

## TESTING OF CONVENTIONAL AND NATURAL COAGULANTS IN SINGLE AND BINARY SYSTEMS TO TREAT TURBID WATER

\*Sarah Tariq Abaas<sup>1</sup>

Ahmed Hassoon Ali<sup>2</sup>

1) Environmental Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq.

2) Environmental Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq

Received 20/11/2019

Accepted in revised form 09/01/2020

Published online 01/09/2020

**Abstract:** In this research the impact of utilizing coagulants from natural sources, Aloe Vera, Arabic Gum, Calcium gene and orange peel and compared with alum  $Al_2(SO_4)_3 \cdot 18H_2O$  conventional coagulant was studied. The research was conducted through a series of jar experiments with initial turbidity of 150 Nephelometric Turbidity Units (NTU). This value was chosen to simulate the Tigris River maximum turbidity in Baghdad. 10 mg/L of natural coagulants and alum were utilized. The results show that the utilization of Aloe Vera as coagulant aid with alum were better compared with the utilization of alum alone and that utilizing of 80% alum + 20% Aloe Vera gave greatest removal efficiency of 99% for initial turbidity of 150 NTU and that utilizing of 50% Alum + 50% Aloe Vera gave removal efficiency of 98%. This decreased the alum dosage from 10 to 5 mg/L and thus decreased the cost and negative health and environmental effects of utilizing alum.

**Keywords:** Coagulation, turbidity, alum, Aloe Vera, jar test

### 1. Introduction

Expulsion of complete suspended solids (SS) in wastewater is of overwhelming significance as this factor not just contributes towards crumbling of water quality but also considered as the earnest environmental problems contributors [1]. The existence of suspended solids in water causes

aesthetic issues of the water body and earnest biological degradation of aquatic environments. All streams convey some suspended solids under natural circumstances [2]. Increasing population, expanded economic activity and industrialization has not just made an expanded interest for crisp water yet additionally brought about serious abuse of these natural resources. World Health Organization (WHO) has set the residual turbidity in drinkable water at 5 NTU. The United States Environmental Protection Agency (USEPA) has defined turbidity as a measure of the muddiness of water; it is utilized to demonstrate filtration activity and water quality. High turbidity levels are connected with more elevated levels of dirt, color, organics and sickness-causing microorganisms, for example bacteria, viruses, and parasites [3]. There is an expanding attention for coagulants dependent on natural plant because imported conventional coagulants cost a lot in the less progressing countries and because of the environment and health issues brought about utilizing them. The conventional coagulants such as alum and polyaluminium chloride [4, 5] for

\*Corresponding author: [sarah.tariq27@yahoo.com](mailto:sarah.tariq27@yahoo.com)

water purification are very expensive and development countries couldn't find the fund to import such large quantities of above coagulants. Because of this, such nations favor strategies with low expenses and techniques that require less affordable expertise and servicing. Right now, over the globe, water treatment plant usually still used polyaluminium chloride and alum which can possibly cause cancer [6, 7]. In dialysis encephalopathy, aluminum is viewed as a basic component that reason poison. Alzheimer sickness may be brought about by Aluminum [8, 9]. Strong impacts of cancer and toxic substance acting in the spooky system are found in polymers that are organic and synthetic like acrylamide [4, 8]. So there raised voice to create cost effective, simpler and environmental friendly procedure of water clarification. The historical backdrop of the utilization of natural coagulants is long. Natural organic polymer has been utilized for over 200 years in India, Africa and China as active coagulants and coagulants aids at high water turbidities. These natural organic polymers are important because comparative to the utilization of manufactured polymer containing acrylamide monomers, no human wellbeing risk and the expense of these natural coagulants would be less affordable over to the conventional synthetic [10].

In this research, the using of conventional coagulant alum and natural coagulants (Aloe Vera, Arabic gum, calcium gene, orange peels) was investigated to treat wastewater contaminated with suspended solid in term of turbidity through series of Jar test experiments.

## **2. Preparation of coagulants solutions**

### **2.1. Aluminum sulphate solution**

1000 ppm of alum was prepared by disbanding 0.1 g of the  $(Al_2(SO_4)_3 \cdot 18H_2O)$  into 100 ml of distilled water and stirred well in order to get the exact concentration.

### **2.2. Aloe Vera**

The Aloe Vera was bought from nursery and washed well to remove the dirt. The thick part is separated from the gel part. The gel part was taken and blended into a mixer and was kept in glass bottle in a refrigerator. 100 mL of distilled water was used to dissolve 1 mL of the gel to obtain 1000 ppm.

