Investigation the Optimum Combined Dosages of Date Seeds Powder as Natural Coagulant with Chemical Coagulants in Domestic Wastewater Pretreatment.

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ABSTRACT

The pretreatment process can be considered one of the important processes in wastewater treatment, especially coagulation process to decrease the strength of many pollutants. This paper focused on using powdered date seeds as natural coagulant in addition to chemical coagulants (alum and ferric chloride) to find the optimum dosage of each coagulant that makes efficient removal of turbidity and chemical oxygen demand (COD) from domestic wastewater as a pretreatment process, then finding the optimum combined dosages of date seeds with alum, date seeds with ferric chloride that make efficient removal for both pollutants. Concerning turbidity, the optimum dosage for date seeds, alum and ferric chloride were 40 mg/l (79%), 70 mg/l (84%) and 60 mg/l (82%) respectively. Concerning COD the optimum dosage for date seeds, alum, and ferric chloride were 40 mg/l (75%), 60 mg/l (83%) and 50 mg/l (86%). The study showed that the optimum combined dosage that made higher turbidity removal (95%) resulted from mixing 70 mg/l date seeds with 50 mg/l alum, while for higher COD removal 90% resulted from mixing 40 mg/l date sees with 70 mg/l ferric chloride.

Key words: coagulation, wastewater treatment, date seeds, turbidity removal, COD removal.

إيجاد التراكيز المشتركة المثلى من مسحوق نوى التمر كمخثر طبيعي مع المخثرات الكيمياوية في المعالجة التمهيدية لمياه الصرف الصحي.

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الخلاصة

تعتبر المعالجة التمهيدية لمياه الصرف واحدة من اهم مراحل المعالجة في محطات معالجة مياه الصرف، وخصوصا عملية استخدام المخثرات الكيمياوية في تخفيف قوة العديد من الملوثات في هذه المياه. هذه الدراسة تركزت على استخدام مادة نوى التمر بعد طحنها كمخثر طبيعي جنبا الى جنب المخثرات الكيمياوية الأخرى مثل الشب وكلوريد الحديد في المعالجة التمهيدية لإزالة العكارة والاوكسجين الكيمياوي المطلوب من مياه الصرف الصحي من خلال إيجاد التراكيز المثلى لكل مخثر على حده. ومن ثم إيجاد التراكيز المثلى المشتركة والناتجة من دمج المخثر الطبيعي مع الشب من جهة ومع كلوريد الحديد من جهة أخرى. بالنسبة لإزالة العكارة بينت النتائج ان التراكيز المثلى للمخثر الطبيعي كانت 40 ملغم باللتر بنسبة إزالة 79%، الشب 70 ملغم باللتر بنسبة إزالة 84% وكلوريد الحديد 60 ملغم باللتر بنسبة إزالة 82% اما فيما يخص إزالة الاوكسجين الكيمياوي المطلوب كان التركيز الأمثل للمخثر الطبيعي 40ملغم باللتر بنسبة إزالة 75%، الشب 60 ملغم باللتر بنسبة إزالة 83% وكلوريد الحديد 50 ملغم باللتر بنسبة إزالة 86%. وكذلك بينت الدراسة ان التركيز الأمثل المشترك لإزالة العكارة كان ناتج من دمج 70 ملغم باللتر من المخثر الطبيعي مع 50 ملغم باللتر من مادة الشب حيث كانت نسبة الازالة 95%، في حين كان التركيز الأمثل المشترك لإزالة الاوكسجين الكيمياوي المطلوب كان ناتج من دمج 40 ملغم باللتر من المخثر الطبيعي و70 ملغم باللتر من مادة كلوريد الحديد حيث كانت نسبة الازالة 90%.

الكلمات الرئيسة: التخثير، معالجة مياه الصرف، نوى التمر، إزالة العكارة، إزالة الاوكسجين الكيمياوي المطلوب.

