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ASSESSMENT TREATMENT OF HIGHLY TURBID WATER USING EXTRACTS OF CORCHORUS OLITORIUS-L WASTE AS NATURAL COAGULANT AIDS

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ABSTRACT

The current study is an attempt to solve the problem of high surface water turbidity that has recently emerged in Egypt. High turbidity may make it difficult for water treatment plants to manage water quality, cost and safety. High doses of Aluminum sulfate result in high residual aluminum values that exceed the WHO specifications. Natural coagulant aids extracted from Corchorus Olitorius L (COL) wastes and evaluated for the treatment of high turbidity of both synthetic and natural flash spill water samples.

Extracts of COL stems and leaves were prepared with water and ethanol, aqueous extracts (C1 of leaves, C0 of stem), (ethanolic extract C2of leaves). Turbidity measured after 5, 10,15and20 min. The pH is measured to follow up the different doses effect. Residual aluminum was measured to ensure that within recommended range for drinking water. Based on the results of jar test, COL extracts are efficient coagulation aids. They have the ability to reduce both the primary coagulant dose from 30ppm to 10 ppm and the residual turbidity from (500 and1000 to 2.4 and 2.7NTU respectively) by using4 and 3 ppm of aqueous extraction C1. Residual turbidity reduced to3.2 and 4.3NTU by using6and 5 ppm of aqueous extractionC0 and also to 3.0, 4.1NTU for 5ppmof ethanolic extractionC2 instead of residual turbidity 27.8, 32 NTU)

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respectively for the same dose of primary coagulant Aluminum sulfate as 10 mg/l only after 20 min.

Keywords: High turbidity; Coagulant aids; Corchorus Olitorius L; flash spill water samples

INTRODUCTION

Current climate change recently causes rainstorm events in Egypt accompanying with flash spill. For example Dragon storm moved over Egypt in March 2020 spreading heavy rain. Rainstorm events lead to elevated levels of turbidity and organic matter found in river waters (Hurst *et al.,* 2004). Flash spill also could cause Watershed response which was often rapid and results in variations in the quality and quantity parameters of turbidity, total microbial count, natural organic matter, suspended matters, etc.),were unusual (Pesic *et al.,* 2016). In fact, high turbidity causes problems that some water treatment plants cannot handle and suddenly stop working. There were studies have shown that turbidity changes directly affect the organic matter quantity in water. Treatment of water could be achieved by coagulation and flocculation using chemical-based coagulants as Aluminum sulfate [Al_2 $(SO_4)_3.18\ H_2O$], due to its availability (SAAE, 2018). Using coagulant factors is important for water treatment (Barrera-Díaz *et al.*, 2018). The properties of used coagulant is the essential factor in determining the performance of coagulation, as it could support or prohibit the efficiency of the treatment (Sun *et al.,* 2017; Verma and Kumar 2016). Researchers used Coagulants and Coagulant aids to improve the coagulation process by both types (organic, inorganic) to produce bigger flocs. Using coagulant aids could reduce the usage amount of primary coagulants. Activated SiO_2 was used by (Alhassan *et al.*, 2021), polyelectrolyte was used by (Jabin *et al.*, 2021). Some of coagulant aids were banned or limited such as polyacrylamides because it has a serious harmful effect on human health (Zhang *et al.*, 2021) otherwise natural coagulant aids are used for water treatment such as Corchorus Olitorius L (COL). Natural coagulants and coagulant aids were prepared or extracted from plants, animals, or other organisms as Sesbania Seed Gum (Chua et al., 2020),Dolichas lablab, Azadirachta Indica as Natural Coagulants by(Saravanan et al., 2017),Moringa used for turbidity removal and microalgae to surface water (Moreno et al., 2016), stem of Corchorus OlitoriusL. (COL)for treatment of turbid water was used by (Al Taher et al., 2016).

From the health point of view, there is significant relationship between Aluminum and Alzheimer’s disease for both workers and people who use water or drink it, moreover might contain high Aluminum content which exceeds the recommend range after purification process (Li *et al*., 2020). There is higher Aluminum content in people’s brain that has Multiple Sclerosis’s disease (Linhart, *et al*., 2020) and also other diseases related with the presence of Aluminum in brain such as Parkinson's disease that the WHO for aluminum mustn’t exceed 0.2 mg/l for drinking water.

Every year in Egypt, high amount of Aluminum sulfate is consumed in water purification process around 365 million tons with large amount of sludge produced. (Abd EL-Razek et al., 2016), around 111 thousand tons with large amount of sludge produced in Greater Cairo Water Company GCWC every year.

In this study waste Corchorus Olitorius L (COL) wastes are used as natural coagulant aids with Aluminum sulfate in highly turbid water treatment to reduce the amount of Aluminum sulfate consumed in order to avoid high cost and harmful effects to humans.

MATERIALS AND METHODS

1. Preparation of highly turbid water

Highly turbid water was prepared by adding kaolin (from AlumCo, Egypt "ASCE") to water supplied from tap water inside the water treatment plant. The characterization of kaolin is represented in Table (1)

Table 1: Chemical composition of kaolin

PARTICLE SIZE	< 20 µM									
Density gm/cm^3	2.65									
L.O.I	11.6									
Oxides %	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	CaO	MgO	TiO_2	P_2O_5	SO_3
	51.5	42.5	1.85	0.03	0.12	0.29	0.1	3.13	0.16	0.32

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Tap water turbidity is (0.5-1.5 NTU) and residual chlorine (0.4-0.5). It should be noted that the chlorine disappeared after adding kaolin. The residual water used in this study represents a real water sample that simulates the surface water properties and components.

First, kaolin suspension of 20 g/l was stirred and settled for about 12 hours then prepared 2000 NTU stored as stock. After that both high turbid concentrations samples 500 and1000 NTU were prepared by diluting using water. At the beginning of each run, homogeneity of the fresh sample is ensured by stirring for 30 minutes for complete hydration.

Initial Alkalinity of suspension 100 mg/l was adjusted by calcium hydroxide to 120 mg/l. The pH was adjusted by NaOH and HCl. Alkalinity and pH were measured by standard methods.

Table 2: Characteristics of turbid water

TURBIDITY (NTU)	PH	RES. ALUM.(MG/L)
500±10	7.5±0.2	0.1
1000±10	7.5±0.2	0.1

2. Preparation of primary coagulant (Aluminum sulfate)doses

The primary coagulant in this study is Aluminum sulfate [$Al_2(SO_4)_3.18H_2O$]; the same used in water treatment plants in Egypt.

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Table 3: Chemical composition of aluminum sulfate

EXAMINATION	RESULT	MAX. RANGE
Aluminum oxide	8.083%	At least 8%
Fe	0.087%	At max 0.35%
pH	1.325	At least 3
Non dissolved substances	0.018%	At max 0.2%

There are other minor substances as Cr, Cd, Hg…. etc.