### **2.3. Arabic gum**

The Arabic gum is available in many local markets where it bought from. It was grinded into small grains. 0.1g of gum was dissolved in 100 ml of distilled water and was diluted for 5 minutes to prepare the concentration of 1000 ppm.

### **2.4 Calcium gene**

Sodium alginate salt from marine brown algae was purchased from local market and its solution was prepared by disbanding 0.001g/l of alginate and 0.1g/L of calcium into 100 ml of distilled water and stirred well in order to get concentration 1000 ppm.

### **2.5 Orange peels**

The orange peels was gathered from the domestic waste and washed with tap water to remove the dirt from it. The sample was dried under the sunlight for four days. Then they were cut into small pieces and grinded into small particle size powder. 0.1 gram of orange peels powder was dissolved in 100 ml of distilled water to obtain a 1000 ppm concentration. Fig.1 Shows the prepared coagulants and jar test apparatus:



**Figure.1** show: (A) Alum, (B) Aloe Vera, (C) Orange peel powder, (D), Arabic gum powder, (E) calcium gluconate, (F) Jar tester apparatus.

## 2.6 Preparation of simulated turbid water

The turbid water was prepared by adding a measured amount of kaolin where 0.4 g of kaolin was added to 1 liter of distilled water. The work was done on turbidity 150 NTU. The suspension mixed gently at 20 rpm for 1h to obtain a homogenous dispersion of kaolin particles. Then leave the suspension For 24 h to allow for full stability of kaolin solution.

## 2.7 Experiments Procedures

Jar apparatus, Fig. 2 was used to simulate the treatment processes: coagulation, flocculation and sedimentation. Jar test consists of six glass beakers with working volume of 1L and stirrers, which could be adapt to the same stirring conditions for all the beakers. The beakers were filled with 1L of suspension and the coagulant was added to all 6 beakers at same time leaving one beaker as control.

When coagulants are added, the mixing time and mixing strength are of major importance for the success of the treatment steps. Mixing process after the addition of coagulants generally contain of two successive steps [10]:

1. A short time, bushy mixing step strive at optimizing conditions for particle coagulant interactions.
2. A longer time, minimal intensive step strive at flocculation of the activated particles to develop strong, large and separable flocks.

The best dose of alum, Aloe Vera, Arabic gum, calcium gene and Orange peels that utilized for removing turbidity was estimated. The procedure was as follows: -

A different type of coagulants was added while maintaining a concentration of 10 mg/L to 150 NTU turbid water. The suspensions were rapidly stirred at 300 rpm (Gradient velocity  $G=390 \text{ s}^{-1}$ ) for 1 min to ensure proper mixing. Followed by a 50 rpm slow mix for 15 min ( $G=44 \text{ s}^{-1}$ ) to form aggregates and precipitation. Then leave the

suspension for 40 minutes and the sample is drawn from a depth of six centimeters for measuring turbidity and pH [11, 12]. Percentage of turbidity removal was calculated by equation (1):

$$R_c (\%) = \frac{T_{ur.in} - T_{ur.out}}{T_{ur.in}} \times 100 \quad \dots (1)$$

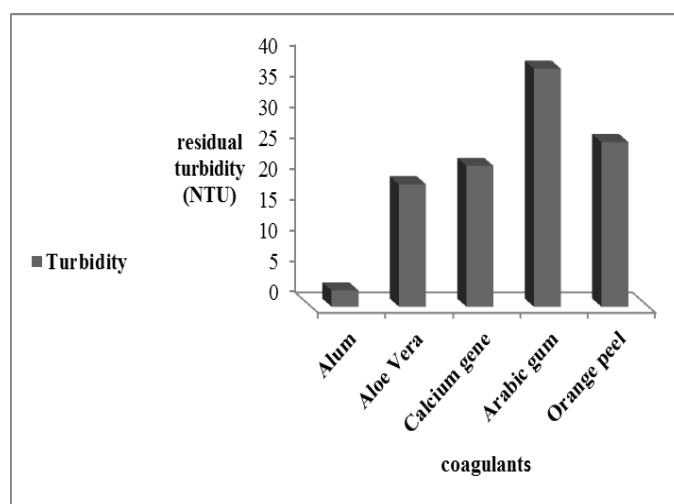
Where,  $T_{ur.in}$  and  $T_{ur.out}$  are the turbidity values before and after treatment process, respectively [13].

