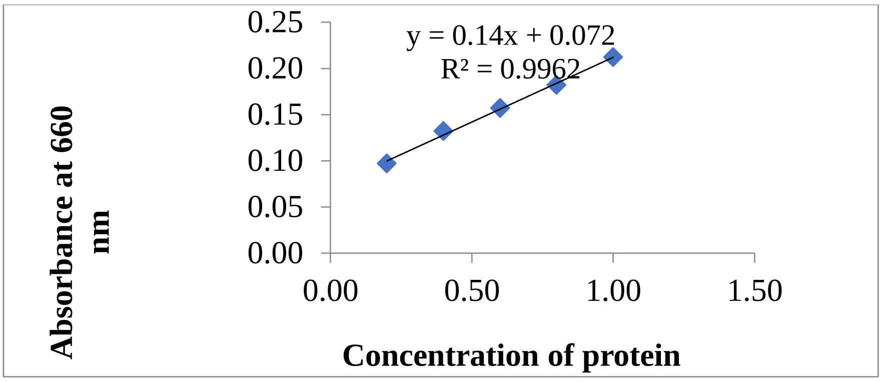

Figure 4. Standard curve for Bovine Serum Albumin

Water Quality of Raw Water Samples

The pH of raw water samples studied ranged between pH 5 and pH 10. In the study of the pH range of raw water samples; Shan Yar Lake (S I), Shan Yar Stream S II), Ohmmar Dane Lake (S III) and Myoe Kyaung (S IV): 6.97-7.5 for the winter season, 7.18-7.41 for summer season, and 7.09- 7.25 for rainy season were determined. The pH range of raw water samples was in agreement with the WHO standard (6.5-8.5) in all seasons see Table 6. The resulting data showed that pH values were significantly different among the three seasons.

The values of turbidity were observed to vary from 3.65 ± 0.01 NTU to 47.96 ± 0.07 NTU in winter season, 2.43 ± 0.05 NTU to 22.65 ± 0.06 NTU in summer season and 23.23 ± 0.03 NTU to 31.19 ± 0.63 NTU in rainy season during study period. According to the data, the values of raw water S I (2.43 NTU) in summer and S III (3.65 NTU) in winter were lower than WHO standard (5.0 NTU), and other raw water samples were greater than WHO standard.

TDS values of raw water samples (SI- SIV) were varied between 6.90 ± 0.17 to 7.50 ± 009 in winter season, 7.18 ±0.02 to 7.41 ±0.04 in summer, and 7.09 ± 0.07 to 7.25 ±0.04 in rainy season see in Table 9. In these results, SI and SIII in rainy season were lower than WHO standard, Samples SI, SII, SIII and SIV in the summer and winter seasons were greater than WHO standard (500 ppm).

The previously reported data of electrical conductivity, total hardness and total alkalinity of these selected raw water samples (SI-S IV) for different three seasons were described in Yin Yin Myint & Hnin Htet Htet Aung, 2020. The electrical conductivity values varied between 91 to 1201 µS/cm, total hardness values varied between 26.54 and 145.60 ppm, and total alkalinity values varied between 11.04 to 63.90 ppm. The ranges of conductivity of four selected raw water samples in three seasons were within the range of WHO standard (10-1000 µS/cm), exception of sample I (1201 µS/cm) in summer that it may believable slightly saline. Both values of total hardness and total alkalinity of all selected water samples were within the permissible level of WHO standard (500 ppm)

Determination of Turbidity Removal Efficiency (% TRE) and Total Dissolve Solids Removal Efficiency (% TDS) of Tamarind Seed

The turbidity removal efficiency of tamarind seeds powdered (0.2 g, 0.4 g, and 0.6 g doses) were comparatively determined on different concentration of 20 NTU, 40 NTU and 60 NTU of synthetic turbid water and raw water samples (SI, SII, SII and SIV) with three different settling time: 30 minutes, 60 minutes and 90 minutes respectively see in Figure 5 and Table 3. The percentage of turbidity removal efficiency (%TRE) of tamarind seeds powdered was calculated on three different dosages and time comparatively. The %TRE of tamarind seeds on all treated water was comparatively presented with synthetic turbid water in Table 5 and Figure 6. The turbidity removal efficiency of tamarind seeds was a little bit reduced when a long time was taken to remove the turbidity of water samples. The results from this study, 6.0 g with a settling time of 60 minutes is the optimum dose and time taken between turbidity varied from 77.97% to 81.71% see Table 5. These results revealed that the turbidity removal efficacy of the coagulant depended on the doses and settling time. Besides, that dosage and settling time may be considered the optimum dosage and time to use the tamarind seed as a coagulant for treating turbid water.