Aluminum sulfate as stock liquid solution 50% w/w concentration supplied from Alum Co, Egypt "ASCE (density 1.325). Add 15.1 ml and 151 ml of stock Aluminum sulfate to 1L of distilled water for preparing two concentrations 1% and 10% respectively. High doses of primary coagulant solutions of 70-120 mg/l were prepared out from 10% conc. solution, while low doses 10-60 mg/l were prepared out from 1%.

3. Preparation of Corchorus Olitorius L extracts.

COL wastes were brought from local market. First step is the drying of the fresh stems and tiny leaves (which were manually selected) for 48 hrs, but in different ways. The ideal condition found to be drying of stems under sunlight in open air, and drying of leaves at shade and room temperature to keep leaves green. Both types of dried mass are individually ground using a domestic electric blender and then sieved to obtain powders with 200 μm particle size.

Three coagulant aids extracted from fresh waste parts of COL; namely are stems and tiny leaves (which are not used in foods); with aqueous and ethanolic extracts. The coagulant aids named as C0, C1 and C2

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1.3 Aqueous extractions of COL stems and leaves

One gram of each powder was soaked in one liter of distilled water for 6 hrs and then stirred for 2 hrs. The suspensions are filtered with Whatman filter paper grade No 1, the supernatants kept in fridge as the extracts stock solutions for two days at most to prevent aging phenomenon.

2.3 Ethanolic extracts of COL leaves

One gram of leaves powder that is stirred soaked and filtered to be extracted in 100 ml of 99.5 % ethanol for 24 hrs. The supernatant kept in fridge as the stock solution.

3. 3 Jar test Coagulation experiments

Jar test VelpScientifica JLT6 Europe is used. All tests were carried out with one liter samples in 6 beakers. Different types and concentrations of coagulant and coagulant aids were added to water samples with different turbidities 500 and 1000 NTU. Rapid stirring was applied at 120 rpm for 2 min to ensure adequate mixing of the suspensions, followed by slow mixing 25 rpm for 20 min to obtain collisions and aggregate of particles. The suspension is allowed to settle at different periods 5, 10, 15, 20 min, and then samples are collected from supernatants for analysis.

4.3 Analytical methods

In order to assess the performance of COL coagulant aids acting with Aluminum sulfate primary coagulant, three physicochemical properties of the treated water were investigated: Turbidity, pH and residual Aluminum concentration. Turbidity was measured using Turbidimeter (Hach 2100N, Hach TL2300 USA). The pH is measured by (HQ440d pH meter) to make sure that pH within the recommended range.

Residual Aluminum is measured by spectrophotometer Jenway 6715 USA, HACH DR 6000 (3500-Al B. Eriochrome cyanine R method).; according to the 23rd edition of "Standard Method for the Examination of Water and Wastewater".

RESULTS AND DISCUSSION

1 Effect of Primary coagulant (Aluminum sulfate) doses on turbidity, pH and residual Aluminum.

1.1 Effect on removal of turbidity:

Aluminum sulfate doses from 10-60 mg/l were added to turbid water 500 NTU while doses from 10-120 mg/l were added to turbid water 1000 NTU. Turbidities were measured after 5, 10, 15 and 20 min for determine the optimum dose of alum. The optimum dose of Aluminum sulfate for both turbidities 500 NTU and 1000 NTU was 30 mg/l. At high turbidity (1000 NTU) there may be more collisions between particles so there were more chances for particles to aggregate with the same dose of Aluminum sulfate as shown in figs 1, 2. Turbidity removal efficiency was slightly decreased by increasing in Aluminum sulfate doses as also suggested by some other authors (Daryabeigi and Hoveidi, 2015, Shen, 2005). After filtration the turbiditiesdecreased to <1.

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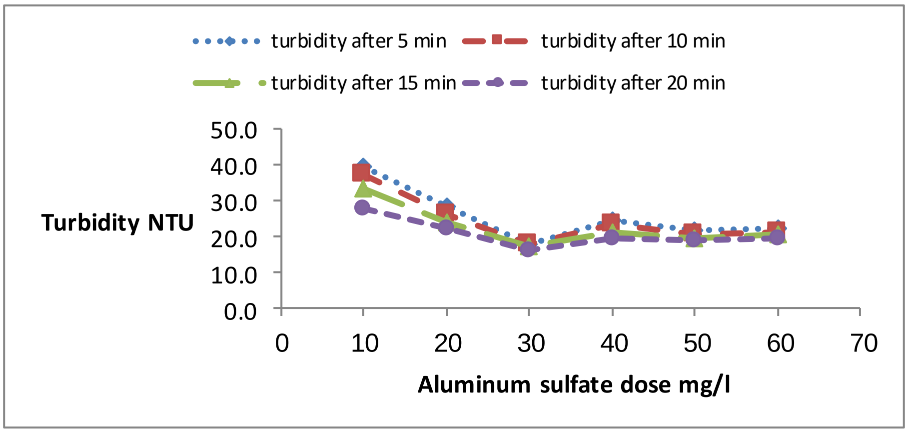
The performance efficiency of primary coagulant and coagulant aids calculated by initial and residual turbidities as following:

$$\text{Efficiency\%} = \frac{(\text{Initial turbidity} - \text{Residual turbidity})}{\text{Initial turbidity}} \times 100$$

(a)



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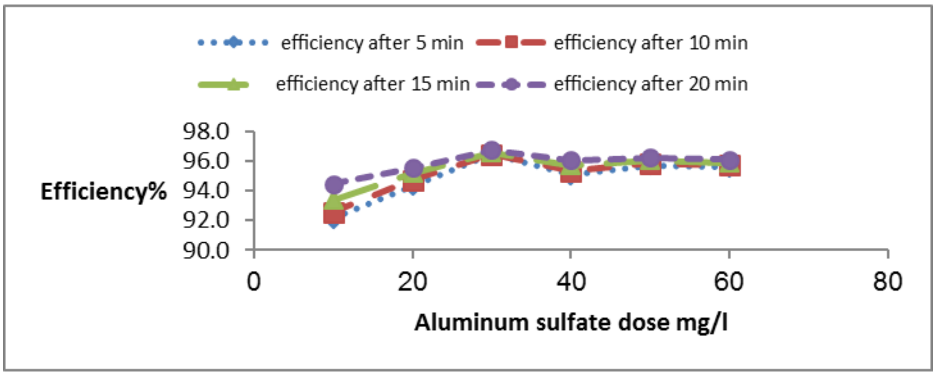

Fig 1 (a): Effect of primary coagulant Aluminum sulfate on removal of turbidity 500, (b) The efficiency of Aluminum sulfate for removal turbidity.

