Sustainable Used of Natural Coagulants Aid for Enhancing the Performance of Alum to Treat Turbid Water

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Abstract. Within the last ten years, many worried about the connection between Alzheimer disease and the residuals of aluminum in the water treatment. Therefore, there has been an increasing interest in developing substances that cause natural coagulation. In this study the effect of using natural coagulants, peeled nut extract and apricot tree gum with alum Al2(SO4)3 and compared to alum alone was investigated. The study was carried out by a series of jar tests with initial turbidity of 22 and 100 NTU. These values were taken to represent the minimum and maximum water turbidity of Tigris River in Baghdad. Different doses of natural coagulation and alum were used (ranged from 2-12 mg/L). After treatment, the turbidity has been measured and the results reflected that, the use of apricot gum and peels nut as coagulant aids with alum were better compared to the use of alum alone and that using of 50% alum + 50% peels nut gave maximum removal efficiency of 95 and 88% for initial turbidity of 22 and 100 NTU respectively and that using of 50% alum + 50% apricot gum gave maximum removal efficiency of 90 and 85% for initial turbidity of 22 and 100 NTU respectively. At the same time, this reduced the alum dose from 12 mg/L to 6 mg/L. This process will reflect on saving cost and reduce health risk associated with using of alum.

1. Introduction
There has been an insistent demand for fresh water due to the growth of population, increasing economy, and industrial development. The second reason of the demand of the fresh water is that the natural resources are used wrongly. There is a threat endangering the water resources across the globe because they are made use of unfairly and they are managed badly and because of the deterioration of the environment. Despite the water can be opaque due to suspended matters, it is used for drinking in many areas in the world. Because of this, the residual turbidity value for the drinkable water was set as 5 (NTU) based on the guideline made by the World Health Organization [1]. Turbidity is considered as a sign of water cloudiness according to (USEPA) United States Environmental Protection Agency; the quality of water and the effectiveness of filtration are indicated by water cloudiness. When there are a large number of organic compounds, color, and clay, this is seen as an indicator of a high level of water turbidity. Thus, this causes microscopic organism that carry diseases represented as bacteria, viruses, and parasites [1].

Coagulation and flocculation are favorable and effective ways for getting rid of suspended particles in water and it is a good way of making water suitable for drinking and making it safer to the heath. This way is favorable due to the effectiveness and simplicity it has [2]. The process starts by adding chemical or
natural coagulants which are used to combine the particles into bigger ones called as (flocs) in order to make sink slowly to get rid of them easily and smoothly [3]. Because they produce desired and intended results, ferric salts and aluminum which are coagulant that are not organic as well as polymers (especially polyethylene imine and polyacrylamide) that are synthetic are greatly used in the treatment of convectional water [4].

There is an increasing interest in coagulants based on natural plant due to large amount that the imported coagulants cost in the less developed countries and due to the issues related to environment and health caused by using them. Depending on coagulants comes as another possibility instead of synthetic polymers and inorganic coagulant.

Much more cost is paid in the less developed countries for importing chemicals such as alum and polyaluminiun chloride [5, 6] for water purification. Because of this, such countries prefer methods with low costs and methods that require less expensive skill and maintenance. At the present time, across the globe, plants of water treatment use polyaluminiun chloride. Polyaluminiun chloride and alum cause impure substances such as, epichlodi ne which has the potential to cause cancer [7, 8]. In dialysis encephalopathy, Aluminum is considered an essential element that cause poison. Alzimer disease might be caused by Aluminum [9, 10]. Aluminum reaction with water alkalinity reduces water pH and its efficiency in cold water [11, 12]. Nevertheless, strong effects of cancer and poison acting in the nervous system are found in polymers that are organic and synthetic like acrylamide [5, 9].

Using proteins and polysaccharides as natural coagulant reflect a sign of development in technology for environmental sustainability [13], because they have effectiveness, are capable of being decomposed by bacteria or other living organisms and are supposed not to be harmful for the health of humans [14]. Spices, legumes, cactus, nut, cereals, and vegetables are coagulants based on plants that are closely observed [2] and they are often in competition with crops of food [15]. For this reason, this causes them to make the cost of their procurement increase rapidly and their uses hindered. Because of this factor, there appeared a need for looking for coagulants based on plant.

Gum is defined as a natural substance of sap that is hardened and derived from the apricot tree groups. The gum harvest is done for commercial purposes and taken from the trees in the wild. glycoproteinins and polysaccharides are mixed together to produce this complicated material known as gum [16].

