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SLUDGE MASS DETERMINED AS A PARAMETER FOR SELECTION OF COAGULANT-A NEW APPROACH

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ABSTRACT

Availability of safe drinking water in developing countries is a gigantic problem consequently, the public is affected due to water-borne diseases. The coagulation-flocculation method can be adopted as this is a low-cost treatment method, and also it is inexpensive. This study's objective is to screen the various natural coagulants depending upon the turbidity reduction in the sample. Two turbid ranges were selected for the study, i.e., 70NTU and 150 NTU, as these are the lowest and highest turbid range observed in the surface water. Comparison studies were conducted to synthesize a Novel coagulant for the highest turbidity removal and low sludge weight. One-way ANOVA performed statistical analysis to determine the significant levels ($p<0.005$) of our experiment. Experimental results obtained by the theoretical and practical were almost the same. Sago and chitin are efficient in removing turbidity and also produced less sludge weight.

KEY WORDS : Natural coagulants, Coagulation, Adsorption, Surface water treatment.

INTRODUCTION

Water is an indispensable component of human life and other life forms (Sandberg *et al.,* 2019). The continuing use of water makes it impure, so water purification is essential (Che *et al*., 2019). Raw water coming from different sources may contaminate due to pollution in the environment. A primary reason for pollution is industrialization and rapid urbanization (Lu *et al*., 2019). Water treatment takes place in two ways; one is natural, and the other isthe conventional methods. Naturally, it happens in the water cycle and self-cleaning of the river. Another way is the traditional method of water treatment. The purpose of water treatment is to make water fit for domestic and drinking purposes (Terpstra, 1999). The water quality standards depend upon the purpose for which it will be used. Different degrees of treatment are required for quality standards, types of natural water sources, and level of contamination (Gupta *et al*., 2012). In the series of the conventional method of treatment, the most crucial parameter is turbidity. It carries suspended matter such as organic matter, inorganic matter, clay, silt, colored compound, plankton, algae, and other microscopic organisms. Turbidity is generally cloudy or haziness appearance of water, and aesthetically unattractive. Turbidity imparts vital problems indirect water use from a natural resource (Davies Colley and Smith, 2011). So, we use various coagulants, depending upon their physical and chemical benefits in treating raw water (Makene *et al.,* 2019). But in the conventional method of water treatment, chemical coagulants are used for turbidity removal. The popular chemical coagulant is an alum.

In conventional treatment, a chemical coagulant like alum and ferric chloride is generally used. In a rural area, the use of natural coagulants is quite widespread. It has been used for more than 2000 years in India, China, and Africa (Jadhav and Mahajan, 2014). The use of a high level of alum in water treatment is hazardous for human health. It may cause diseases like Alzheimer's (Flaten, 2001). In this study, an attempt has been made to use natural coagulants in water treatment instead of chemical coagulants. Natural coagulants in water treatment may help reduce the health effect and cost of chemical coagulants. Some of the natural coagulants used are rice husk, tamarind seed, groundnut shell, chitin, and sago (Sutherland *et al.*, 1990).

The natural coagulant has potential in water treatment because of its low cost, readily available, multifunctional, biodegradable, and eco-friendly characteristics (Renault *et al*., 2009). In chemical, coagulation adds a primary coagulant, poly aluminum chloride (PACl), to increase the flocculation process's flow formation. Coagulation and flocculation have a difference in the rate of mixing (McCurdy *et al.*, 2004). In coagulation, add coagulant and combined with a high speed of rotation so that negatively charged chemical attracts positive charge impurity on it. After coagulation, we reduce the rate of mixing so that the time of contact will increase. After this process, filtration takes place so that the filterable material can be removed easily Aims of the study are

- To screen the coagulant for removal of turbidity.

MATERIALS AND METHODOLOGY

The analysis was carried out in the laboratory of GITAM University. Coagulation experiments were carried out using synthetic turbid water and analyzed using the conventional method, i.e., jar test apparatus.

Preparation of Synthetic Water

Synthetic turbid water was prepared by using bentonite clay by adding 5g in 500 ml distilled water. For achieving uniform distribution of clay, the suspension was stirred for one hour using a Jar test apparatus and was allowed to settle for 24 hours for complete hydration.

Coagulants Used and Preparation

Rice husk

The Rice husk preparation method was adopted from Adams *et al.,* (2013). The removal of dust in the rice husk was washed with distilled water and later dried using an oven for 24 h at 110 C. By using mortar and pestle, rice husk was ground to achieve 0.2 mm particle size.