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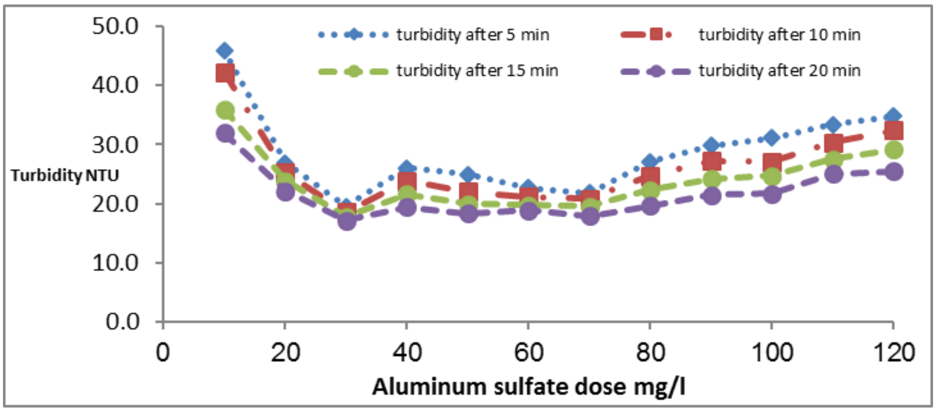
(a)



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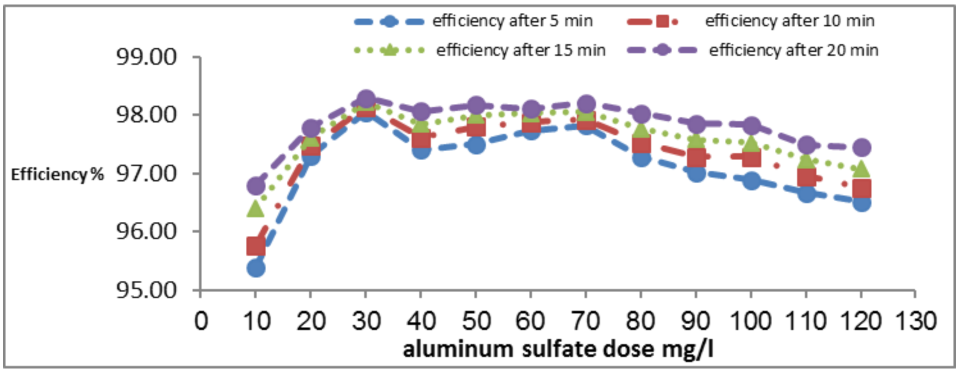

Fig 2 (a): Effect of primary coagulant Aluminum sulfate on removal of turbidity 1000, (b) the efficiency of Aluminum sulfate for removal turbidity.

1.2 Effect on pH

In the beginning of the experiment the pH was at about 7.5. The pH deceased with the increase of Aluminum sulfate doses. The pH for the least Aluminum sulfate dose 10 mg/l decreased to 7.3 for both turbidities. At the optimum dose 30 mg/l pH decreased to 7, 7.1 for the turbidities 500 and1000 NTU respectively. Increasing of result turbidities were accompanying with decreasing of pH especially for high Aluminum sulfate doses from 80 to 120 mg/l. The pH decreased to below the specification of WHO for the Aluminum sulfate doses 80-120 that the pH was 6.4-5.9 that reduction may be accompanying with charge reversal and destabilization of colloidal particles because of overdosing than usual was shown in fig 3.4.As the Aluminum sulfatedose increased, the pH decreased that also suggested by some other researchers. (Donovan et al., 2018)

1.3 Effect of on residual aluminum

In the beginning of experiment the turbid water's residual aluminum was about 0.1 mg/l. the residual Aluminum is varied after the addition of different doses. The concentration of residual Al expressing as going down at the beginning and then going up later for both turbidities. The residual aluminum was 0.18, 0.19 mg/l for the Aluminum sulfate dose 10 mg/l for turbidities 500, 1000 NTU, while the residual aluminum was 0.16, 0.17 mg/l for the optimum Aluminum sulfate dose 30 mg/l for turbidities 500, 1000 NTU respectively. The residual aluminum exceed the WHO specification at high doses as shown in figs 3 and 4.Unstable suspended or particulate aluminum could be simply decreased from the water during the coagulation and sedimentation process especially along with optimum dose of Aluminum sulfate30mg/l for both turbidities 500 NTU and 1000 NTU. According to Krupińska et al., 2019, when Aluminum coagulants were added to water a series of soluble hydrolysis species are formed as: Al^{3+}, $Al(OH)^{2+}$, $Al(OH)_2^+$, $Al(OH)_3$, $Al(OH)_4^-$.monomers and nonionic, anionic and also cationic polymers. As the aluminum sulfate concentration increasing, the residual Aluminum increased after the coagulation process too.

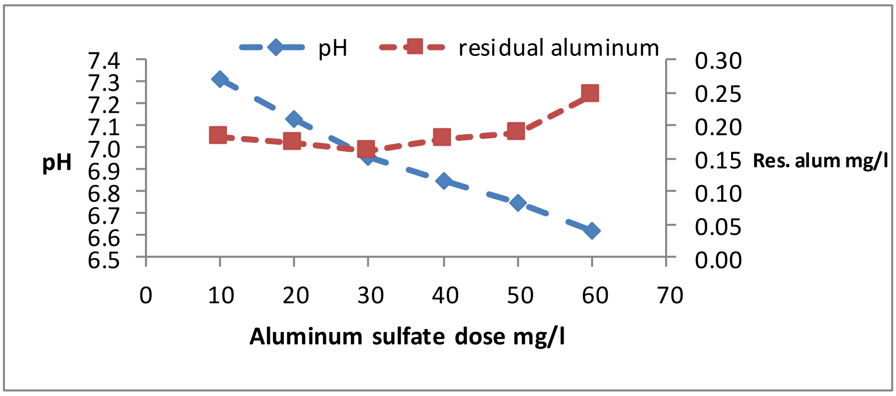

Fig 3: The effect of Aluminum sulfate dose on pH and residual Aluminum without filtration for highly turbid water 500 NTU

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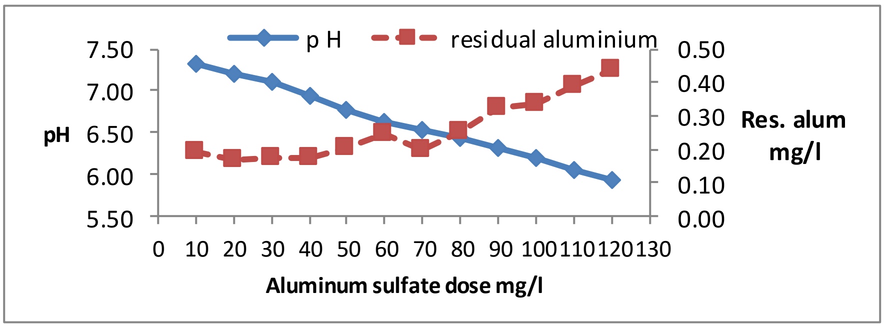

Fig 4: The effect of Aluminum sulfate dose on pH and residual Aluminum without filtration for highly turbid water 1000 NTU.

2 Synergistic effects of Corchorus Olitorius L extracts as coagulant aids accompanying with Aluminum sulfate on turbidity, pH, and residual aluminum.