1. INTRODUCTION

Generally, one of the main causes of pollution is the effluents that are discharged from wastewater treatment systems and these effluents have adverse effects to aquatic ecosystems and to humans. Some of these impacts can include water toxicity from industrial wastewater, algal blooms, death of aquatic life, and habitat destruction from sedimentation, **Canada Gazzette, 2010.** Wastewater is 99.94 percent water by weight and the rest 0.06 percent is suspended solids and dissolved solids materials, **Lee, 2000.** Chemical characteristics are pH, alkalinity, suspended solids, dissolved solids, chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved gases, nitrogen and phosphorus compounds, **Frank, 2003**. Wastewater turbidity is resulted from soluble organic compounds, suspended solids (organic and inorganic matters), such as clay, silt, and plankton and microorganisms, **Harashit, 2014**. In order to remove the suspended solids and turbidity from water and wastewater there is two important preliminary processes coagulation and flocculation. Coagulation process is a chemical process uses chemical either organic such as polymers or natural plants or inorganic salts such as aluminum sulphates, aluminum chloride, sodium aluminates, ferric sulphates, ferric chloride and ferric chloride sulphates. The purpose of coagulation is to neutralize charges and form a bridge of particles thus forming very large particles enough to be settled. Flocculation is gentle stirring or agitation to encourage the agglomeration of particles into masses large enough to be settled or be filtered from solution because of the increment in size and density of particles, which leads to faster rate of settling. The most common material that used in coagulation process in water and wastewater treatment is the Alum, aluminum sulphates $Al_2(SO_4)_3.18H_2O$. The second common material used in coagulation process is ferric chloride. They have been in use and they still in use in the form of powder dispensed by one of the several forms of mechanical dry feeder units in water and wastewater treatment plants.

As a coagulant M. oleifera seed used in water or wastewater treatment, the extracted protein from the seeds showed a removal percentage of suspended solids up to 99%, **Katayon, et al., 2006**. The natural coagulant produced from M. oleifera seed was capable of improving turbidity removal up to 98%, **Sutherland, et al., 1994**. Using a combined dosage of chemical coagulant $Al_2(SO_4)_3$ and natural coagulant M. oleifera produced a turbidity removal up to 98%, **Ali** and **Afuye, 2010**. Plant origin coagulant such as Coccinia indica (Kundru) used as a coagulant for synthetic turbid water treatment, the efficiency of turbidity removal was 99% and at a range of pH 6.5 to 8, **Madhukar** and **Yogesh, 2013.**Using aluminum silicate as a coagulant for synthetic turbid wastewater treatment was studied by, **Ho, et al., 2009**. They discovered that the maximum turbidity removal occurred when the salt dosage was more than 20 mg/l and pH was more than three. The removal efficiency for turbidity in wastewater was 99%, **Rubi,** and **Fall, 2009** studied sedimentation and coagulation treatment of wastewater effluents from car washing workshop. The influence of the chemical coagulants (aluminum hydrochloride $Al_2Cl_4(OH)_2$, diallyldimethyl ammonium chloride $C_8H_{18}NCl$, aluminum sulfate $Al_2(SO_4)_3$ and ferric chloride $FeCl_2$ was studied. Coagulation process produced removal of 74%, 88%, 92%, and 90% for COD, TSS, turbidity and oil respectively. Sedimentation process produced removal of 82%, 88% 73% and 51% for oils, TSS, COD, and turbidity, respectively. **Ammar and Yilian, 2013** studied using hybrid copolymer $Fecl_2$ as a new alternative flocculent to remove COD and turbidity from municipal wastewater, the optimum turbidity and COD removals were 96.56% and 83.54% respectively. **Safaa, 2011** showed that when increasing the