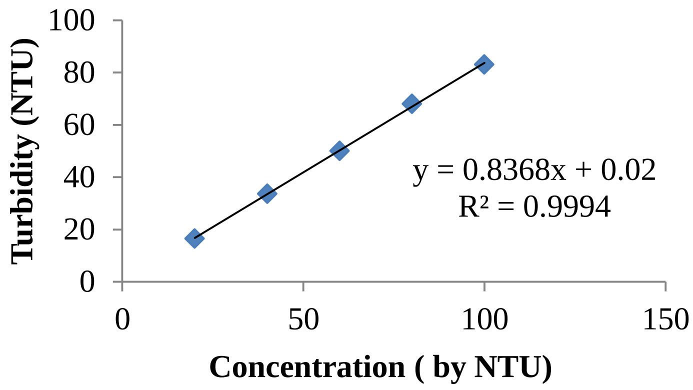

Figure 5. Standard curve of turbidity *vs.* conc.of synthetic turbid water

Table 3. Turbidity Removal Efficiency of Three Dosages of Tamarind Seed with Three Different Reaction Times on Synthetic Turbid Water

Conc (NTU)	Dose (g)	Turbidity(NTU)				%TRE		
		Initial	Final					
			30 mins	60 mins	90 mins	30 mins	60 mins	90 mins
20	0.2 0.4 0.6	16.50 ± 0.08	6.30 ±0.24 5.57 ± 0.04 4.93 ± 0.05	4.74 ±0.06 4.41 ±0.04 2.60 ±0.13	6.40 ± 0.04 4.16 ± 0.06 4.05 ± 0.06	53.82 59.61 64.24	65.62 68.00 81.10	55.48 69.81 70.61
40	0.2 0.4 0.6	33.64 ± 0.11	11.37± 0.02 10.47± 0.04 8.11 ± 0.07	5.86 ±0.03 6.42 ±0.07 4.86 ±0.04	11.08± 0.08 9.35 ± 0.07 7.54 ± 0.07	59.60 62.79 71.17	79.16 77.17 82.71	60.63 66.76 73.20
60	0.2 0.4 0.6	50.00 ± 0.22	18.71± 0.05 16.82± 0.03 11.67± 0.07	9.04 ±0.04 8.57 ±0.06 6.75 ±0.03	13.61± 0.04 12.08± 0.04 10.45± 0.03	55.29 59.80 72.10	78.38 79.51 83.85	67.46 71.12 75.01
80		68.00 ± 2.30						
100		83.00± 0.00						

Moreover, pH values varied from 6.90 to 7.50 of raw water sample change to 6.39-7.14 were observed after treated with coagulant at settling time 60 minutes. These values were not significantly change after being treated with tamarind seeds powdered for all doses see Table. These values are in line with the WHO permissible value and it seems to be hygienic water for household application.

Table 4. Comparing the Turbidity Values of Raw Water Samples before and after treatment with Tamarind Seed