## 3. Results and discussion

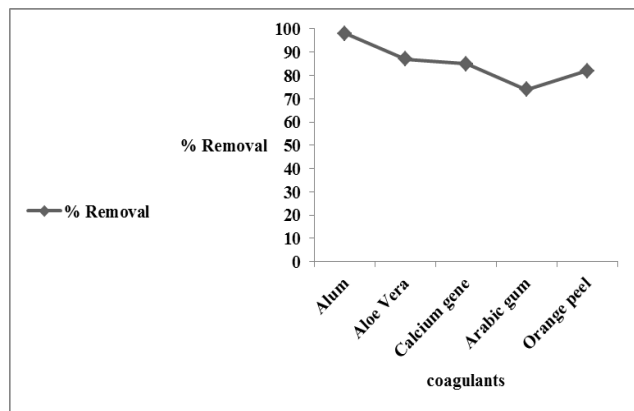
### 3.1 Experiments in single system

#### 3.1.1 Effect of coagulants

Figures 2 and 3 shows the effect of alum, Aloe Vera, calcium gene, Arabic gum and Orange peels on the initial turbidity of 150 NTU. That's where the dose of coagulants was 10 mg /L.



**Figure.2** Residual turbidity verse dose of alum and natural coagulants at the initial turbidity of 150 NTU.



**Figure 3.** Removal efficiency verse dose of alum and natural coagulants at the initial turbidity of 150 NTU.

As noticed from the above Figures that the percentage removal of the turbid water is varied with different coagulants used. For alum the turbidity value decreased from 150 to 2.63 NTU where the percentage removal is 98%. For Aloe Vera the turbidity decreased from 150 to 19.82 NTU where the percentage removal is 87%. For calcium gene the turbidity decreased from 150 to 22.79 NTU where the percentage removal is 85%. For Arabic gum the turbidity decreased from 150 to 38.51 NTU where the percentage removal is 74%. For Orange peels the turbidity decreased from 150 to 26.64 NTU where the percentage removal is 82%. And hence the best natural coagulant after alum was aloe Vera where the removal efficiency was 87%. In general, natural coagulants show good ability in treating relatively high turbidity value and thus could be considered as promising coagulants of nature origin.

The order of coagulants used as a function of turbidity reduction and removal efficiency is as below:

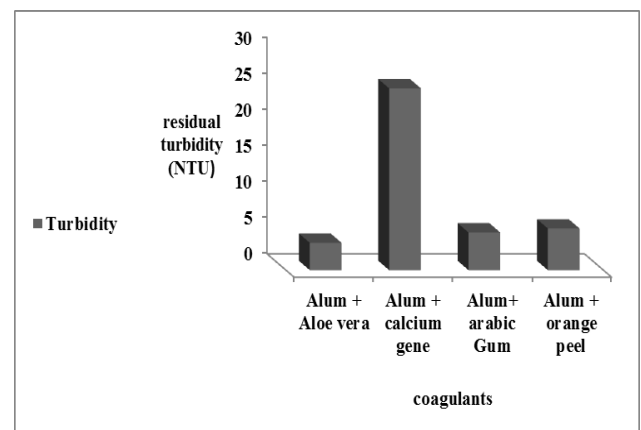
Alum (98%) > Aloe Vera (87%) > Orange peels (82%) > Calcium gene (74%).

Ali et al., 2019 tested coagulants natural including apricot tree gum and peeled nut extract and conventional including alum ( $Al_2(SO_4)_3 \cdot 18H_2O$ ). They found that used of peels nut and apricot gum as coagulant aids with alum were better compared to the use of alum in single system. Their results showed that using of 1/2 alum dosage+ 1/2 peels nut dosage gave percentage removal of 95 and 88% for turbidity

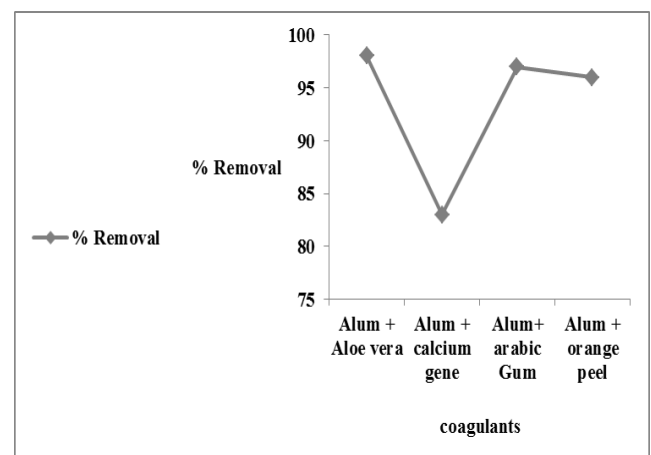
values of 22 and 100 NTU, respectively and that using of 1/2 alum dosage + 1/2 dosage apricot gum gave percentage removal of 90 and 85% for the same turbidity values. At the same time, this decreased the alum dosage significantly from 12 to 6 mg/L [13]. In next experiment alum and Aloe Vera were used as best coagulants to study various parameters.