periods of slow mixing and sedimentation resulted more removal percentage in turbidity removal from water , the turbidity removal percentage was 97% using alum dosage 50 mg/l and period of sedimentation varied from 35 to 60 minutes. **Faris, 2012** studied using of chemical coagulants (alum and powdered activated carbon PAC) to treat the oily wastewater, the optimum dosages of alum and PAC were 125 and 100 mg/l that resulted a removal of 97.8%, 97.4% and 99.3% for oil grease, COD, and total suspended solids respectively. **Mohammad, et al., 2013** made a comparative study between starches as a natural coagulant and alum as a commercial coagulant in treatment of semiconductor wastewater to remove the heavy metals. They found that the starches have the same capability to remove heavy metal as the alum. Another efficient method to remove wastewater turbidity is the electrocoagulation method. **Saidat, et al. 2012** showed that electrocoagulation can be considered as an efficient way to remove wastewater turbidity in spite of environmentally friendless and very large cost method.
The aim of this study is to decrease the turbidity and COD strength domestic wastewater and to improve biological treatment through the following investigations:

1) The optimum coagulant dosages of chemical coagulants (alum and ferric chloride).
2) The optimum coagulant dosage of natural coagulant (date seeds powder).
3) The optimum combined coagulant dosage (alum plus date seeds powder).
4) The optimum combined coagulant dosage (ferric chloride plus date seeds powder).

2. EXPERIMENTAL WORK

2.1 Apparatus

The jar testing apparatus contains four paddles as shown in **Fig. 1,** which stir the contents of four 1-liter containers. The mixing speed in all of the containers can be controlled uniformly by a rpm gage built in the device, while the time of mixing can be controlled by a digital timer.

2.2 Materials and Methods

2.2.1 Raw domestic wastewater

Domestic wastewater collected from the primary clarifier influent at Al Aziziyah wastewater treatment plant. Raw wastewater samples were stored at 10°C; the properties of raw domestic wastewater were shown in **Table 1.**

2.2.2 Preparation of alum solution

Stock solutions of alum were prepared according to the APHA procedure for coagulation process enhancement, by dissolving 100 grams of aluminum sulphates $Al_2(SO_4)_3.18H_2O$) in one liter of distilled so one ml of this stock gives alum solution of 100 mg/l concentration. Then after that by titration methods a ten different concentrations of Alum were prepared ranged from 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 mg/l, **APHA, 1998**.

2.2.3 Preparation of ferric chloride solution

Stock solutions of Ferric Chloride were prepared according to the APHA procedure for coagulation process enhancement, by dissolving 100 grams of ferric chloride $FeCl_2$ in one liter of distilled so one ml of this stock gives ferric chloride solution of 100 mg/l concentration. Then by titration methods a ten different concentrations of Alum were prepared ranged from 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 mg/l, **APHA, 1998.**

2.2.4 Preparation of natural coagulant solutions (Date Seeds Coagulant)

In this study, the local Iraqi dates were collected from date trees then the seeds were separated. Then, the seeds were washed in tap water and dried in an oven at 50°C for six hours. The seeds then were crashed and powdered using flour grinder machine and finally sieved through a 250µm sieve. Stocks solutions of this natural coagulant (seed dates coagulant) were prepared for coagulation process enhancement, by dissolving 100 grams of seed powder in one liter of distilled, so one ml of this stock gives seed coagulant solution of 100 mg/l concentration. In order to be sure that this solution was free of residual particles, it was filtered using 1µm filter paper. Then by titration methods a ten different concentrations of seeds coagulant were prepared ranged from 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 mg/l.

2.3 Experimental Procedure

Sedimentation and Jar test were carried out to determine the coagulation properties of each coagulant and to obtain the optimal dosage for each coagulant (alum, ferric chloride and seed dates). One beaker was used as a control and other in the beakers, various dosages of each coagulants was added at ranges from 10 to 100 mg/l. Then a rapid mixing for 2 minutes and 100 rpm was subjected to the samples then 30 min with a slow mixing at 25 rpm, when the mixing was completed, the flocs allowed to settle, **ASTM, 1995.** for 60 minutes. In order to measure the residual turbidity, samples were withdrawn using a pipette from a height of 4cm below the surface of each beaker, and residual turbidity was measured. So the optimal dosage can be calculated by calculating the best turbidity removal percentage for each coagulant. After finding the optimal dosage of alum, a combination dosage consisted of this fixed alum dosage (optimal dosage) with different ranges of natural coagulant started from 10 mg/l to 100 mg/l in order to find the optimal mixing ratio of these two coagulants (alum and date seeds). Same procedure was done with the optimal dosage of ferric chloride, a combination consisted of this fixed ferric dosage (optimal dosage) with different ranges of natural coagulant started from 10 mg/l to 100 mg/l in order to find the optimum mixing ratio of these two coagulants (ferric chloride and date seeds).The effect of optimal mixing dosage ratios of chemical and natural coagulants combinations on the removal of turbidity and chemical oxygen demand was examined.

