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Treatment of Synthetic Turbid Water using Natural Tamarind Seeds at Atmospheric Conditions.

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ABSTRACT

Abundant waste water generated due to an industrialization. Thus, the treatment of industrial effluent becomes essential for recycle, reuse to achieve sustainable development. The waste water contains suspended fine solid particles which requires larger residence time for it's settling. To remediate, coagulation method is generally preferred to facilitate fine particles agglomeration to attain rapid settling. During coagulation a chemical coagulant (alum) is generally used, which makes treated water unsuitable for drinking. In this study, Tamarind seeds extracts were used as a natural coagulant to treat the turbid water. Initially, the active components present in the tamarind seeds were extracted using water and NaCl. A synthetic turbid water with different concentration were prepared using kaolin ($Al_2Si_2O_5(OH)_4$) and considered as effluent for the present study. The results revealed that the tested natural coagulant works better in low turbid water than high due to limitation in the coagulation mechanisms like hindered settling and Brownian movement. The maximum turbidity removal is 70% at pH 7 suggesting low and high pH condition are inadequate. The 0.5M NaCl extracts more active component from the tamarind seeds that facilitates the maximum turbidity reduction. Further increasing concentrations leads to the salting out effect renders poor proteins extraction.

Key words: Coagulation; Tamarind seed; Turbidity; Brownian movement

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1 INTRODUCTION

Water, air and food are very important for a life to survive. Our planet is covered by water- over 70% which includes 2.5% as fresh water out of which 1% is accessible for our use [1]. Due to Industrialization and change in lifestyle the quality of fresh water available is decreasing each day. According to WHO and UNICEF Joint Monitoring Programme (JMP), 663 million people (1 out of 10 lakhs) access to fresh water. Proper treatment techniques are required to provide safe drinking water. Major problem in surface water is turbidity (cloudy appearance). The allowable turbidity is 0.5 NTU maximum, while the recommended level is about 0.1 NTU [2].

Coagulation is the growing of fine particles that occurs as a result of it's collisions. Chemical reactions are often incomplete. They have numerous side reactions with other substances in the wastewater [3]. Coagulation varies with various factors like pH [4], temperature and dosage [5]. The four basic mechanisms involved in this process are double layer compression, charge neutralization, sweep flocculation and adsorption. This method is not feasible in many developing countries due to high fixed capital and unavailability of chemical coagulants. There are a lot of problems arising due to the use of synthetic or chemical coagulants. Alum treated water contain residual aluminum that leads to serious health issues such as the development of Alzheimer's disease (AD) and senile dementia [6]. In addition, using of inorganic coagulants complicates the handling and disposal operations. Due to these downsides of chemical coagulants, natural coagulants are taking uplift from environment’s point of view. Further more, natural coagulants produces biodegradable and minimum volume sludge 20-30% that of chemical coagulant.

Twenty one type of natural coagulant was already tried. Certain coagulants were also able to remove common bacteria present in surface water. They were even able to removed heavy metals [7]. Though there are a lot of advantages, there are also certain limitations like releasing of organic matter and nutrients when it is applied in large scale. But it is proved to be best suitable in rural areas [8]. Coagulants like Surjana, Maize and Chitosan were used to remove congo red dye. Surjana seed powder showed high efficiency than the rest [9]. The protein extracted from *Cocos nucifera* and *moringa olefera* were similar in characteristics. The extracts more effective for silica particles [10]. *Moringa olefera* seed extract using NaCl shows more coagulation than the seed extract using distilled water [11]. Different extraction methods were tried with NaCl, NaOH and compared with conventional extraction. Sodium chloride with 0.5M was found to be more effective with *Moringa olefera*, *Strychnos potatorum*, *Phaseolus vulgaris* seeds [12]. Different levels of turbid water (100 NTU to 500 NTU) was also implied [13]. *Moringa oleifera* seeds after oil extraction was done for POME treatment. Sludge recovery was about 87% at optimum pH of 5 [14]. *Moringa oleifera* seed could remove turbidities similar to that of polyaluminum chloride at a constant dosage [15]. Moringa was also used to treat secondary oxidation pond effluents whose turbidity was ranging from 30-100 NTU [16]. Apart from these *Cannabis indica*, Okara gum and Nirmali seeds were used at different levels of turbidity and the effect of pH was also studied. Flocculation was rapid at pH 6.5 to 8 [17]. In general, adsorption followed by neutralization or polymeric bridging effect occurs while using natural coagulants[18]. Oil extracted seeds shows more efficiency. Oil extraction is done by soxhlet apparatus [19]. High efficiency was witness for coagulant of oil extracted peanut seeds with NaCl as solvent [20].