### 3.1.2 Experiments in binary system

In this experiments alum was used as primary coagulant and Aloe Vera, calcium gene, Arabic gum and Orange peels as coagulant aids to treat the turbid water with turbidity value of 150 NTU utilizing 50% alum + 50% natural coagulants. The dose of each coagulant was 10 mg /L. The outcomes are shown in Figures 4 and 5:



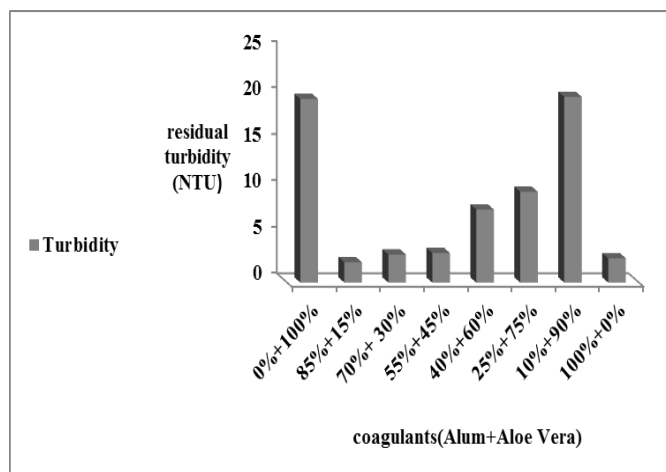
**Figure 4.** Residual efficiency verse dose of alum in conjunction with natural coagulants at the initial turbidity of 150 NTU.



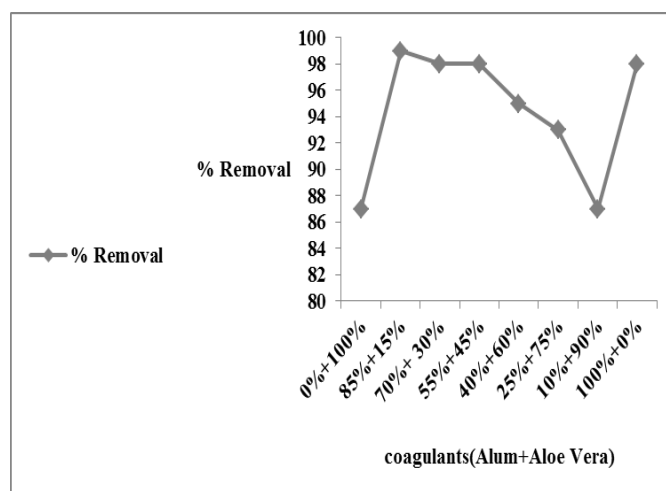
**Figure 5.** Removal efficiency verse dose of alum in conjunction with natural coagulants at the initial turbidity of 150 NTU.

It is clear from the figures 4 and 5 reduces the use of alum in half in conjunction with other natural coagulants gives removal efficiency equal to removal efficiency when using alum alone. The use of 50% alum+50% Aloe Vera the turbidity decreased from 150 to 3.8 NTU where the percentage removal is 98%. The use of 50% alum+50% calcium gene decreased turbidity from 150 to 25.23NTU where the percentage removal is 83%. The use of 50% alum+50% Arabic gum the turbidity decreased from 150 to 5.23NTU where the percentage removal is 97%. The use of 50% alum+50% Orange peels decreased turbidity from 150 to 5.78NTU where the percentage removal is 96% Compared to 98% using alum alone that reduced the dose of alum from 10 to 5 mg/L. This reduces the use of alum and therefore reduces health risks as well as costs.

Since Aloe Vera best coagulants removal for turbidity both when used alone or when mixed with alum. So it was studied the Mix of Aloe Vera with alum and using different doses of alum and aloe Vera. Figures 6 and 7 shows the results:



**Figure 6.** Residual turbidity verse dose of alum combination with Aloe Vera using different concentrations at the initial turbidity of 150 NTU.