3. RESULTS AND DISCUSSION

3.1 Finding the Optimum Coagulants dosages For Turbidity and COD Removals

A set of experiments were done using jar test device to calculate the optimum dosage for each coagulant (alum , ferric chloride and date seeds) for turbidity and COD removals. A range of concentrations from 10 mg/l to 100 mg/l for each coagulant was used separately. The study showed that the optimum dosages for turbidity removal using alum, ferric chloride and dates seeds were 70 mg/l, 60 mg/l and 40 mg/l and the turbidity removal percentages were 84%, 82% and 79% respectively as shown in the **Fig. 2**. While the optimum dosages for COD removal using alum, ferric chloride and dates seeds were 60 mg/l, 50 mg/l and 40 mg/l and the COD removal percentages were 83%, 86% and 75% respectively as shown in the **Fig. 3.**

3.2 Finding the Optimum Combined Coagulants dosages For Turbidity Removal

Another set of experiments were done using jar test device to calculate the optimum dosage for combination of optimum fixed dosage of ferric chloride which was 60 mg/l with a different dosages of date seeds ranged from 10mg/l to 100 mg/l. The optimum mixing dosage was 60 mg/l ferric chloride plus 40 mg/l date seeds and this combined dosage produced turbidity removal percentage up to 93% as shown in the **Fig. 4**. From the other hand a set of experiments were done using also jar test device to calculate the optimum dosage for combination of optimum fixed dosage of alum, which was 70 mg/l with different dosages of date seeds ranged from 10mg/l to 100 mg/l. The optimum mixing dosage was 70 mg/l alum plus 50 mg/l date seeds and this combined dosage produced turbidity removal percentage up to 95% as shown in the **Fig. 5.** This highly removal of turbidity can be attributed to the fact that the powdered of date seeds has a very good adsorption for the suspended solids beside the highly effect of formation of aluminum coagulant hydrolysis products which considered the most important cause of suspended solids destabilization.

3.3 Finding the Optimum Combined Coagulants dosages For COD Removal

Another set of experiments were done using jar test device to calculate the optimum dosage for combination of optimum fixed dosage of ferric chloride which was 40 mg/l with a different dosages of date seeds ranged from 10mg/l to 100 mg/l. The optimum mixing dosage was 40 mg/l ferric chloride plus 70 mg/l date seeds and this combined dosage produced COD removal percentage up to 90% as shown in the **Fig. 6.** From the other hand a set of experiments were done using also jar test device to calculate the optimum dosage for combination of optimum fixed dosage of alum, which was 60 mg/l with different dosages of date seeds ranged from 10mg/l to 100 mg/l. The optimum mixing dosage was 60 mg/l alum plus 50 mg/l date seeds and this combined dosage produced COD removal percentage as shown in the **Fig. 7.** The removals of COD were attributed by the formation of sediments from the combination of ferric coagulant and the soluble organics **Tebbutt, 1998**. And this finding was fully agreement with study of **Dialynas, et al., 2008** he showed that $FeCl_2$ was more efficient than alum in removing of organic content of landfill leachate and this was due to $FeCl_2$ increases the flocs size and decreasing settling time more than alum.