season	Sample	Initial turbidity (NTU)	Final turbidity (NTU)								
			0.2 g			0.4 g			0.6 g		
			30 mins	60 mins	90 mins	30 mins	60 mins	90 mins	30 mins	60 mins	90 mins
Winter	SI	10.03 ± 0.02	6.82 ± 0.04	4.17 ± 0.22	6.74 ± 0.03	5.78 ± 0.06	2.86 ± 0.13	5.44 ± 0.10	5.26 ± 0.05	2.21 ± 0.35	4.81 ± 0.09
	SII	18.96 ± 0.09	13.23 ± 0.02	7.83 ± 0.11	10.72 ± 0.04	10.12 ± 0.07	5.42 ± 0.29	7.54 ± 0.04	8.70 ± 0.0	3.51 ± 0.28	6.68 ± 0.03
	SIII	3.65 ± 0.01	3.04 ± 0.11	1.52 ± 0.28	2.06 ± 0.03	2.85 ± 0.09	1.04 ± 0.23	1.53 ± 0.04	2.79 ± 0.22	0.67 ± 0.14	1.21 ± 0.03
	SIV	47.96 ± 0.07	26.26 ± 0.25	19.98 ± 0.51	22.86 ± 0.02	15.04 ± 0.04	13.72 ± 0.51	14.14 ± 0.03	14.31 ± 0.04	8.89 ± 0.59	21.17 ± 0.32
Summer	SI	2.43 ± 0.05	1.65 ± 0.04	1.02 ± 0.04	1.62 ± 0.02	1.36 ± 0.04	0.85 ± 0.04	1.26 ± 0.03	1.21 ± 0.02	0.58 ± 0.13	1.07 ± 0.03
	SII	16.18 ± 0.04	10.85 ± 0.06	7.11 ± 0.08	8.58 ± 0.08	8.57 ± 0.08	4.36 ± 0.21	5.97 ± 0.05	7.92 ± 0.03	3.68 ± 0.05	5.16 ± 0.02
	SIII	14.85 ± 0.05	9.38 ± 0.06	6.02 ± 0.04	8.54 ± 0.02	8.11 ± 0.06	3.91 ± 0.16	7.16 ± 0.02	7.49 ± 0.06	2.86 ± 0.06	5.02 ± 0.04
	SIV	22.65 ± 0.06	12.97 ± 0.06	9.26 ± 0.26	12.05 ± 0.03	11.78 ± 0.03	7.97 ± 0.16	10.47 ± 0.06	9.94 ± 0.02	5.65 ± 0.23	9.68 ± 0.03
Rainy	SI	23.23 ± 0.03	15.31 ± 0.04	9.35 ± 0.10	12.76 ± 0.04	11.54 ± 0.05	5.68 ± 0.05	9.17 ± 0.05	10.76 ± 0.04	4.25 ± 0.06	5.49 ± 0.09
	SII	28.00 ± 0.13	15.68 ± 0.04	11.9 ± 0.03	13.76 ± 0.08	9.03 ± 0.02	8.23 ± 0.13	8.82 ± 0.05	8.49 ± 0.04	5.42 ± 0.04	10.86 ± 0.07
	SIII	23.68 ± 0.11	12.83 ± 0.03	9.86 ± 0.07	11.27 ± 0.07	7.42 ± 0.05	6.74 ± 0.03	8.17 ± 0.04	6.84 ± 0.03	4.59 ± 0.06	7.76 ± 0.03
	SIV	31.19 ± 0.63	13.37 ± 0.05	12.11 ± 0.03	13.98 ± 0.06	11.64 ± 0.03	8.38 ± 0.26	11.20 ± 0.05	6.42 ± 0.06	5.81 ± 0.03	625 ± 0.07

WHO standard for turbidity ≥ 5 NTU

Table 5. Comparing Turbidity Removal Efficiency of Tamarind Seed on Raw Water Samples

Sample	Season	% TRE								
		0.2 g			0.4g			0.6g		
		30 mins	60 mins	90 mins	30 mins	60 mins	90 mins	30 mins	60 mins	90 mins
S I	winter	30.01	58.42	32.80	42.37	71.48	45.76	47.56	77.97	52.04
	summer	32.10	58.03	33.33	44.03	65.02	48.50	50.21	76.13	55.97
	rainy	34.09	59.75	45.07	50.32	75.54	60.53	53.68	81.71	66.37
S II	winter	30.22	58.70	43.46	46.62	71.41	60.23	54.11	81.48	64.77
	summer	32.94	56.06	46.97	47.03	73.05	63.10	51.05	77.26	68.11
	rainy	44.00	57.54	50.86	67.75	70.61	68.50	69.68	80.64	61.21
S III	winter	16.71	58.35	43.56	21.92	71.50	58.08	23.56	81.64	66.84
	summer	36.84	59.60	42.49	45.39	73.67	51.79	49.00	80.74	66.20
	rainy	45.82	58.36	52.41	68.67	71.54	65.49	71.12	80.62	67.23
S IV	winter	45.24	58.34	52.33	68.64	71.39	70.51	70.16	81.46	55.85
	summer	42.74	59.12	46.80	48.01	64.81	53.78	56.12	75.06	57.26
	rainy	57.13	61.17	55.18	62.68	73.12	64.09	79.42	81.37	69.96

Table 6. pH Analysis of Four Water Samples Before and After Treatment with Tamarind Seed in Three Different Seasons