2.1 Synergistic effect on turbidities

During preparation of Corchorus Olitorius L and according to the authors experimental trials in the current study, drying of leaves under direct sunlight, results in an extract with notable poor efficiency as coagulant aid. It may due to some degree of thermal decomposition of the bio-polymer. COL extracts as coagulant aids C0, C1, C2 doses accompanying with 10 mg/l Aluminum sulfate were added to turbidity 500, 1000 to indicate the optimum dose of this coagulant aid as shown in figs 5,6,7,8,9 and10.The optimum dose of leaves aqueous extract C1 was 4, 3 mg/l with turbidities 2.4, 2.7 NTU for turbidities 500, 1000 NTU respectively. The optimum dose of leaves ethanolic extract

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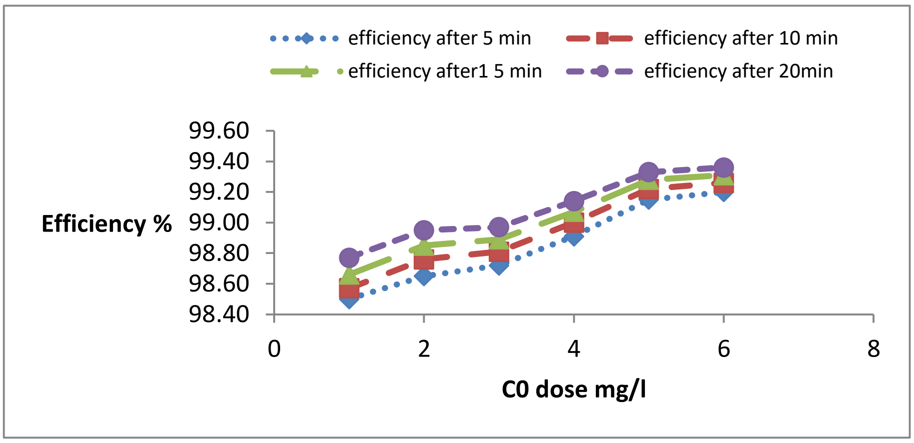
C2 was 5 mg/l with turbidities 3.0, 4.1 NTU for turbidities 500, 1000 NTU respectively. While the optimum dose of stem aqueous extract C1 was 6, 5 mg/l with turbidities 3.2, 4.3 NTU for turbidities 500, 1000 NTU respectively. So, the COL leaves aqueous extract C1 as coagulant aids could be better than aqueous extract C0 and leaves ethanolic extract C2. Turbidities had decreased with settling time. Corchorus extracts as coagulant aids had collected flocs at the center of jar rabidly and more homogeneous. The layer of water above those flocs was clear than Aluminum sulfate only. Turbidities of all samples decreased after filtration to <1.At Turbidities 500, 1000 NTU all coagulants aids efficiency exceed 99% with slightly better efficiency for C1 99.5% was more than C0 and C2 99.4% as shown in figs 5, 6, 7, 8, 9, and 10.



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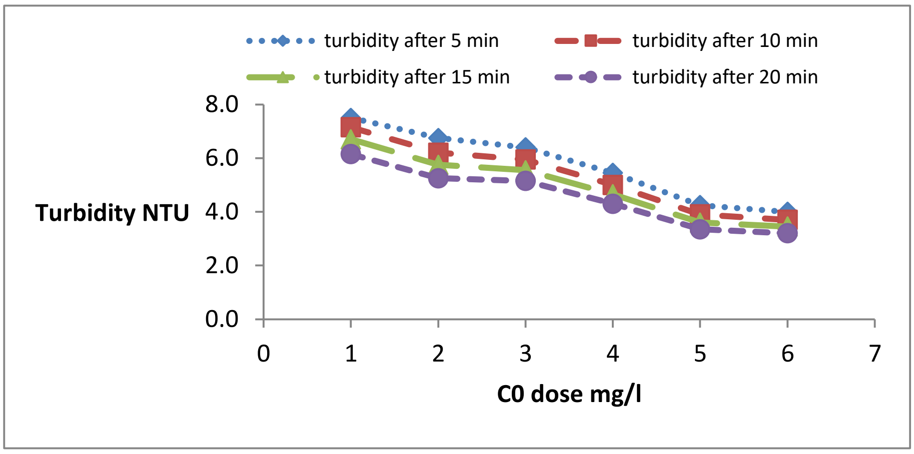
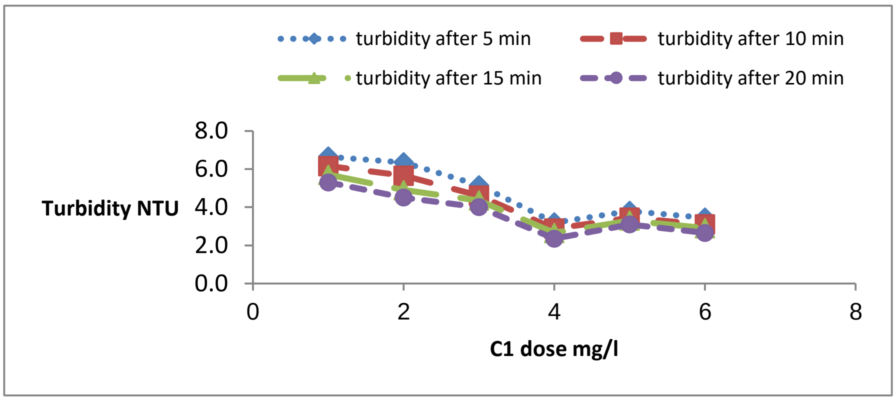


(b)

Fig 5 (a): Effect of dose of Corchorus Olitorius L C0 (aqueous extraction) accompanying with Aluminum sulfate dose 10 mg/l on highly turbid water 500 NTU (b) efficiency of C0 on highly turbid water 500 NTU.



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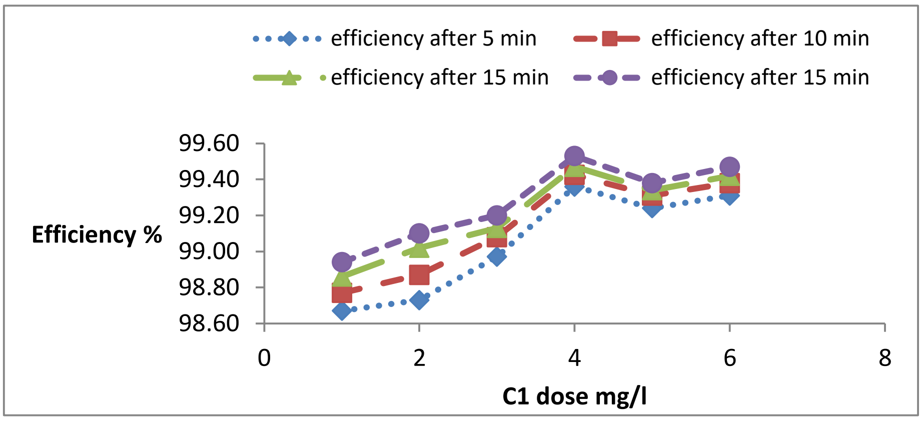

(b)

Fig 6 (a): Effect of dose of Corchorus Olitorius L C1 (aqueous extraction) accompanying with Aluminum sulfate dose 10 mg/l on highly turbid water 500 NTU (b) efficiency of C1 on highly turbid water 500 NTU .