4. CONCLUSIONS

This study has found the possible benefits and effectiveness of using dates seeds as a natural coagulant that could be used in coagulation process in domestic wastewater pretreatment to remove the turbidity and chemical oxygen demand (COD), and the removal efficiency for both parameters (turbidity and COD) could be increased when a combination is done between this natural coagulant (date seeds) and other chemical coagulants such as ferric chloride and alum.

The study showed that the optimum combined dosage used to remove initial turbidity of domestic wastewater (250 NTU) was 120 mg/l resulted from (70 mg/l date seeds plus 50 mg/l alum) and the turbidity removal percentage was 95%. The study also showed that the optimum combined dosage used to remove initial COD of domestic wastewater (390 mg/l) was 110 mg/l resulted from (40 mg/l date seeds plus70 mg/l ferric chloride) and the COD removal percentage was 90%.

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Figure 1. Jar test apparatus.

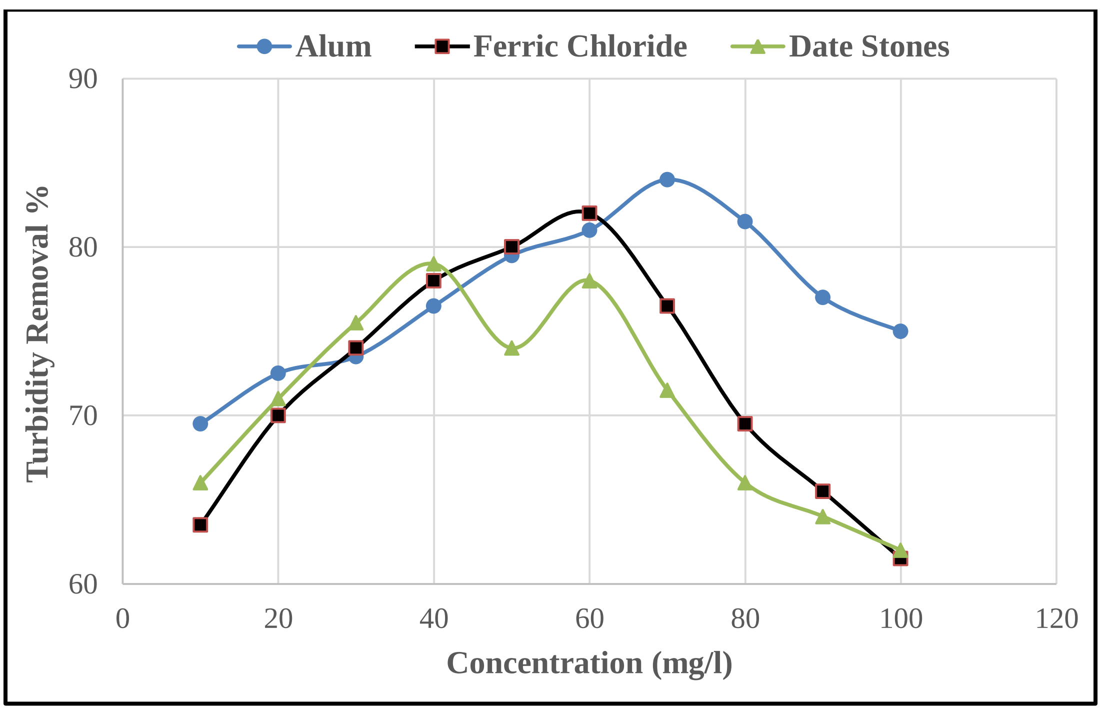

Figure 2. Variation of turbidity removal with coagulant concentration.