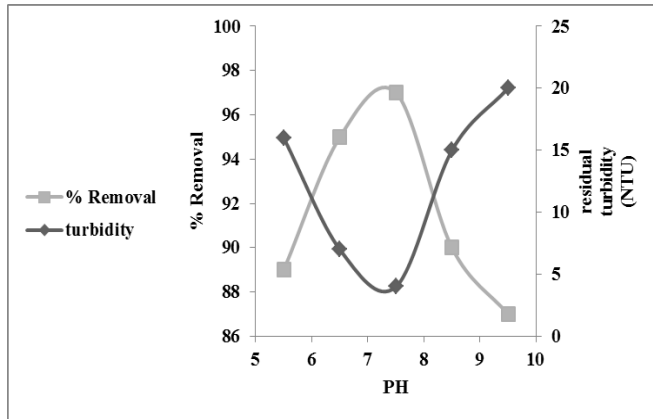
**Figure 7.** Removal efficiency verse dose of alum combination with Aloe Vera using different concentrations at the initial turbidity of 150 NTU.

Referring to Figures 6 and 7 it is seen that the use of alum in different concentrations with Aloe Vera gives removal efficiency equal to the removal efficiency when using alum alone. For 85% alum+15% aloe Vera the turbidity decreased from 150 to 2.2 NTU where the percentage removal is 99%. For 70% alum+30% aloe Vera the turbidity reduced from 150 NTU to 3.04 NTU where the maximum removal efficiency is 98%. For 55% alum+45% aloe Vera the turbidity reduced from 150 NTU to 3.2 NTU where the percentage removal is 98%. For 40% alum+60% aloe Vera the turbidity decreased from 150 NTU to 7.89 NTU where the percentage removal is 95%. For 25% alum+75% aloe Vera the turbidity decreased from 150 to 9.8 NTU where the percentage removal is 93%. For 10% alum+90% aloe Vera the turbidity decreased from 150 to 20.04 NTU where the percentage removal is 87%. From above results show that the use of aloe Vera with alum gives high removal exceed alum removal alone hence reducing the use of alum and thus reducing the related environmental and health risks coming from using of alum alone since there are many concerns about the relation present between

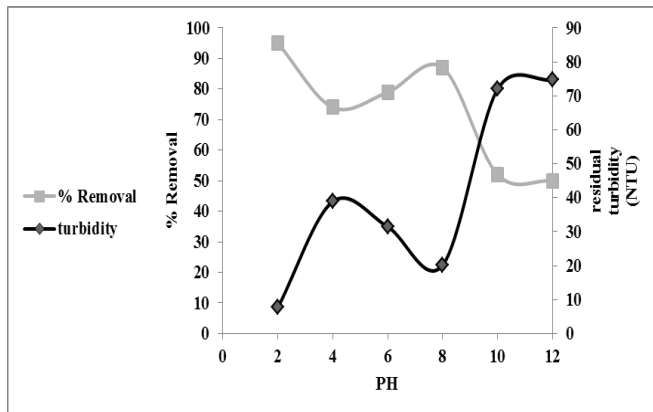
Alzheimer disease and the residuals of aluminum in the treated water [13].

### 3.1.3 Effect of pH in single and binary systems

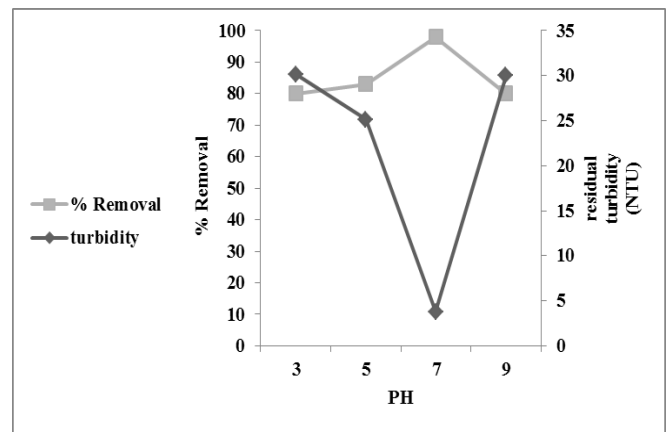
Figures 8, 9 and 10 shows the optimum pH of alum, Aloe Vera both separately and mixed:



**Figure 8.** Determination of optimum pH for 10mg/L alum with initial turbidity 150NTU.



**Figure 9.** Determination of optimum pH for 10mg/L Aloe Vera with initial turbidity 150NTU.



**Figure 10.** Determination of pH for 10mg/L alum and aloe Vera where the dose was 50% alum and 50% aloe Vera with initial turbidity 150NTU.