There is a composition having rich nutrient (mineral, Vitamin, protein, and oil) in the nuts peel (Juglans regia L) and it is also a high proportion of calorific material. Walnuts products are made in Turkey, Iran, USA, and China. The importance of the design of the device for processing, managing, accumulating, gathering as a harvest the kernel peeled and shelled nuts lies in the details of the dimension of the size, porous qualities, volume, and densities that are large and real, friction factor, and finally the terminal velocity.

In this study, the use of conventional coagulant alum and natural waste coagulant apricot gum and peels nut was investigated to remove turbidity from river water and simulated wastewater using Jar test apparatus.

2. Materials and Methods
2.1 Alum solution
The preparation of the solution of Alum is made throughout the dissolution of only one gram of the $\text{Al}_2(\text{SO}_4)\cdot18\text{H}_2\text{O}$ into one litter of water that was subject to distillation. It is then moved and mixed properly to generate 1% solution concentration. Thus, each 1ml of this solution is equivalent to 1 mg of alum.

2.2 Apricot Gum solution
Apricot gum waste was brought from the local market and grinded in to fine grains and sieved using standard 200 µm sieve. One gram of this powder was incorporated in 1L of water distilled and then it was stirred with heat at 50 °C for 45 minutes, then allowed to stand for one hour to settling the imputers and to produce a 0.1% solution concentration. In which 1ml of this solution is equivalent to 1 mg of this materials. The same procedure was followed by [17, 18].
2.3 Peeled nuts
The peeled nuts were collected from the local herbal stores and put in storage at room temperature. The dried peeled nuts were then grinded and then sieved using standard 200 µm sieve to obtain the powder. Peeled nuts are a source of complex resin and pigment materials. The suspensions were made by adding one gram of peeled powder to 1 litter of distilled water and they were mixed together for 10 minutes by using a rotary shaker. Then, equivalent filter paper (Whatman Number.1) was used to filter the suspensions. The ratio of w/v was 0.1 % which are the results of the filtration for each solution which used as the seed extracts. Preparation of New solutions of seed extracts were done each day of work. Figure1 shows the two prepared coagulants.

Figure 1. (a) Apricot gum and (b) Peels nut

2.4 Preparation of simulated turbid water
The turbidity of the river water (22 NTU) was adjusted to 100 NTU using Kaolin synthetic stock solution. The kaolin solution was prepared by adding a 10 g of kaolin to 1 litter of distilled water and stirred at 20 rpm for one hour. Then, the suspension was left for 24 hours to allow a complete hydration of the kaolin. These two values of turbidity were chosen to represent the river water turbidity at different seasons.

2.5 Experiments Procedures
Figure 2 represents the jar tester of sedimentation (Aztec environmental control LTD) which used to simulate flocculation, conventional clarification, sedimentation steps, and coagulation. It contains six stirrers and beakers (1L of volume). The stirrers have the ability to be adjusted to the same conditions of stirring for all the beakers. 1L of the specimen was added to fill the beakers and the coagulant was simultaneously added to the entire beakers. The method applied was according to [19]. The optimum dose of alum, apricot gum and peeled nuts that used to remove turbidity was determined. The procedure was as follows:

Different type and concentration of coagulants were added to real and synthetic water with different turbidities. In order to ensure suitable mixing, the suspensions were stirred for 1 minute rapidly at (200 rpm) (G=390 s⁻¹). After the rapid mixing, slow mixing for 20 minutes at 20 rpm and G=44 s⁻¹ were achieved to allow the collisions of particle and formation of aggregate. Then, the suspension was left to settle down for 40 minutes and the sample was strained at depth of 6 cm from the supernatant to measure the final turbidity. pH of solution was fixed at 7 using NaOH/HNO₃. The turbidity removal efficiency is determined using Eq. (1):

\[ R_e(\%) = \frac{Tur_{in} - Tur_{out}}{Tur_{in}} \times 100 \]

Where, \( Tur_{in} \) and \( Tur_{out} \) are the turbidity in raw and treated solutions, respectively.
3. Results and Discussion

3.1 Single Coagulant Experiments

Dosage is regarded as an important parameter for identifying the optimum condition for the performed function of the coagulant use in the process of flocculation and coagulation. Figures 3 to 8 show the impact of different sizes of the dose of alum, apricot gum, and peels nut on taking away of turbidity from water with turbidity that is initial which is 22, 100 NTU. The figures are shown for alum, apricot gum, and peels nut respectively.