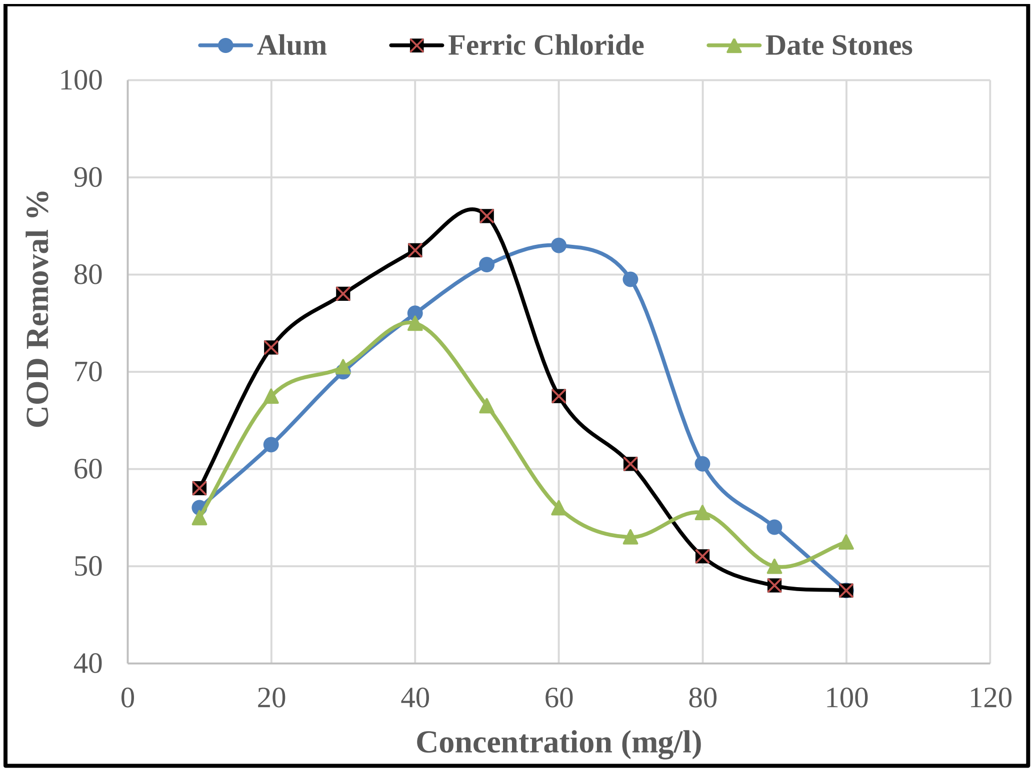

Figure 3. Variation of COD removal with coagulant concentration.

