Improving the Coagulation Process Efficiency Using Added Materials

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Abstract

In this study natural coagulant is used in addition to alum. The natural coagulant used in this study is *schanginia*, which is considered as available and low cost material. The experiments are performed in three stages at the same operating conditions. The first stage involves using alum alone, the second one is carried out using natural coagulant (*schanginia*), and third stage involves using a mixture alum and natural coagulant (*schanginia*) with the same quantity for each one. The optimum doses of alum, *schanginia* and mixture of alum and *schanginia* are (40, 50 and 60) mg/l, which have accomplished turbidity removal of (91.92, 73.74 and 76.77) %, respectively. According to these results, *schanginia* can be used as a coagulant alternative to alum or can be used with alum in water purification, because it gives satisfactory results in turbidity removal. In addition, it is a low cost material and it can be considered as an effective coagulant, taking into account the value of pH, dosage of coagulant, rapid and slow mixing time. The results indicate that the removal efficiency is affected by doses of coagulant. However, the experimental results at the same operating conditions, reveal that the removal efficiency of turbidity is higher for alum alone compared to natural coagulant (*schanginia*) and a mixture of alum and *schanginia*.

Keywords: Coagulation, Flocculation, Water treatment, Alum, Natural coagulants.

1- Introduction

The most common techniques applied in water treatment process, are coagulation and flocculation. Coagulation is a process used for removing suspended particles (colloids) from water by destabilization of colloids existing in water using several chemical agents such as ferrous sulfate (Fe (SO4)), aluminum sulfate or alum (Al2 (SO4)3.18H2O), and Poly Aluminum Chloride (PAC). However, to speed up the coagulation process, some chemical materials (like polyacrylamides) are usually added to water to increase floc size. Flocculation is generally the creation of aggregates from the destabilized colloids and it implies consistent mixing to enable affective collisions between particles to create thick flocs, which can be excised from water by settlement [1], [2], [3], [4]. Coagulation and flocculation processes happen in sequential steps leading to overcome the forces that make the suspended particles in stable state and then the particles will collide with each other leading to the growth of floc. Coagulants materials have positive charges, which lead to particle destabilization and charge neutralization, on other hand the colloid particles show Brownian motion in the water leading their surfaces have negative charges, so they repel one another, and then form a stable dispersed suspension [5], [6], [7]. Choosing coagulant materials for water treatment process depends on several factors, which include raw water condition, the nature of the suspended particles, design of treatment facility, zeta potential, cost of coagulant chemicals, and Van der Waal’s forces. Jar test is used to select appropriate coagulants amount for the treatment process. Many factors must be considerable such as overall dosage cost of coagulant and sludge handling disposal cost for any treatment process to be effective [8]. The coagulant is added in basin at water treatment plants, under a turbulent flow to ensure appropriate contact with suspended particles. The turbulent flow path induced in the flocculation basin ensures adequate contact between destabilized particles and promotes floc formation. Detention time in sedimentation basins allow flocculated particles to settle out of the system [9]. Many natural coagulants were used as an alternative coagulants to the use of synthetic chemicals in water purification such as Moringa oleifera (MO) [10], Plantago ovata [11], powdered seeds of M. olifeira, H. sabdariffa and C. tridens and all these coagulants had given satisfactory results in water treatment [12].

Objective of study

In this study, a natural coagulant is used as alternative to chemical coagulants, because it is available and has low cost or it can be added with alum to reduce its cost. The material used in this study is *schanginia*.

2-Materials and methods

A- Collection of samples

The samples of raw water were made by adding impurities to the distilled water to get a turbid water. The characteristics of water used in this study are shown in Table 1.

Table 1. Characteristics of water used in this study

Parameters	Units	Value
Turbidity	NTU	49.5
pH	-	7.8
TDS	Mg/l	752
Ec	**µ**s	1511
Temperature (T)	C^0	25.6

B- Preparation of natural coagulant

The dry *schanginia* was crushed until being a powder. Then, it was washed several times with distilled water to remove impurities and exposed to sunlight to be dried. Figure 1 shows *schanginia* in different forms.

(a) (b) (c)

Figure 1. (a) The schanginia, (b) dry schanginia, and (c) schanginia as powder.

C- Experimental Procedure

Jar test experiments were adopted in this study. Aluminum sulfate (alum) ($Al_2 (SO_4)_3.18H_2O$) was used for compression, in addition to the use of natural coagulant (*schanginia*). A certain doses of coagulant (alum and *schanginia*) was added on the beakers. The experiments were done in three stages at the same conditions. The first stage was accomplished using alum alone, the second one was carried out using a natural coagulant (*schanginia*) alone, and third stage was performed using a mixture alum and *schanginia* with the same quantity for each one. All stages were carried out using the following experimental conditions: coagulants doses of (20, 30, 40, 50 and 60) mg/l, rapid mixing time of 1min with mixing speed of (250 rpm), slow mixing time of 20 min with speed of 40 rpm, and after slow mixing the mixture left for 30 min for settling of flocculants[6]. Supernatant samples were taken from 2 cm below the water surface for turbidity measurements. Experimental characteristics for the jar test experiments in this study are summarized in Table 2.