![Figure 3](image-url)  
**Figure 3.** Plot residual turbidity vs. alum dose for river water with initial turbidity 22 NTU

\[ y = 0.1967x^2 - 3.9404x + 20.29 \]

\[ R^2 = 0.9631 \]
Figure 4. Plot residual turbidity vs. alum dose for simulated water with initial turbidity 100 NTU

Figure 5. Plot residual turbidity vs. apricot gum dose for river water with initial turbidity 22 NTU

Figure 6. Plot residual turbidity vs. apricot gum dose for simulated water with initial turbidity 100 NTU
Figure 7. Plot residual turbidity vs. peeled nuts dose for river water with initial turbidity 22NTU

Figure 8. Plot residual turbidity vs. peeled nuts dose for simulated water with initial turbidity 100 NTU

As seen from above Figures, initially as the coagulants dose increased, removal efficiency of turbidity from the solution test was increased. For alum the turbidity reduced from 22 NTU to 1.9 NTU where the maximum efficiency was 91%. For 100 NTU it reduced to 10NTU where the maximum removal efficiency is reached to 90%. For apricot gum the turbid reduced from 22 and 100 NTU to 10 and 40 NTU respectively where the maximum removal efficiency is 54.5 and 63% respectively. For peels nut, the turbidity reduced from 22 and 100 NTU to 7 and 40 NTU where the corresponding efficiency is 68.2 and 60% respectively. The dose for alum, apricot gum and peels nut that achieved maximum removal efficiency is 12 mg/L. The turbidity decreasing could be ascribed to as increasing of precipitation of metal hydroxide lead to increase the efficiency of sweep flock. Thus, the value of final turbidity became lower due to particles collided were took in structure of metal hydroxide flock. At coagulant dose lower than 2 mg/L, the flock did not show clearly because of coagulant quantity was not enough to compress the double layer of the colloid particles or the precipitation of metal hydroxides decreased which caused in decreasing the mechanism efficiency of sweep flock with formation of very small size flocks. Coagulant with a high dose in the suspension lead to stabilization of charge of the colloid particles because of the counter ions adsorption (AL⁺³ was in our case). Increase in dose of alum (more than 12 mg/L) increased the turbidity due to the extra counter ions adsorption that made the colloid
particles charge to be positive (i.e colloid particles re-stabilization), which had resulted in the particles separation because of electrostatics repulsion and in appearance of low flock. This finding is in agreement with results obtained by Lin, [20]. Apricot gum and peels nut show good performance both in low and high initial turbidity which could be considered as promising natural coagulants.

3.2 Binary and Ternary Combination Coagulants Experiments
The alum combination as a primary coagulant with apricot gum and peeled nuts as natural coagulants aid to treating the turbid water with initial turbidity of 22 and 100 NTU was studied using different alum+ apricot gum+ peels nut ratios. The results is shown in Figures 9 and 10.

![Figure 9](image1.jpg)
Figure 9. Plot residual turbidity vs. dose of alum in conjunction with apricot gum and peels nut for river water with initial turbidity 22 NTU

![Figure 10](image2.jpg)
Figure 10. Plot residual turbidity vs. dose of alum in conjunction with Apricot gum and peeled nut for simulated water with initial turbidity 100 NTU
Examining Figures 9 and 10, it is clear that decreasing the consumption of alum obtained by using it in conjunction with apricot gum and peels nut (as coagulants aids) in binary and ternary combinations and achieved the same removal efficiency that alum achieves if it used alone in its optimum doses. The performance take the following orders:

50% alum + 50% peels nut > 50% alum + 50% apricot gum > 50% alum + 30% peels nut + 20% apricot gum > 50% alum + 30% apricot gum > 20% peels nut.

The maximum removal efficiency using 50% alum + 50% peels nut was 95 and 83% for initial turbidity of 22 and 100 NTU respectively compared to 90 and 91% using alum alone. Where the dose of alum used is reduced to 6 mg/L instead of 12 mg/L. Also as cleared from Figures. 9 and 10, the using of 50% alum + 50% apricot gum also reduced the using of alum dose and achieve a good removal efficiency and this reflect on cost saving and reduced health risk associated form using of alum alone.

4. Conclusions and Recommendations

Based on the results of the experiments and tests conducted in this research, the using of natural coagulants show good ability in reducing the turbidity of water to reasonable values and could be used alone or in conjunction with alum. It is cleared that the using of alum with peels nut and alum with apricot gum could reduce the alum dose by 50% and achieve the same efficiency which could be considered as a promising treatment process. This could reduce both cost of using alum alone and consequently the health hazard a raised from using alum. Future studies will be done to study the cost-benefit analysis for using different ratio of alum with different rations of peels nut and apricot gum. Also, pilot continues study will be used to simulate the real treatment unit. Different parameters including pH, temperature, mixing speed will be studied in more details.

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