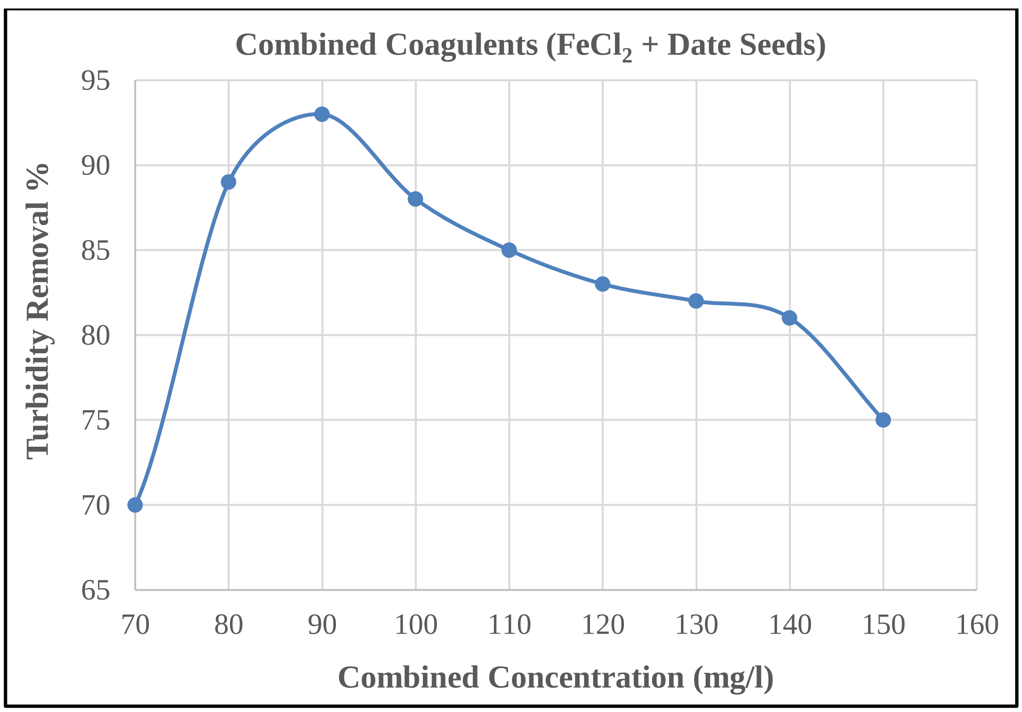

Figure 4. Variation of turbidity removal with combined coagulants.

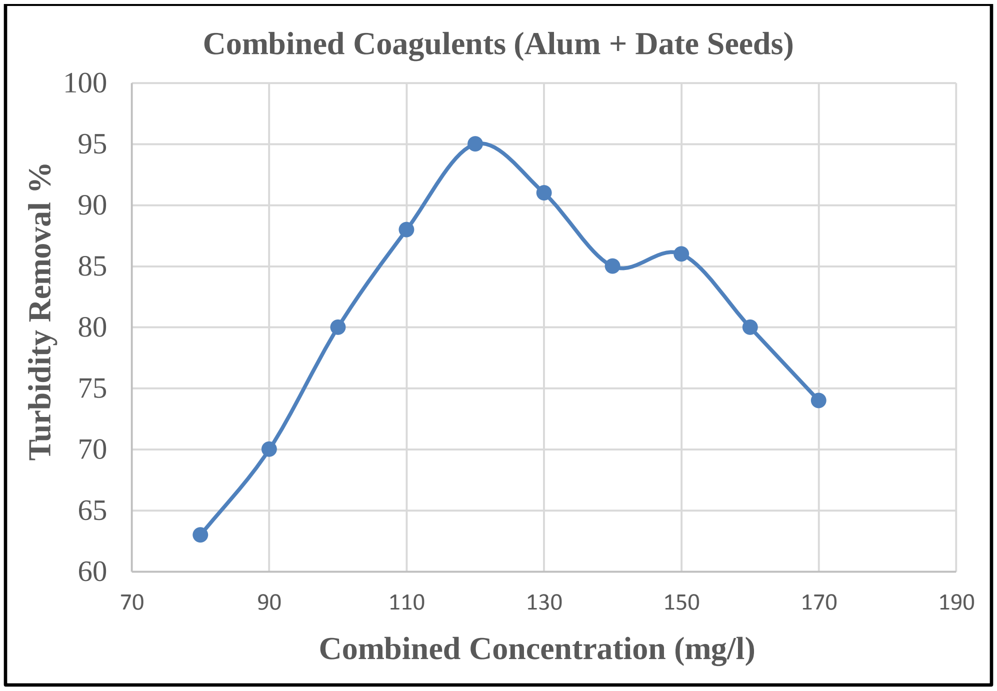

Figure 5. Variation of turbidity removal with combined coagulants.