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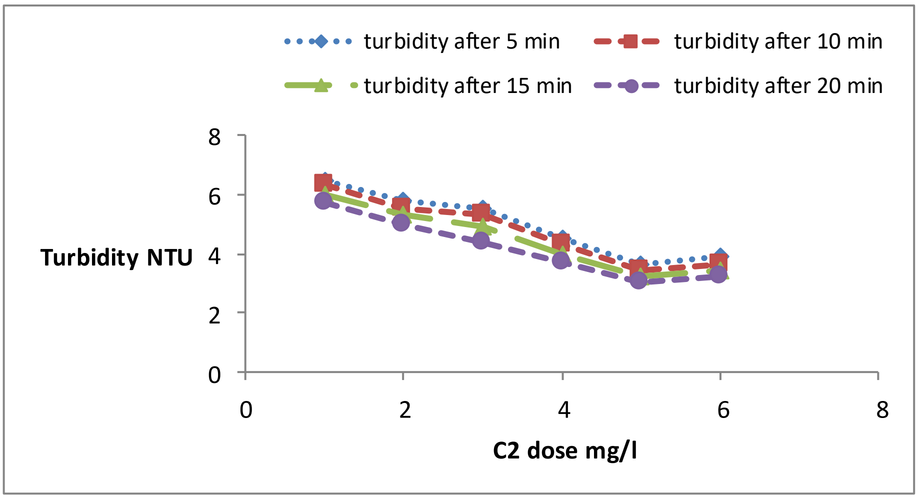
(a)



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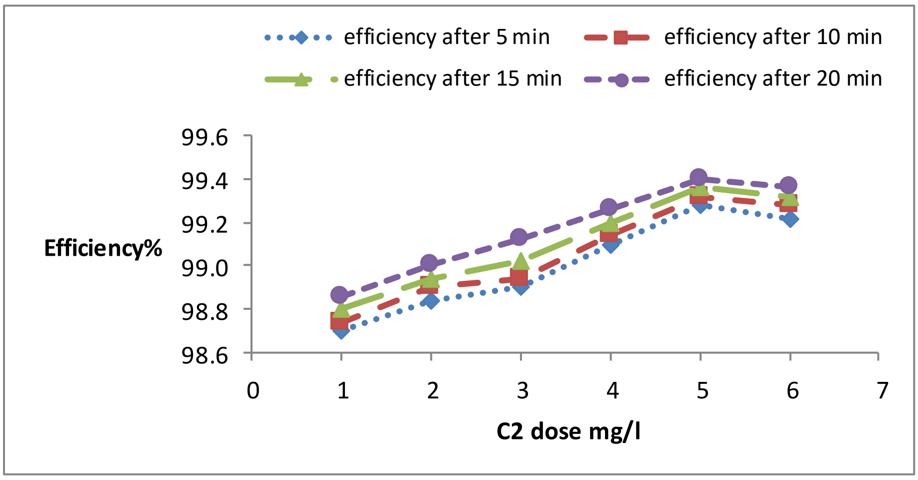

Fig 7 (a): Effect of dose of Corchorus Olitorius L C2 (ethanolic extraction) accompanying with Aluminum sulfate dose 10 mg/l on highly turbid water 500 NTU (b) efficiency of C2 on highly turbid water 500 NTU .

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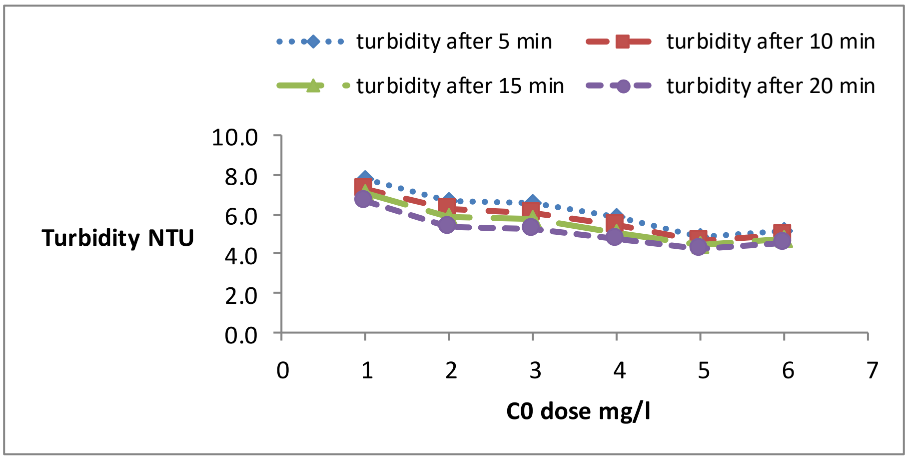
(a)



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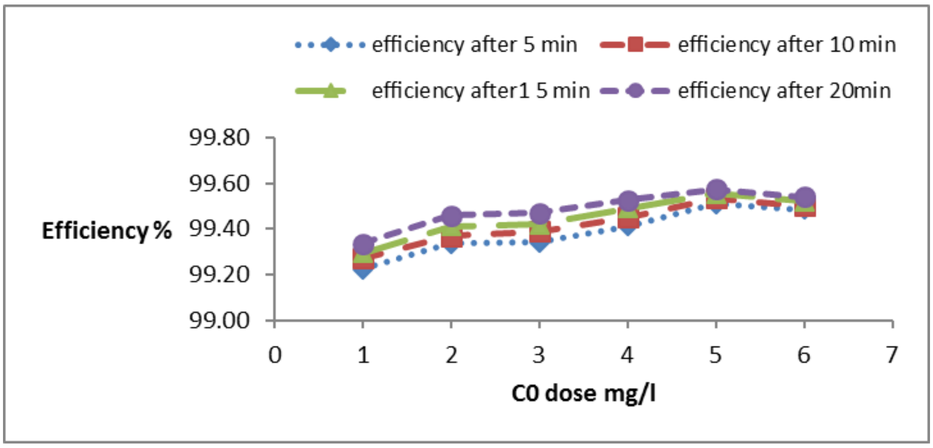

Fig 8 (a): Effect of dose of Corchorus Olitorius L C0(aqueous extraction) accompanying with Aluminum sulfate dose 10 mg/l on highly turbid water 1000 NTU (b) efficiency of C0 on highly turbid water 1000 NTU .