Sample	Season	pH (±SD)			
		Before	After		
			0.2g	0.4 g	0.6g
SI	Winter	6.90 ± 0.17	6.39±0.12	6.43 ± 0.18	6.37 ± 0.08
	Summer	7.24 ± 0.02	6.64 ± 0.07	6.76 ± 0.11	6.60 ± 0.02
	Rainy	7.10 ± 0.13	6.56 ± 0.07	6.72 ± 0.02	6.65 ± 0.05
S II	Winter	7.50 ± 0.09	6.90 ± 0.24	7.03 ± 0.08	6.97 ± 0.08
	Summer	7.41 ± 0.04	6.82 ± 0.05	7.02 ± 0.09	6.86 ±0.02
	Rainy	7.25 ± 0.04	6.63 ± 0.02	6.86 ± 0.07	6.75 ± 0.03
S III	Winter	7.20 ± 0.17	6.60 ± 0.30	6.70 ± 0.26	6.60 ± 0.67
	Summer	7.18 ± 0.02	6.61 ± 0.04	6.73 ± 0.15	6.54 ± 0.03
	Rainy	7.23 ± 0.03	6.60 ± 0.06	6.87 ± 0.10	6.63 ± 0.05
S IV	Winter	7.50 ± 0.09	6.99 ± 0.11	7.14 ± 0.04	6.97 ± 0.56
	Summer	7.39 ± 0.03	6.74 ± 0.02	6.94 ± 0.02	6.74 ± 0.07
	Rainy	7.09 ± 0.07	6.58 ± 0.03	6.61 ± 0.04	6.46 ± 0.03

*WHO standard for pH 6.5-8.5

After treatment with a coagulant, TDS values were significantly decreased and lower than the WHO standard (500 ppm). TDS removal efficiency of three dosages of coagulant for three different seasons was comparatively presented in Table 7. According to the TDS removal efficiency (%TDS) of tamarind seeds, they were potentially removed by increasing the dosage of the coagulant at optimum settling time.In the comparison of the observed results, tamarind seed revealed that 0.6 g dose at 60 minutes settling time significantly reduced the total dissolved solids of raw water samplesThe data obtained were summarized in Table 7.

Table 7. TDS Removal Efficiency and TDS Analysis of Raw Water Samples Treated with Tamarind Seeds

Sample	Season	TDS (ppm) (±SD)				% TDS		
		Before	After					
			0.2 g	0.4 g	0.6 g	0.2 g	0.4 g	0.6 g
S I	winter	720.00 ± 7.48	225.00 ±7.48	156.00 ±11.05	79.00 ± 6.13	68.75	78.33	89.03
	summer	356.00 ± 3.39	109.00 ±3.30	81.00 ± 2.16	35.00 ± 5.35	69.38	77.25	90.17
	rainy	136.00 ± 3.27	43.00 ±6.88	31.00 ± 4.50	15.00 ± 3.74	68.38	77.21	88.97
S II	winter	980.00 ±10.34	30.00 ± 12.36	208.00 ± 3.90	117.00 ±8.18	68.89	78.78	88.06
	summer	897.00 ± 6.16	242.00 ± 5.72	188.00 ± 6.94	107.00 ±5.73	73.02	79.04	88.07
	rainy	780.00 ± 5.44	241.00 ± 5.91	163.00 ± 6.94	86.00 ± 6.13	69.10	79.10	88.97
S III	winter	420.00 ± 14.20	135.00 ± 4.92	86.00 ± 7.41	46.00 ± 3.90	67.86	79.52	89.05
	summer	487.00 ± 7.93	155.00 ± 7.85	107.00 ± 5.72	63.00 ± 9.90	68.17	78.03	87.06
	rainy	141.00 ± 13.89	42.00 ± 5.66	32.00 ± 6.94	15.00 ± 2.62	70.21	77.31	89.36
S IV	winter	1460.00 ±39.94	155.00 ± 7.85	107.00 ± 5.72	63.00 ± 9.90	68.90	77.53	89.04
	summer	998.00 ± 4.49	309.00 ± 6.34	229.00 ± 5.66	169.00 ±6.18	69.04	77.05	83.07
	rainy	640.00 ± 13.02	185.00 ± 4.24	134.00 ± 8.49	76.00 ± 4.11	71.09	77.06	88.13