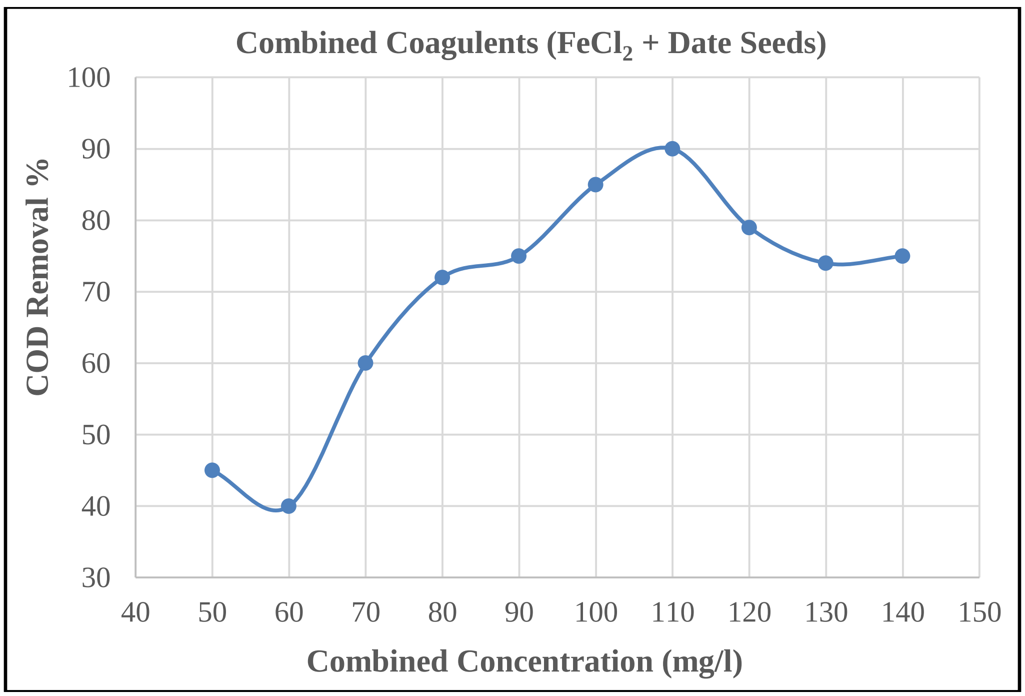

Figure 6. Variation of COD removal with combined coagulants.

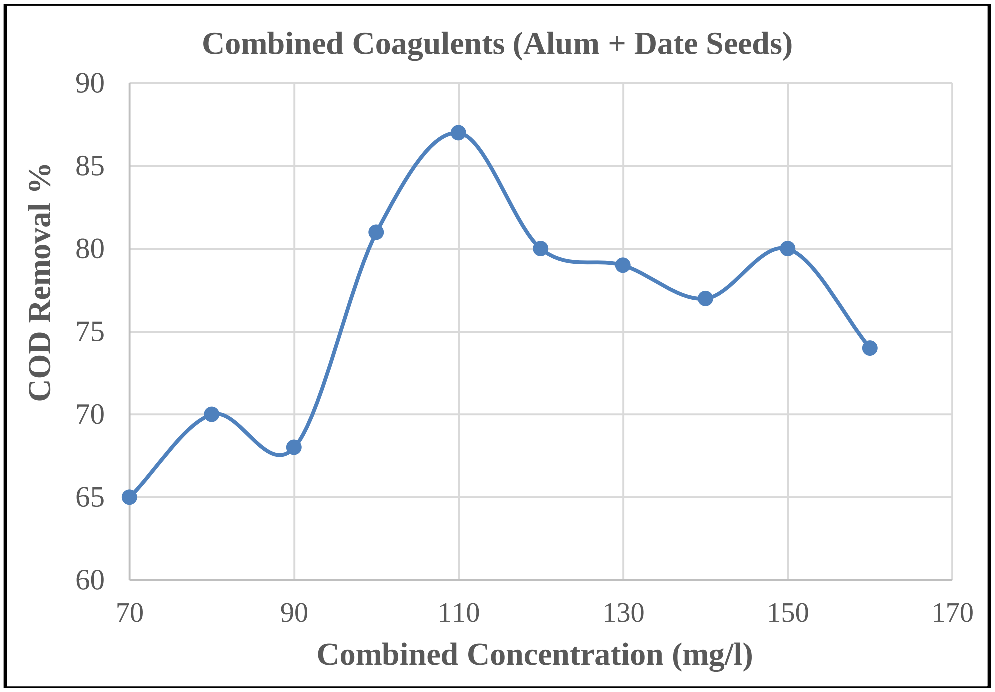

Figure 7. Variation of COD removal with combined coagulants.

Table 1. Characteristics of the domestic wastewater.

Constituent	Concentration*	Unit
BOD	220	mg/L
COD	390	mg/L
Turbidity	250	NTU
pH	7.1-7.4	-

*Average of 3 values