The synthetic coagulant with higher coagulation efficiency is combined with natural coagulant for treating higher turbidity effluents [21]. *Strychnos potatorum* was combined with chemical coagulant alum. The blended coagulant SP: ($Al_2(SO_4)_3$) of 40:60 ratio gives better turbidity removal [22]. Researchers used *Moringa olefera* in combination with alum. It was seen that the COD removal was increased [23]. Sludge when dewatered readily produce sludge with higher solids content that improves handling characteristics [24]. There is an optimum level of pH to improve the turbidity removal [25]. Tamarind seed is able to remove heavy metals Zinc and Chromium [26]. Hence, present study encompasses use of tamarind seed as a natural coagulant to treat synthetic turbid water.

2. MATERIALS AND METHODS

2.1 Plant materials

The *Tamarindus indica* seeds were collected from the south of Tamil Nadu and it was dried at 50 °C for about 8 hours and grounded using Ball Mill.

2.2 Chemicals and Reagents Used

The chemicals used for current experimental studies are Kaolin powder Extra pure (LOBAL Chemie laboratory, India), 99.0% of Sodium Chloride (Himedia, India), 35-37% of Hydrochloric acid (Fisher Scientific, India), 97.0% of Sodium Hydroxide (Fisher Scientific, India) and Whatman filter paper No.1 (Himedia, India).

2.3 Preparation of Synthetic Turbid Water(STW)

STW was prepared by dispersing kaolin in distilled water. 1 g, 5 g and 10 g of kaolin was dispersed in 1 liter of distilled water to prepare low, medium and high levels of STW. The suspensions were stirred at 20 rpm for 1 hour to achieve uniform suspension of the kaolin particles followed by stand for 24 hours for complete hydration of kaolin. The physico-chemical characteristics of STW are tabulated in Table 1.

Table 1 Physico-chemical characteristics of STW

Parameter	Low Turbid Water	Medium Turbid Water	High Turbid Water
Turbidity (NTU)	199	698	1004
pH	7.75	7.81	7.98
Conductivity (µs)	63.90	57.023	56.56
TDS (ppm)	33.21	33.28	33.18
COD (ppm)	60	76	96
Temperature (^oC)	27	27	27

2.4 Collection and Preparation of Tamarind Seed Powder

Tamarind fruit is collected from the south of Tamil Nadu (since dry weather is required during the period of fruit development) and the seed is taken out manually and cleaned to take out the pulp that is still clinging on to the seed as represented in Figure 1. The Tamarind seeds were dried in atmosphere temperature and then the seeds were dried in an oven for about 8 hrs at 50 °C [27]. The dried seeds were subjected to pulverizer to bring down its size and then grounded using a ball mill for an hour. The grounded seeds were sieved through 0.4mm sieve and stored. The photographic view of grounded Tamarind seed powder is shown in Figure 2.

Figure 1 Tamarind seed

Figure 2 Tamarind seed powder

2.5 Preparation of Active Component

200 mg of the grounded tamarind seed is weighed and mixed with 0.5 M NaCl solution or distilled water. This mixture is stirred for about 1 hour at 750 rpm for maximum blending and filtered using Whatman filter paper no.1. This extract (filtrate) is used for coagulation studies. The photographic view of active-component preparation is shown in Figure 3.

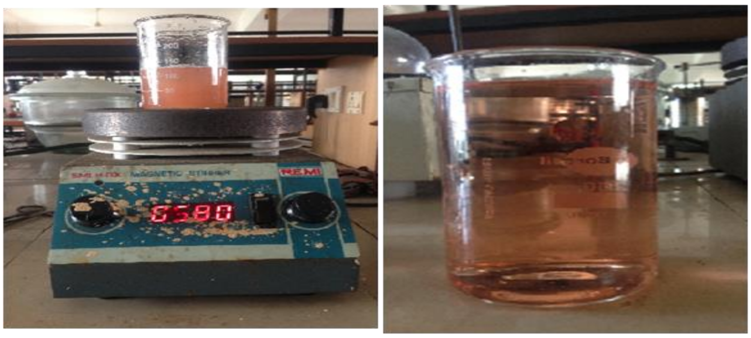

Figure 3 Active component preparation

2.6 Jar Test Apparatus (JTA)

JTA is used to do jar test. Six 1 liter beakers are filled with turbid water. Paddles are set and stipulated doses of coagulants are added to each beaker simultaneously. Initial stirring was done at 80 rpm for about 5 minutes to disperse the added coagulant distributes uniformly. Further, to get proper mixing the stirring is set at a slower speed of about 40 rpm for flocculation. The slower stirring is maintained for 25 minutes. After stirring, the settling period of about 1 hour is allowed. The turbidity is recorded at the end of the settling period [28].