Tamarind Seeds

Tamarind seeds (500 ± 0.5 g) were purchased from the local market and were washed with distilled water and later dried using an oven for one h at 105 °C. By using mortar and pestle, seeds were crushed by using a domestic blender. After milling, the powder obtained is used as a coagulant.

Ground nutshell

Sun-dried ground nutshells are collected and washed with deionized water to remove the impurities and dried at 1100 ^{o}C for 24 hours. The groundnut shells were powdered by using mortar and pistol.

Chitin

Chitin was procured from Hi-media.

Sago

Sago seeds were collected and dried in an oven at 110 ^{o}C and, once weakened; the crushed using a mortar and pestle the, the powder is as a coagulant.

Jar Test Operations

Coagulation-flocculation analysis was done using the Jar test apparatus, as it is the most common method adopted for the study. Samples were tested batch-wise and were mixed homogeneously. Initial analysis was done by measuring turbidity and coliform count for the samples.

Two turbid ranges were selected for the study, i.e., 70 NTU and 150 NTU, as these are the lowest and highest turbid range observed in the surface water. Different coagulant doses were selected in this study to know their effect on flocculation and obtain the optimum condition for each parameter.

Coagulants with different concentrations were added in beakers and kept for agitation with two mixing speeds, i.e., 100 rpm for 1 minute and 30 rpm for 30 minutes.

Samples were allowed to settle for 30 minutes, and the supernatant solution was filtered. The filtered selection was used for the post-analysis, i.e., physicochemical and bacteriological analysis.

Analytical Methods

Turbidity is one of the vital parameters to assess the quality of water. Turbidity was measured using a turbidity meter (ELICO – C52D). The pH of the water was measured by using a pH meter (ELICO-LI615).

ANOVA Analysis

One-way ANOVA was performed to test the coagulants' efficiency for the highest turbidity

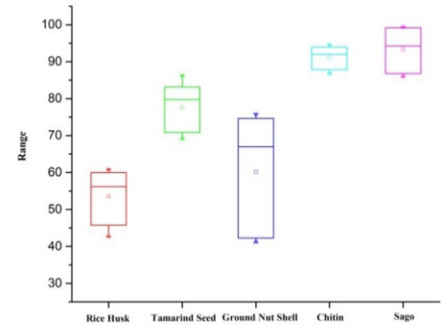

Fig. A. Comparison of turbidity removal by 5 Coagulants

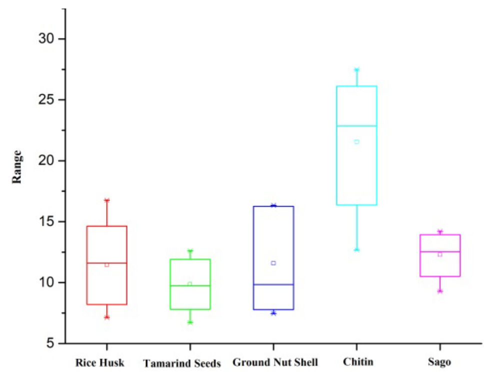

Fig. B. Comparison of Sludge volume by 5 Coagulants

removal and low sludge weight. And we found that p values are less than 0.005 ($p<0.05$). And comparison plots showed chitin and sago are the most efficient ones.

RESULTS

Rice Husk

Turbidity removal and settled sludge obtained by treating with rice husk, turbidity removal decreased with increasing dose of coagulant and dropped sludge increased with increasing coagulant dose. The highest turbidity removal was 60.86%, and the lowest settled sludge was 7.12 g/l obtained with an amount of 1 g/l (Fig. 1).

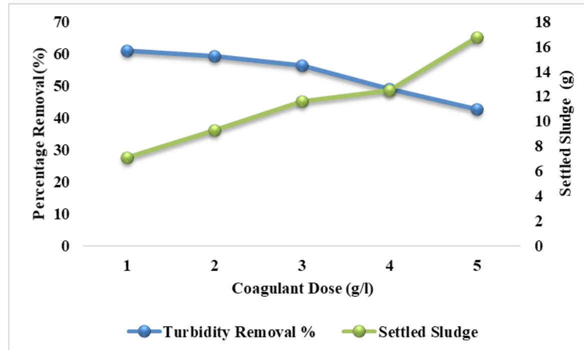

Fig. 1. Turbidity Removal and Settled Sludge by Rice Husk

Tamarind Seeds

Turbidity removal and settled sludge obtained by treating with tamarind seeds, turbidity removal decreased with increasing dose of coagulant and dropped sludge increased with increasing coagulant dose. The highest turbidity removal was 86.29%, and the lowest settled sludge was 6.7 g/l obtained with 1 g/l. (Figure 2).