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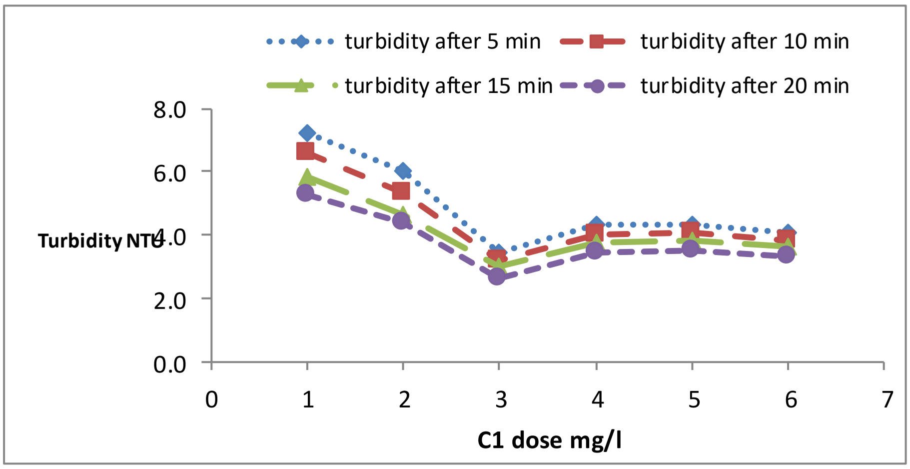
(a)



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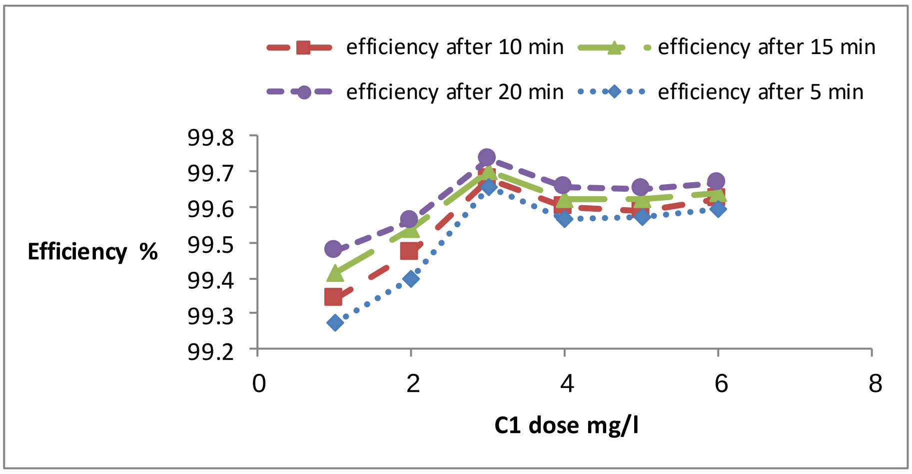
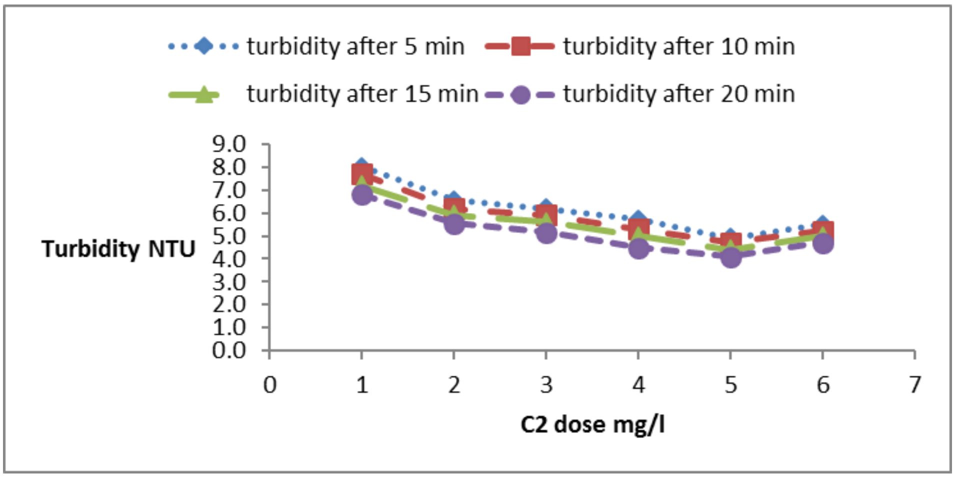


Fig 9 (a): Effect of dose of Corchorus Olitorius L C1(aqueous extraction) accompanying with Aluminum sulfate dose 10 mg/l on highly turbid water 1000 NTU (b) efficiency of C1 on highly turbid water 1000 NTU

(a)



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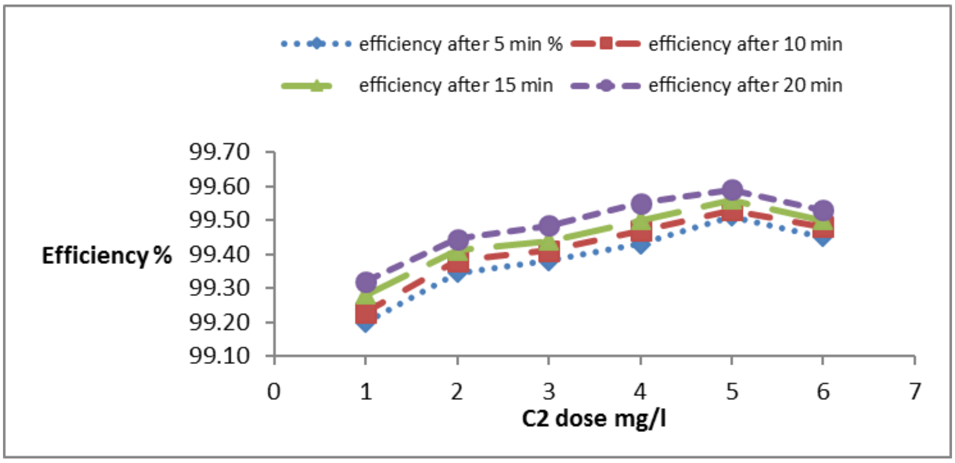

Fig 10 (a): Effect of dose of Corchorus Olitorius L C2(ethanolic extraction) accompanying with Aluminum sulfate dose 10 mg/l on highly turbid water 1000 NTU (b) efficiency of C2 on highly turbid water 1000 NTU

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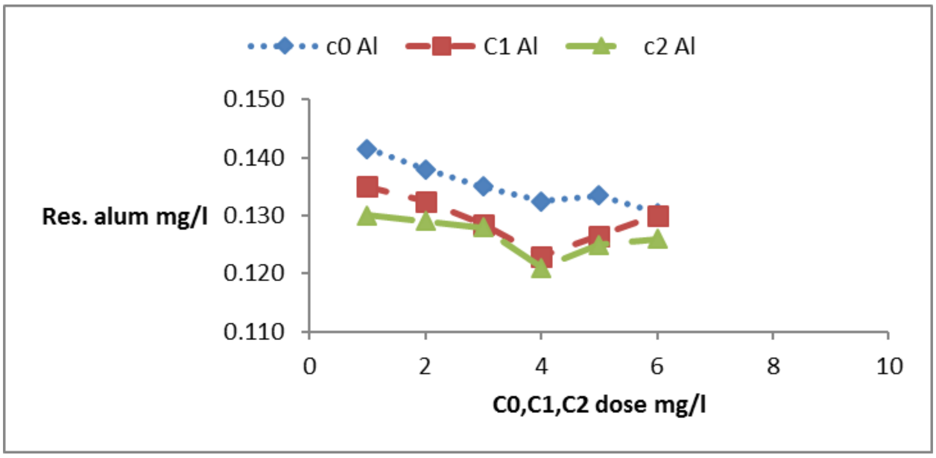
3.2. The effect on pH

There wasn't significant variation in pH after adding the coagulants aids (aqueous or ethanolic) C0, C1or C2. The used doses just decreasing pH within0.01 - 0.04pH units shift.