3 RESULTS AND DISCUSSIONS

3.1 Effect of dosage on different levels STW

The influence of active-component dosage on different turbid water is shown in Figure 4. A fixed dosage of active-component was used on different levels of turbid water (low, medium and high) 199 NTU for low, 698 NTU for medium and 1004 NTU for high turbid water. It was observed that turbidity reduction was higher in low turbid water than medium and high. The percentage reduction for low turbid water was 65%, whereas for medium and high it was only 42% and 41%, respectively. This may be due to the hinder settling happening in high turbid water which does not have enough time to settle down and high Brownian movement in turbid water having high turbidity.

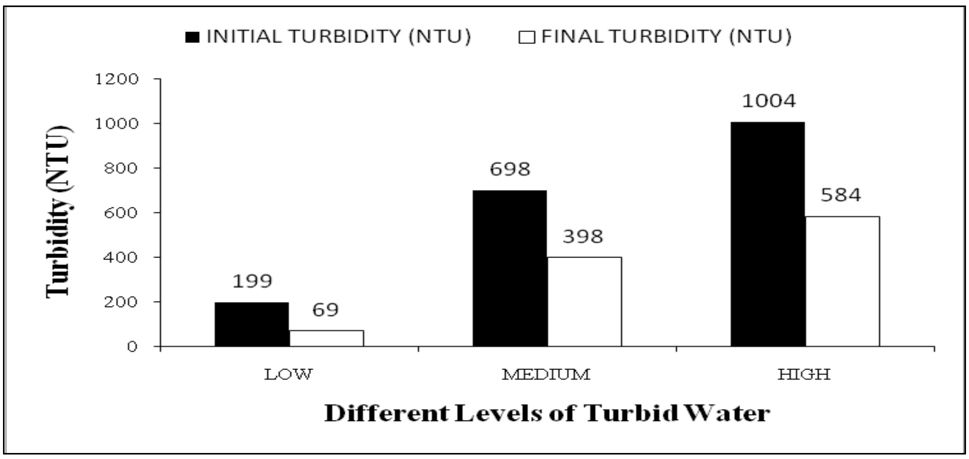

Figure 4 Effect of dosage on different levels STW

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3.2 Effect of Different solvents on STW

It can be easily observed from Figure 5, sodium chloride and distilled water were the two solvents that were used to extract protein which was the active component. NaCl was found to be more effective than distilled water. The final turbidity of NaCl extracted active-component was 96 NTU and the percentage reduction was 69%. Whereas for distilled water extracted active component, the final turbidity was only 147 NTU and the percentage reduction was 29%. This is because dissolution of protein in NaCl is higher than distilled water.