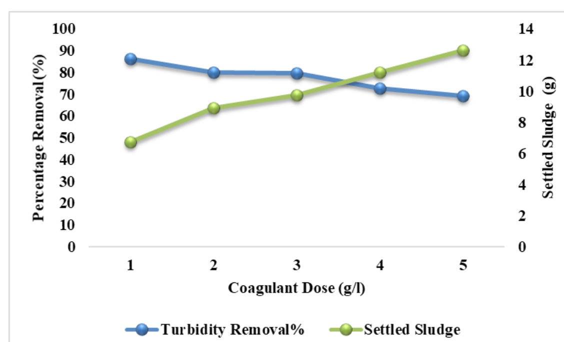

Fig. 2. Turbidity Removal and Settled Sludge by Tamarind Seeds

Table 1. One way- ANOVA comparison of Coagulants

S.No	Source of variation	*df*	SS	MS	VR	*F* pr.<0.05
1.	Comparison of turbidity removal by 5 coagulants	4	6399.50962	1599.87741	18.55917	**0.0001**
	Residual	20	1724.08276	86.20414		
	Total	24	8123.59238			
2.	Comparison of Sludge volumes by 5 coagulants	4	439.44686	109.86171	7.52132	**0.0001**
	Residual	20	292.13399	14.6067		
	Total	24	731.58085			

Groundnut Shell

Turbidity removal and settled sludge obtained by treating with groundnut shell, turbidity removal decreased with increasing coagulant dose, and dropped sludge increased with increasing coagulant dose. The highest turbidity removal was 75.86%, and the lowest settled sludge was 7.44g/l obtained with an amount of 1g/l. (Figure 3).

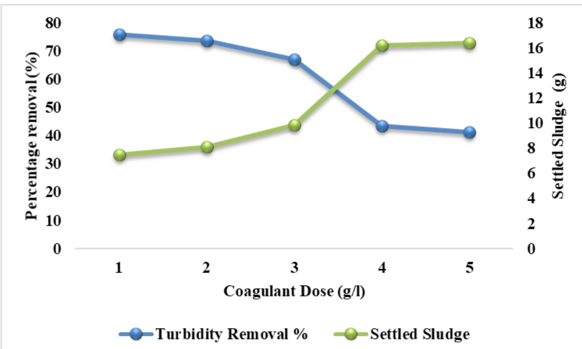

Fig. 3. Turbidity Removal and Settled Sludge by Ground Nutshell.

Chitin

Turbidity removal and settled sludge obtained by treating with chitin, turbidity removal increased with increasing dose of coagulant from 1g/l to 2g/l, at 3 g/l the turbidity removal was least 86.72% while turbidity removal increased with increasing coagulant dose. Settled sludge increased with increasing coagulant dose. The highest turbidity removal was 94.57%, and the lowest settled sludge was 12.68 g/l obtained with an amount of 5 g/l and 1g/l, respectively (Figure 4).

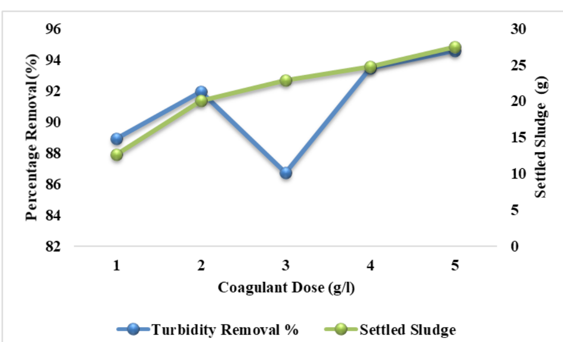

Fig. 4. Turbidity Removal and Settled Sludge by Chitin

Sago

Turbidity removal and settled sludge obtained by treating with sago, turbidity removal increased with increasing dose of coagulant from 1 g/l to 2g/l, from 3 g/l to 5 g/l was a decrease in turbidity removal with increasing coagulant dose. Settled sludge increased with increasing coagulant dose. The highest turbidity removal was 99.45%, and the lowest settled sludge was 9.27 g/l obtained with an amount of 2 g/l and 1g/l, respectively (Figure 5).