3.2.3The effect on residual Aluminum

There wasn't significant differences after adding The extracts (aqueous - ethanolic) of Corchorus Olitorius L C0, C1, C2on the resulted residual Aluminum that is because Aluminum sulfate dose 10 mg/l was used in all experiments and doses of different extracts C0, C1, C2 that may help in improving the turbidities and decreased them to low values, but it slightly effect on residual Aluminum by fractions of thousands to hundreds. Colethanolic extraction C2 results in low values of residual Aluminum than C1 and C0 because it may have slightly better precipitation of Aluminum. The residual Aluminum values for all COL extractions as coagulant aids were less than residual Aluminum of Aluminum sulfate only as shown in figs3, 4, 11.

(a)



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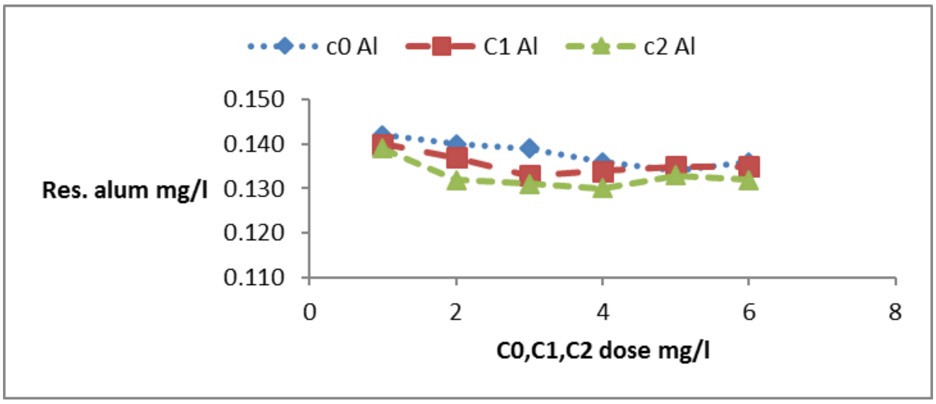

Fig 11: (a)The effect of Corchorus Olitorius L coagulant aids C0,C1,C2 on residual Aluminum without filtration for highly turbid water 500 NTU(b) The effect of Corchorus Olitorius L coagulant aids C0,C1,C2 on residual Aluminum without filtration for highly turbid water 1000 NTU.

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In this study corchorus olitorius L different parts (leaves and stem) extracts with water and ethanol are used for treatment of highly turbid surface water 500 and 1000 NTU. Surface water characterization is taken into consideration. Residual aluminum is measured to ensure that the used doses within the range of WHO. Low dose of aluminum sulfate was used 10 mg/l with col aids On the contrary (Al Taher et al., 2016) used stem only for treatment of 100 NTU with high doses.

3.3. Flash spill water samples treatment by Corchorus Olitorius L extracts as coagulant aids

Natural highly turbid flash spill water samples were collectedfrom Sharkawiya Canal in Shobra El Khema, in north of Cairo. The prepared coagulants aids were tested for the coagulation process of these samples. Characteristics of Flash spill water tabulated in Table 4 as following:

Table 4: Characteristics of Flash spill water

TURBIDITY (NTU)	PH	RES. ALUMINUM (MG/L)
500±10	7.5±2	0.08

Primary coagulant different doses were added to this turbid water to indicate the optimum dose. Residual Aluminum for optimum dose was measured. The least residual turbidity had been 13.2 for the optimum dose of Aluminum sulfate 50 mg/l the turbidity decreased to <1 after filtration. The residual Aluminum for this dose was 0.24 mg/l which exceed the recommended range of drinking water.

Stem and leaves aqueous extracts C0, C1 doses accompanying with 10 mg/l Aluminum sulfate were added to the real sample to determine the optimum dose of the coagulant aids. C1and C0 could decrease turbidity from 500 to 4.9, 3.6 that were better than Aluminum sulfate only as shown in fig 12, 13 and 14.

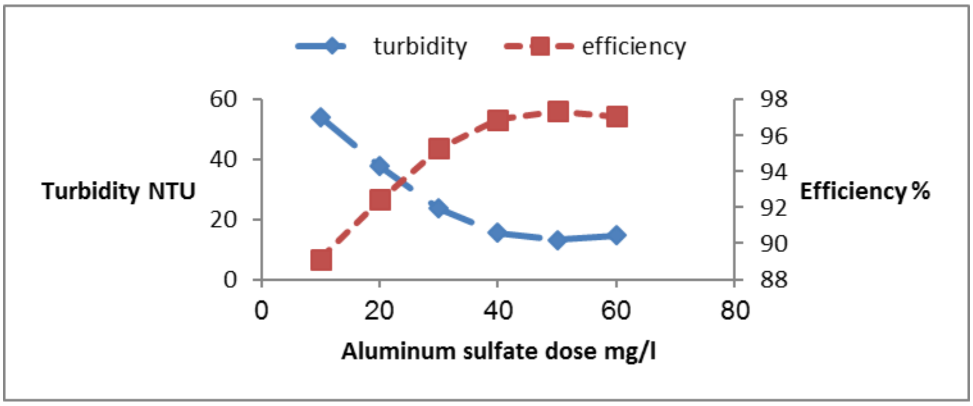

Fig 12: Effect of Aluminum sulfate doses on real samples of high turbid water 500 NTU during flood from Sharkawiya canal in Shobra El khema plant.

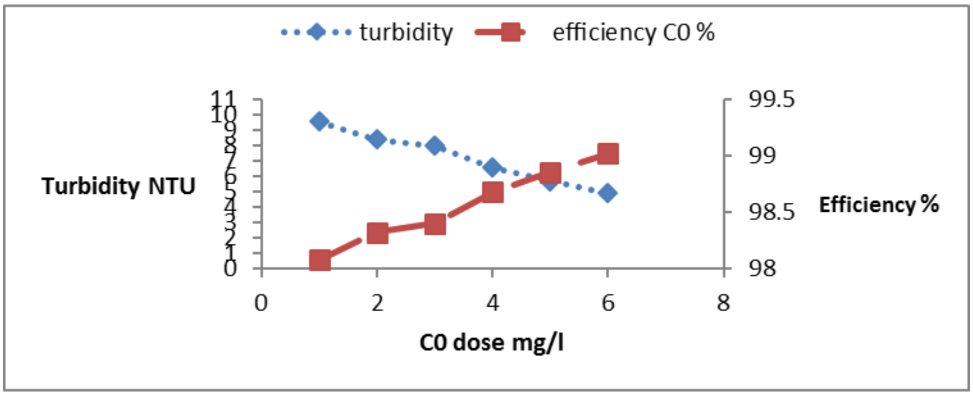

Fig 13: Effect of Corchorus Olitorius L extract (C0) doses accompanying with Aluminum sulfate 10 mg/l on real samples of high turbid water 500 NTU during flood in Shobra El Khema Plant.