*WHO standard for TDS 500 ppm

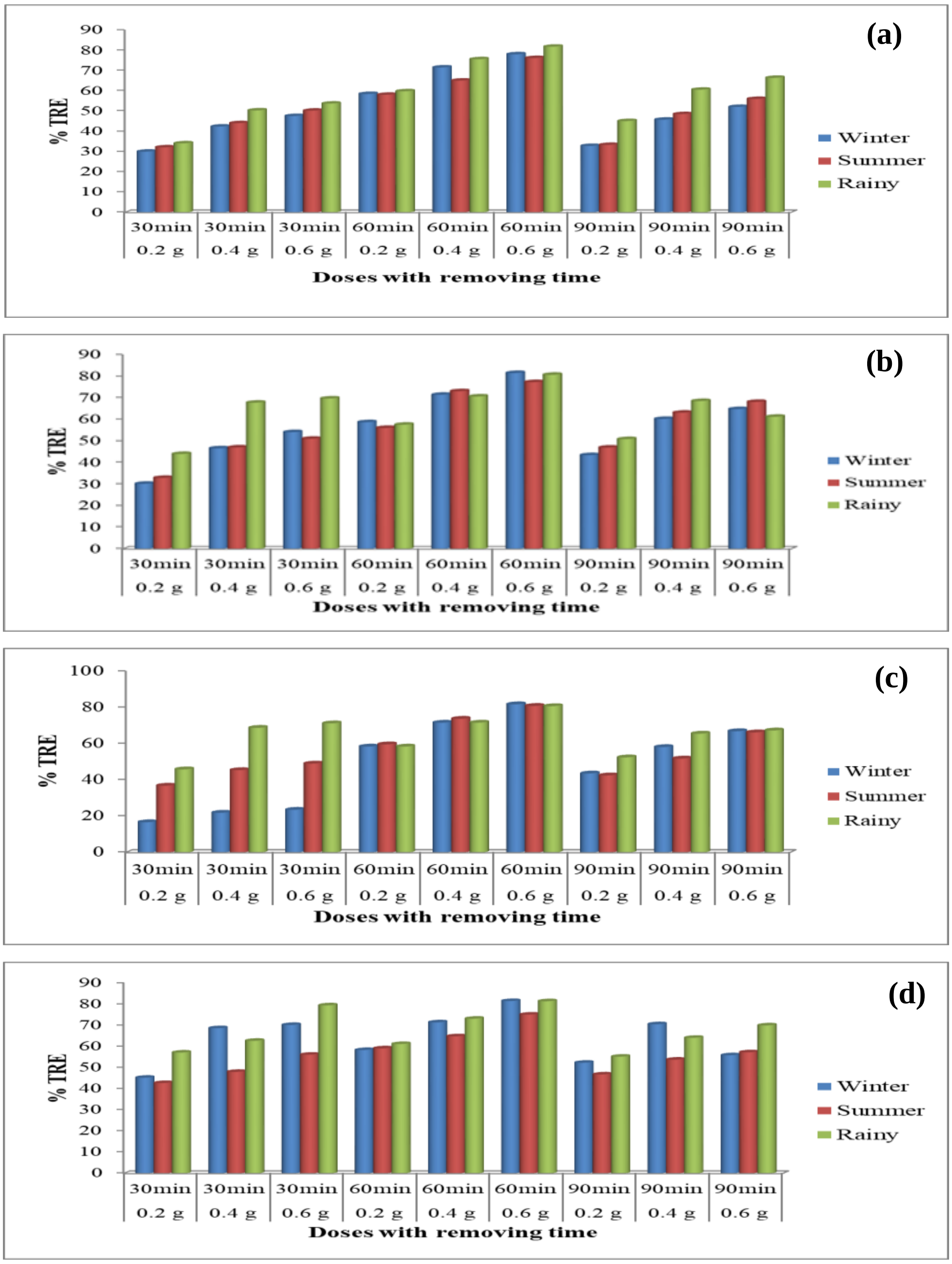

Figure 6. Comparatively % TRE of 0.2 g, 0.4 g and 0.6g dose of tamarind seed with three different settling times; (a) S I, (b) S II, (c) S III and (d) S IV

Conclusion

Tamarind seed has been found to be a coagulant aid to remove turbidity and total dissolved solids in four water samples and is used in conventional water treatment. It has no significant change in pH values 6.37- 6.97 in that studied. These values are in line with the WHO permissible value. The optimum turbidity removal efficiency (% TRE) and TDS removal efficiency (% TDS) were observed at 77.97%- 81.71% and 83.07% -90.17% of 0.6 g dose at a settling time 60 minutes. Hence, tamarind seed would provide to reduce the incidence of diseases that is caused by chemical coagulants such as aluminium and it is an eco-friendly method of water treatment.

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