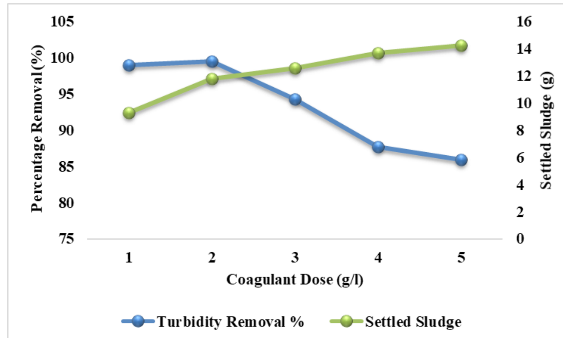

Fig. 5. Turbidity Removal and Settled Sludge Volume by Sago

DISCUSSION

Screening for suitable natural coagulant has been taken up in the present study. Five coagulants were evaluated for their coagulation efficiency. The difference in the coagulation efficiency of the coagulants can be attributed to the fact that coagulation is governed by multiple factors, including initial temperature, the turbidity of the water, pH, and water composition, mixing speed, dos, and type of coagulant, among others.

Rice Husk

In the present study, 60.86% of turbidity removal was reported by rice husk with a coagulant dose of 1g/l, a surrogate parameter for removing suspended solids. At a concentration of 1.5g/l effective removal of suspended solids was not obtained as per the studies of Chidozie Charles *et al.*, 2017 (Boyi *et al*., 2017). When rice husk ash was compared to wheat straw husk for hardness removal, rice husk showed only 55% removal at doses as high as 17.5 to 20.0g/l (Wu *et al.*, 2019). At lower coagulant doses of 0.4 to 2g/l, rice husk performed better than rice husk ash in removing turbidity, as reported by Anjitha and Goerge, (2016).

Tamarind Seeds

In the present study, 86.29% of turbidity removal was reported by rice husk with a coagulant dose of 1g/l. With a coagulant dose between 0.5 to 2.5g/l, seed powder of *Tamarindus indica* has efficiently absorbed 90% of metals from wastewater (Viotti *et al*., 2019). Turbidity reduction from 26.5 NTU to a minimum of 4.79NTU was achieved at a 15 ppm dosage of *Tamarindus indica* seed extracts along with coagulant aid Polyacrylamide (Saleem and Bachmann, 2019). Hussein and Jasim, (2019) reported that *Tamarindus indica* seed powder's turbidity removal was better with low initial turbidity. Still,it has shown hindrance to the constraint of coagulation mechanisms at higher initial turbidity, including stalled settling and Brownian movement. They have also reported a restriction of pH value for this coagulant's performance, stating pH 7 to be suitable.

Ground Nutshell

In the present study, 75.86% of turbidity removal was reported by rice husk with a coagulant dose of 1g/l. Many studies reported the efficiency of groundnut shell for its excellent adsorption properties, which is strongly governed by pH variations. It was successful in adsorbing 99% anionic dye at pH 2 (Ahmad *et al.*, 2019), removing turbidity (Alexander *et al*., 2019), 85% adsorption of Ni (II) (Ajmal *et al*., 2006), removal heavy metals (Gürses, 2019), adsorption of lead (Isaiah *et al.*, 2012), etc. from aqueous solutions.

Chitin

The highest turbidity removal was 94.57% with 5 g/l of coagulant dose. Chitin has been studied forthe removal and recovery of Ni (III), Cr (III), and Cu (II) as an adsorbent by Kalyani *et al.,* (2005). Robinson-Lora *et al.*, 2010 have shown that the chitin-associated proteins suggest supplementary sorption sites for manganese, leading to its removal at different pH conditions. Chitin is perceived to be attractive in terms of economy owing to its abundance next to cellulose. Darder *et al.,* (2003) presented physicochemical properties of chitin-based biocomposite, stating its potential for adsorption. During recent years, chitin is being used for treating water and wastewater as a cationic coagulant.

Sago

The highest turbidity removal was 99.45% at 2 g/l of coagulant dose. Sago waste was found to be a promising adsorbent for the lead with amounts more significant than 3 g/l at pH range 4.5 to 5.5. Kadirvelu *et al.,* (2003) reported Hg (II) adsorption at a concentration of 20 mg/l to 50 mg/l upon contact time for 120 min. When used as coagulant aid turbidity removal of 98.9%, native sago trunk starch was achieved in the presence of polyaluminum chloride at a concentration of 6 g/l (Kadirvelu *et al.*, 2004; Zamri *et al.*, 2018; Dwarapureddi *et al*., 2018).

CONCLUSION

Though ample research has been done on these technologies, the criteria for selecting natural coagulants are not quantified. This study provides a quantified method of using sludge mass as one of the parameters for choosing natural coagulants. Further, the results were presented in correlation with a dose of coagulant and turbidity reduction, which is proved mathematically using One-way ANOVA. The present study is thus considered to fill the gaps in selecting a coagulant.

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