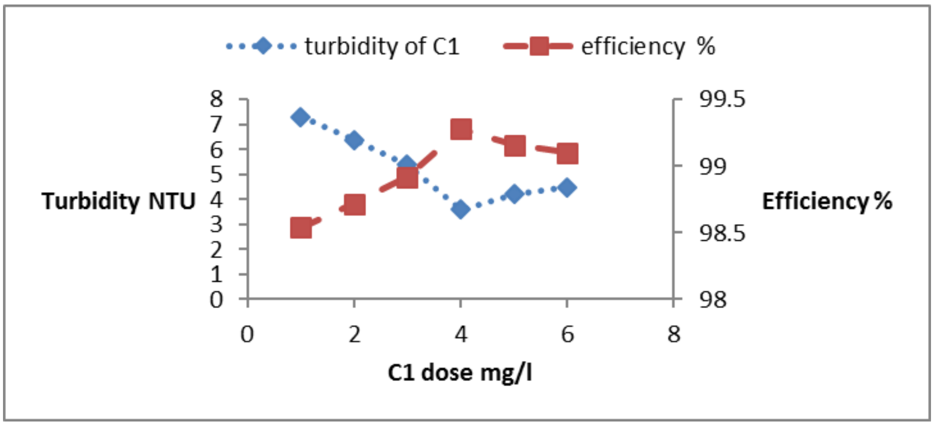

Fig 14: Effect of Corchorus Olitorius L extract (C1) doses accompanying with Aluminum sulfate 10 mg/l on real samples of high turbid water 500 NTU during flood in Shobra El Khema plant.

3.4 Coagulation mechanism of Corchorus Olitorius L

COL leaves and stem have high amount of polysaccharide (rhamnose, glucose, galacturonic, glucuronic, uronic acids,Galactose, arabinose and mannose), total phenols and total flavonoids too (Hassan *et al.,* 2019, Yousef *et al*,. 2020, Yakoub *et al*,. 2020) they have many function groups as (H-bonded OH group, phenols Carboxyl acid groups, , hydroxyl and carboxyl groups) so they could have higher adsorption ability (Chakraborty *et al.,* 2020). All of these functional groups are typical acidic functional groups, which may favor the adsorption of highly turbidities of surface water, (Hashem and Amin, 2016) support that explanation. According to Kurniawan *et al.,* (2020) and Hussain and Haydar (2021), the interparticle bridging may takes place through highly reactive group for polymers (polysaccharides and protein), so the flocs will be high compact and less in volumes. Other authors were support similar explanation of the act of natural coagulants and coagulant aids as (Lim *et al*,. 2022, Díaz *et al*,. 2017,Teh, *et al*,. 2016, Shak and Wu, 2015, Li *et al*,. 2006).

CONCLUSIONS

This study was conducted to evaluate of Corchorus Olitorius L (COL) wastesextracts as natural coagulant aids performance in treatment of highly turbid water of initial turbidity 500 and 1000 NTU. Aluminum sulfate was used as a primary coagulant. Different parts of COL (leaves and stem) extracts asC0, C1 and C2 showed excellent removal of high turbidities at their optimum doses, and could reduce Aluminum sulfate consumption more than 60%, neglecting the effect on both pH and residual residual aluminum concentrations. Leaves aqueous extract C1 has better results than ethanolic extract C2.

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تقييم معالجة المياه مرتفعة العكارة باستخدام مستخلصات مخلفات نبات الملوخية كمساعدات مروبات طبيعية

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المستخلص

تم عمل هذه الدراسة كمحاولة لحل المشكلة الطارئة الخاصة بارتفاع عكارة المياه السطحية التى وجدت مؤخرا فى مصر. تجد محطات مياه الشرب صعوبة بالغة فى معالجة العكارات المرتفعة والتحكم بجودة مياه الشرب طبقا لمواصفات منظمة الصحة العالمية نتيجة استهلاك كمية كبيرة من الشبة اثناء ارتفاع العكارة مما يسبب ايضا ارتفاع التكلفة. في هذا البحث تم استخدام مستخلصات مخلفات نبات الملوخية (الساق– الاوراق الصغيرة التى لا يستخدم فى اغراض الطعام) كمساعدات مروبات و استخدامها في معالجة عينات مياه عالية العكارة اصطناعية وأخري طبيعية. تم تحضير مستخلصات مخلفات الملوخية بالماء و الكحول الايثيلى. اطلق اسم C1 على المستخلص المائى لورق الملوخية و C0على المستخلص المائى لساق الملوخية و C2 على المستخلص الكحولى لورق الملوخية. استخدمت هذه المستخلصات فى عملية تحسين العكارات ٥٠٠–١٠٠٠ مع المروب الاساسى الشبة. تم قياس الاس الهيدروجينى لمعرفة تاثير الجرعات المختلفة. وقياس الالومونيوم المتبقى للتأكد انه مطابق للمواصفات القياسية لمياه الشرب. تم قياس النتائج الخاصة بالعكارة بعد ٢٠،١٥،١٠،٥ دقيقة و كانت الجرعة المثالية بعد ٢٠ دقيقة. بناءا على نتائج اختبار الجار فإن مستخلصات الملوخية اثبتت كفاءة عالية كمساعد مروب في تقليل العكارة من ١٠٠٠ و٥٠٠ وحدة عكارة نفلوميترية الى ٢،٧،٢،٤ وحدة عكارة نفلوميترية للمستخلص المائى للورقC1 عند الجرعات ٤–٣مجم/ لتر و تقليل العكارة الى ٤،٣،٣،٢ وحدة عكارة نفلوميترية لمستخلص الساق C0عند الجرعات ٦–٥ مجم/ لتر و ايضا تقليل العكارة الى ٤،١،٣وحدة عكارة نفلوميترية للمستخلص الكحولى C2 للجرعة ٥ مجم/ لتر بدلا من ٣٢،٢٧،٨ وحدة عكارة نفلوميترية لجرعة الشبة ١٠ مجم / لتر فقط على الترتيب بعد ٢٠ دقيقة. لوحظ تحسن فى عملية التنديف باستخدام جرعات قليلة جدا من من المستخلصات ١–٦ مجم/ لتر والتى اعطت نتائج فضل لعملية المعالجة.

الكلمات المفتاحية: العكارة العالية،مساعدات الترويب، نبات الملوخية، مياه الفيضان