Table 2. Experimental characteristics for the jar test experiments in this study

Characteristic	Description
Coagulant	Alum and *schanginia*
Coagulant dose	(20,30,40,50,60) mg/l
pH	7.8
Turbidity	49.5 NTU
rapid mixing	1.0 min at 250 (rpm)
slow mixing	20 min at 40 (rpm)
settling	30 min

3-Results and discussion

Figure 2 shows the removal efficiency of turbidity using alum within doses of (20, 30, 40, 50 and 60) mg/l. The optimum dose of alum for turbidity removal is (40 mg/l) with removal of (91.92%). Figure 3 shows the turbidity removal efficiency using natural coagulant (*schanginia*) with different doses of (20, 30, 40, 50 and 60) mg/l. the optimum dose *schanginia* of for turbidity removal was (50 mg/l) with removal efficiency of (73.74%). At the same conditions of using alum and schanginia, Figure 4 shows the removal efficiency of turbidity using a mixture of alum and schanginia having the same mixing quantities. The optimum dose for this mixture is (60mg/l) with removal efficiency of (76.77%). Table 3 shows a summary of results in this study. According to the results in Table 3, *schanginia* can be used as a coagulant alternative to alum or can be used with alum in water purification, because it gives satisfactory results in turbidity removal in addition to its low cost and availability taking into account pH, dosage of coagulant, and rapid and slow mixing times. The results indicated that the removal efficiency affected by doses of coagulant. The coagulation process and turbidity removal was c affected by pH, coagulant dosage, as well as turbidity of water [3]. Generally, the results reveal that the removal efficiency of turbidity is higher for alum alone, compared to natural coagulant (*schanginia*) and a mixture of alum and *schanginia*.

Table 3. Summary of results in this study

Dose of coagulant (mg/l)	Removal efficiency of turbidity (R%) using different coagulants		
	Alum	*Schanginia*	Mixed (alum & *schanginia*)
20	81.54	65.253	69.293
30	85.86	70.71	71.313
40	91.92	72.53	70.30
50	69.23	73.74	70.91
60	77.98	67.273	76.77

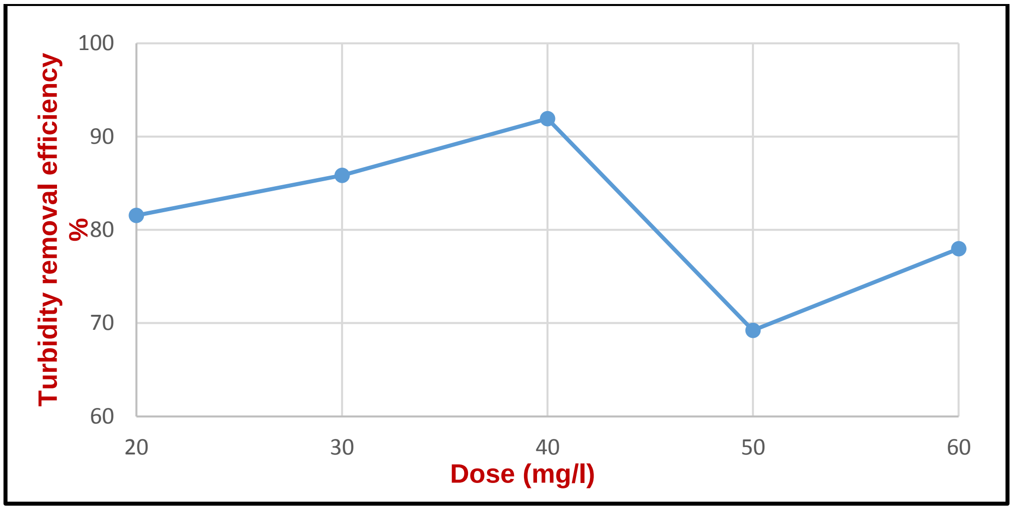

Figure 2. Removal efficiency of turbidity using alum alone.