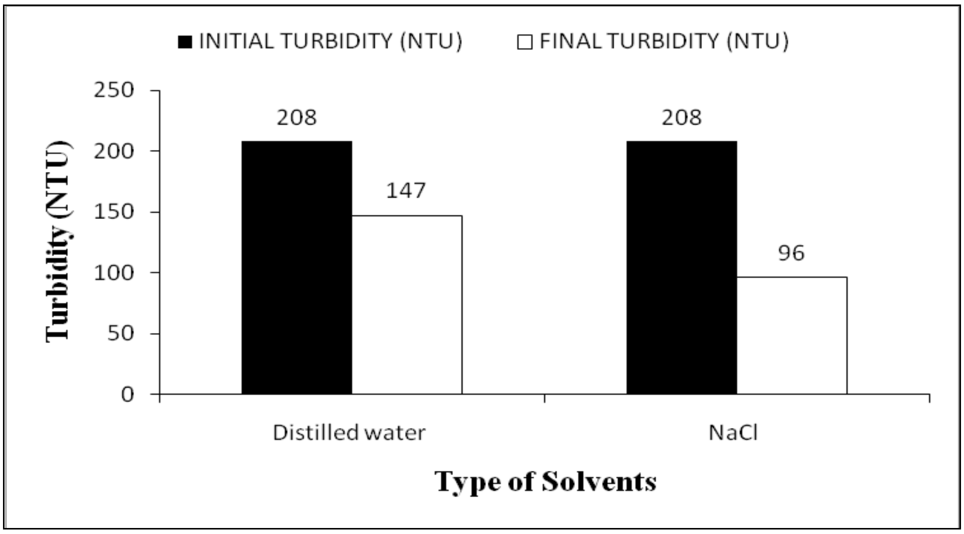

Figure 5 Effect of different solvents on STW

3.3 Effect of NaCl solvent concentration extract on STW

The effect of NaCl solvent concentration extract on turbidity is shown in Figure 6. The different solvent concentration 0.1M, 0.3M, 0.5M, 0.7M and 0.9 M were prepared by dissolving 0.58 g, 1.74 g, 2.92 g, 4.06 g, 5.22 g of NaCl in 100 ml distilled water. It was observed that 0.5 M NaCl shows turbidity reduction of 65% with end turbidity of 78.75 NTU. The results revealed that solubility of active components is good when the concentration increases however, after a particular concentration i.e., 0.5 M, salting out effect takes place. Hence, solubility of proteins decreases with increase in salt concentration.

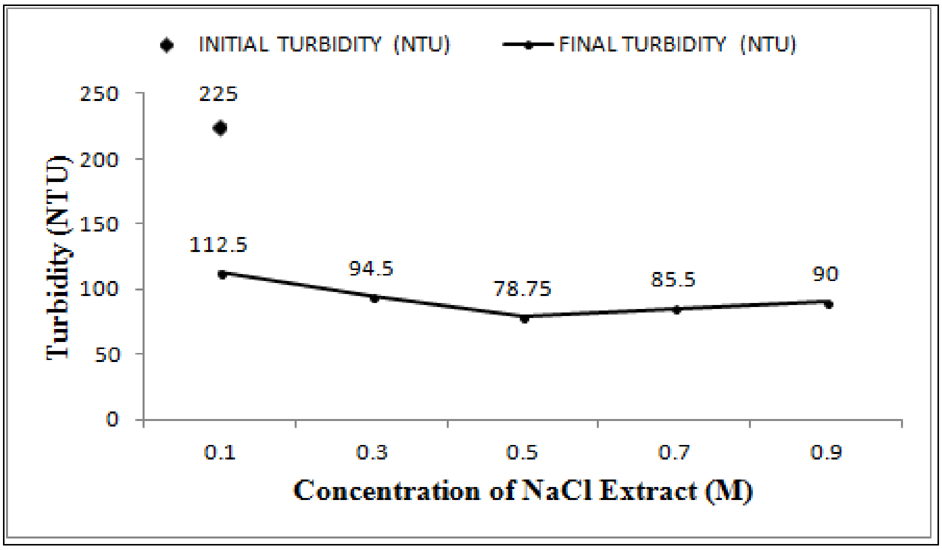

Figure 6 Effect of NaCl solvent concentration extract on STW

3.4 Effect of NaCl extract dosage on STW

Figure 7 depicts the effect of extract dosage on turbidity. Different dosages i.e., 50, 100, 150, 200, 250, 300, 350, 400,450 and 500 mg/l of extract were added to each jar simultaneously. It was noted that, when dosage was increasing from 50-500 mg/l, reduction was good in 400 mg/l particularly. The final turbidity was 63 NTU and percentage reduction as 70% but it reduces later. This is because, in later stages coagulant itself may add to the turbidity leads to increase in turbidity.