Examining figures 8 and 9 unmistakably, show the ideal pH for alum was 7 and was like the obtained outcomes by Divakaran, [14] and the ideal pH for aloe Vera was 2 and 8 and from figure 10 show the ideal pH was 7 for their mixture. Also it is clear that the aloe Vera have less sensitivity to the variation in pH when it mix with alum, so the aloe Vera can work at wide range of pH.

### 4. Conclusions and Recommendations

In light of the consequences of the experiments and tests made in this research, the utilizing of natural coagulants show great capacity in lessening the turbidity of water to sensible values and could be utilized alone or in combination with alum. It is cleared that the use of alum with natural coagulants could less the dose of alum by fifty percent and reaches the same removal efficiency which could be considered as promising treatment technique. This could less both cost and health risks of applying alum alone.

Upcoming researches will be done to investigate the economic and health issues resulted from using alum with different ratio of natural coagulants and how that reduces the cost of use alum alone. Also, will be studied Different

parameters including temperature, and speed of mixing in more specifics.

### Acknowledgements

Authors would like to express their grateful to the college of Eng./Mustansiriyah University for her back up to carry out the present work.

### 5. References

1. Bilotta, G.S., & Brazier, R.E. 2008 "Water research, Understanding the influence of suspended solids on water quality and aquatic biota", 42 (2008), pp. (2849 – 2861).
2. Ryan, P.A. 1991" Environmental effects of sediment on New Zealand streams", a review. New Zealand J. Mar. Freshwater Res, 25, pp. (207-221).
3. Connachie, G. L., Folkard, G.K., Matawali, M. A. and Surtherland, J.P. 1999 "Field trials of appropriate hydraulic flocculation process" J. Water Research, 33 (6),pp. (1425-1434).
4. Ghebremichael, K A 2004 "Moringa seed and pumice as natural alternative materials for drinking water treatment", Ph. D. Thesis, Royal Institute of Technology, Stockholm, Sweden.
5. Yarahmadi M, Hossieni M, Bina B, Mahmoudian MH, Naimabadie A and Shahsavani A 2009 "Application of Moringa olifera Seed Extract and Polyaluminium Chloride in Water Treatment", World Applied Sciences Journal, 7 (8)pp. (962-967).
6. Muyibi S and Alfugara MS, 2003 "Treatment of surface water with Moringa olifera seed extract and alum- a comparative study using a pilot scale water treatment plant Intern", J. Environ. Studies, 60 (6) pp. (617-626).
7. Ghebremichael KA, Gunaratna KR, Henriksson H, Brumer and Dalhammar G 2005, "a simple purification and activity assay of the coagulant protein from Moringa olifera seed", J. Water Research, 39 (11) pp. (2338-2344).
8. Okuda T, Baes AU, Nishijima W and Okada M 1999" Improvement of extraction method of coagulation active components from Moringa olifera seed", J. Water Research, 33 (15), pp. (3373-3378).
9. Sharma P, Kumari P, Srivastava MM. and Srivastava S. 2006 "Removal of cadmium from aqueous system by shelled Moringa oleifera Lam Seed powder", Bio resource Technol. 97 (2)pp. (299-305).
10. VanNieuwenhuijzen, 2002 A.F., "Scenario studies into advanced particle removal in the physical-chemical pre-treatment of wastewater", Ph.D.thesis, DUP, Delft, NL.
11. Sulaymon A.H, Ali A. M., Al Naseri S.K. 2009"Natural Organic Matter from Tigris River Water in Baghdad, Iraq", Desalination, 245, pp. (155-168).
12. Hoontrakul, S., 2006 "Evaluation of Coefficients Related to Floc Strength in Multilayer Floating Plastic Media Flocculator", Master's thesis, Kasetsart University.
13. Ahmed, H. A., Younis, S. T., Zainab, A. N., 2019 "Sustainable Used of Natural Coagulants Aid for Enhancing the Performance of Alum to Treat Turbid Water", ICSET journal, pp.(1-9).
14. Divakaran, R., Pillai, V.N., 2002 "Flocculation of river silt using chitosan". Water. Res., 36:pp. (2414-2418).