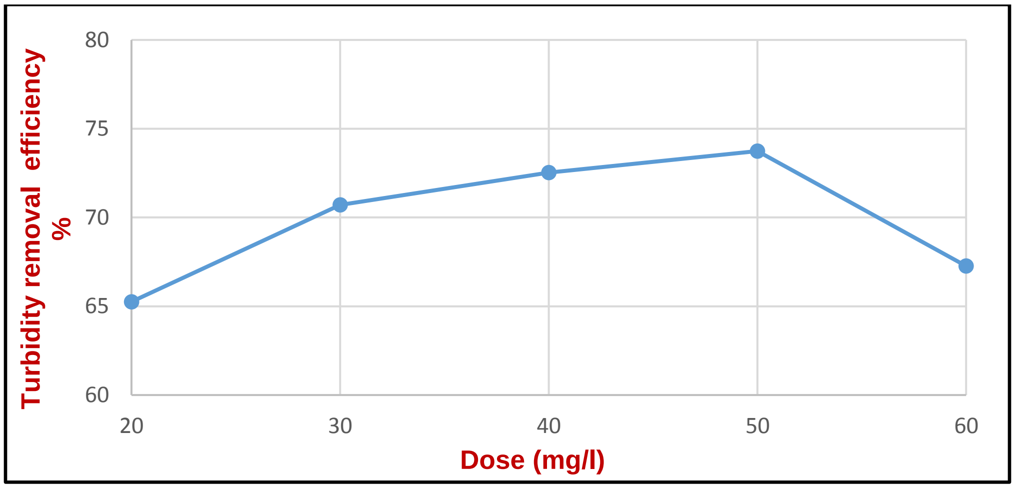

Figure 3. Removal efficiency of turbidity using schanginia alone.

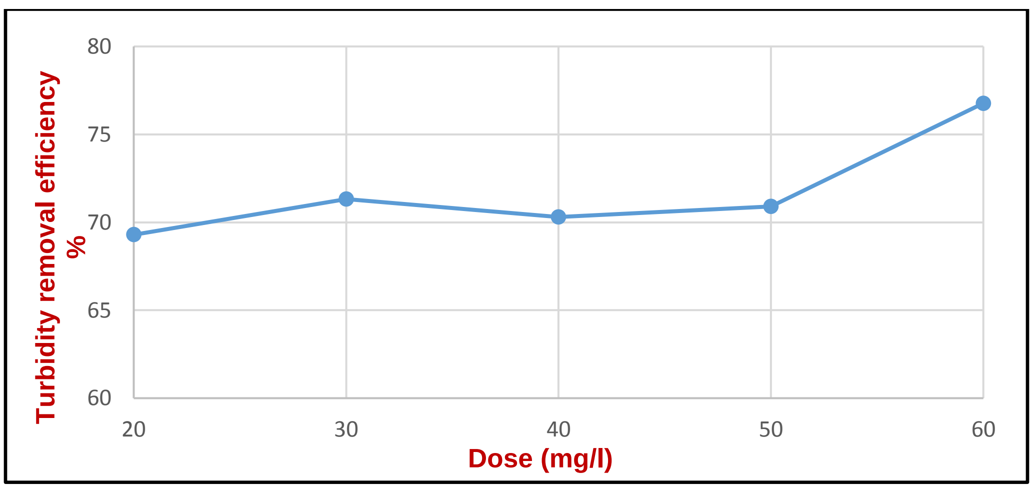

Figure 4. Removal efficiency of turbidity using a mixture of alum and *schanginia*.

4-Conclusion

The results indicate that the turbidity removal efficiency using alum alone is higher than using *schanginia* and a mixture of alum and *schanginia* at the same experimental conditions. According to the results *schanginia* can be used as a coagulant and alternative to alum or can be used with alum in water treatment, because it gives satisfactory results in turbidity removal in addition to its low cost and availability taking into consideration the value of pH, dosage of coagulant, rapid and slow mixing time.

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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الخلاصة

في هذه الدراسة تم استخدام مختثرات طبيعية بالإضافة إلى الشب. المختثرات الطبيعية المستخدمة في هذه الدراسة هو نبات الطرطيع(schanginia)، والذي يعتبر مادة متوفرة ومنخفضة التكلفة. تم إجراء التجارب على ثلاث مراحل تحت نفس ظروف التشغيل. تتضمن المرحلة الأولى استخدام الشب بمفرده، أما المرحلة الثانية تم تنفيذها باستخدام المختثرات الطبيعية نبات الطرطيع (schaginia)، أما المرحلة الثالثة فتتضمن استخدام مزيج من الشب ونبات الطرطيع (schaginia) بنفس الكمية لكل منها. وكانت قيم الجرعات المثلى لكل من الشب ونبات الطرطيع ومزيج الشب والطرطيع هي (40، 50 و60) ملغم / لتر، وبنسب ازالة للكدرة (91.92، 73.74، 76.77) ٪، على التوالي. وفقا لهذه النتائج، يمكن استخدام نبات الطرطيع schanginia كبديل عن الشب أو يمكن استخدامها مع الشب في تنقية المياه، لأنها اعطت نتائج مرضية في إزالة كدرة المياه. بالإضافة إلى ذلك، فهي مادة منخفضة التكلفة ويمكن اعتبارها مختثرات فعالة، مع الأخذ في الاعتبار قيمة الرقم الهيدروجيني، جرعة او كمية المادة المختثرة، وزمن الخلط السريع والبطئ. اشارت النتائج إلى أن كفاءة الإزالة تتأثر بجرعة المادة المختثرة ومع ذلك، فإن النتائج التجريبية اظهرت ان أن كفاءة إزالة الكدرة كانت أعلى للشب وحدها مقارنة مع نسب الازالة لنبات الطرطيع (schanginia) ومزيج من الشب ونبات الطرطيع تحت نفس ظروف التشغيل.

الكلمات الداله: التخثير، التلبيد، معالجة المياه، الشب، مختثرات طبيعية.