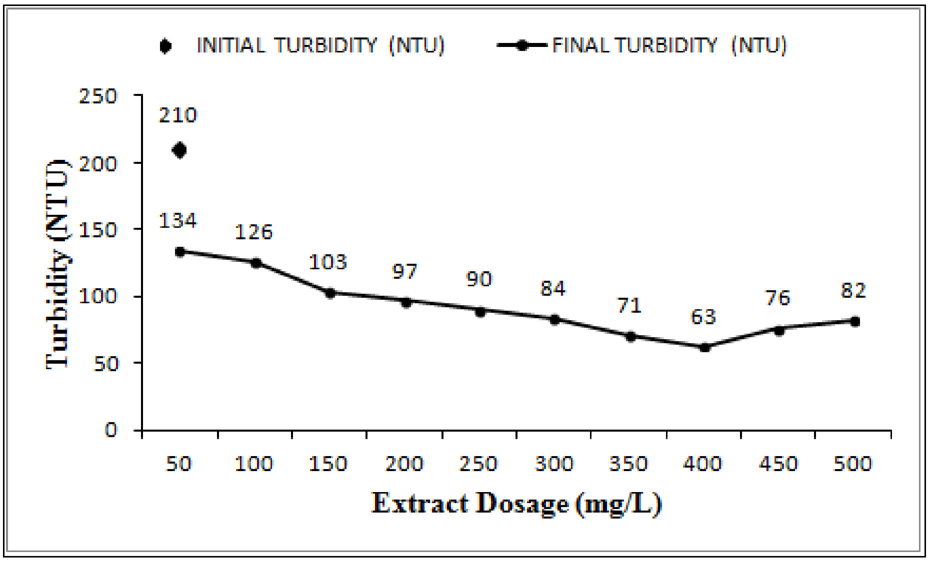

Figure 7 Effect of NaCl extract dosage on STW

3.5 Effect of pH on STW

The pH effect on turbidity is portrayed in Figure 8. pH was varied for each turbid water using 0.1M HCl and 0.1M NaOH solutions. Six pH values, namely 3, 5, 7, 9, 11 and 13 were adopted for this study. It is observed that when the pH was maintained at 7, final turbidity was observed as 54 NTU with reduction of 70%. Its efficiency was high compared to the removal observed when the pH was 3, 5, 9, 11 or 13. At low pH, coagulant undergoes degradation and become soluble in aqueous solution. At higher pH, the net surface charge on the coagulant becomes less positive. In general, charge imbalance leads to increase in turbidity. So the perfect pH for coagulation to occur is pH 7. Initial turbidity is 180 NTU.

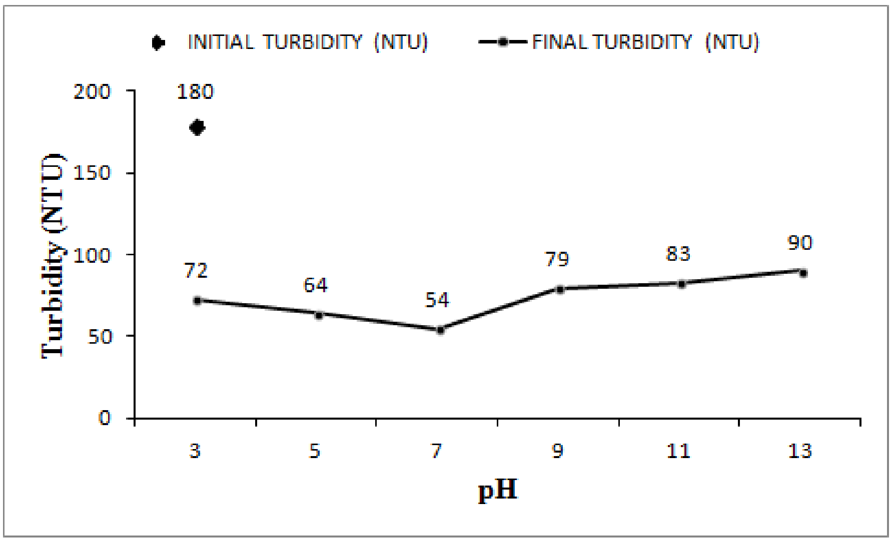

Figure 8 Effect of pH on STW

4. CONCLUSIONS AND RECOMMENDATIONS

In this study, the natural coagulant was used for the treatment of turbid water. The primary reason being it's economical, simple and requires less capital. In this investigation two different solvents such as water and NaCl with different concentration were used as extracting agent. The effect of coagulant dosage and pH were also studied. The results revealed that the tested natural coagulant works better in low turbid water than high due to limitation in coagulation mechanisms like hindered settling and Brownian movement makes natural coagulant unsuitable for high turbid. Low concentration of NaCl (0.5 M NaCl) seems to be suitable for extracting active-component from the natural coagulant thereby maximum removal of turbidity was observed, whereas high concentration of NaCl leads to the salting out effect. The maximum reduction of turbidity was observed at pH 7. Low and high pH condition is not suitable for coagulation, the reason being there is an imbalance of charged ions in the sample making it unsuitable. Thus the natural tamarind seed can also be used as a coagulant to treat the turbid water.

5. ACKNOWLEDGEMENTS

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