Reducing the Turbidity of Wastewater by Some Plant Based Coagulants

Majid R. Majeed[1], Hiba A. Jasim[2]

Department of Biotechnology, College of Science, University of Baghdad, Baghdad, Iraq

Abstract: ***The aim of current study is estimate the ability of plant wastes in treatment of waste water that contains high levels of turbidity by Batch system method; with determine the best plant waste for treatment according to the changing of a number of parameters. This study involved four different samples of plant wastes for using as natural coagulants that prepared in laboratory, each sample Include one part of each plant which was Cactus leaves, Okra fruit peels, Okra seeds and Fenugreek seeds. A different mounts of each plant coagulants (5gm, 10gm and 15gm) were used for coagulation study. Additionally, the current work has examined other chemical and physical parameters such as: pH values, total salinity (TS), total dissolved solids (TDS) and electrical conductivity (EC).On the other hand, experimental conditions were used for carry out of coagulation process were pH 6 and contact time 120 minutes with continuous shaking. Also, alum was used in this study under same conditions as common traditional coagulant for comparison. The obtained results showed the best efficiency of coagulation process was 78% for cactus leaves with the weight 5 gm for all chemical and physical parameters. While, the lowest efficiency of coagulation process was 34% with the weight 15gm of cactus leaves. In same time, the best efficiency of coagulation process was 76% for alum. While, the lowest efficiency of coagulation process was 33.4% for alum. On the other hand, other natural coagulants such as: Okra fruits, Okra seeds and Fenugreek seeds didn't show any efficiency as natural coagulants for coagulation process and all parameter values of waste water were increased after treated with it.***

Keywords: Natural coagulants, plant wastes, wastewater, turbidity.

1. Introduction

A healthy freshwater for drinking must be without any pollutants such toxic metals, turbidity, organic and inorganic materials and pathogenic microorganisms. Moreover, it is important for drinking fresh water as aesthetic values. Organic materials in polluted water might established and formed from ecological, industrial and agricultural processes, which participate with other materials in increasing of pollution of water such as trichloromethane, fuel of vehicles, plant and animal wastes and pesticides (Stumm and Morgan, 1996). Conventional treatments of water often include coagulation, flocculation, sedimentation, filtration and disinfection. Term of coagulation refers to the destabilization of particles that means a changing state in the distribution of colloidal particles (size of dissolved particles between 1 nm and 1 µm) (Rich and Cherry, 1987). The coagulating materials that used widely for treatment polluted water are Iron (III) sulfate (Fe_2 $(SO_4)_3$) and alum ($Al_2(SO_4)_3$). These salts acts as coagulants by equalizing the colloidal particles charge through absorb or trap them and facilitate the coagulation of particles during slow mixing process in flocculation (WHO, 2008). The aluminium element is considered a very toxic for neurons (nerve cells) and may lead to the development of Alzheimer's disease. Uptake of aluminium by human body through drinking of the water that contains this element is expected to be low, because the absorbing capacity of aluminium by the gastrointestinal tract is poor. In spite of that, the bioavailable of aluminium existence in drinking water can been refused completely (Flaten, 2001). Also, Iron salts(ferric salts) are essential compounds in human nutrition. Determination of requirement for iron salts depends on age, gender, and health status, iron bioavailability is ranged from 10 to 50 mg/day for humans. The average oral lethal dose of iron is 200–250 mg/kg of body weight, but death occurs after the ingestion of low doses such as 40 mg/kg of body weight. Therefore, the bioavailable of iron existence in drinking water can been refused completely (NRC, 1979). As an alternative to the chemical toxic coagulants, many researchers were used parts and wastes of plants as a safety natural coagulants and eco-friendly, such as: Bark, leaves, seeds and fruit peel of plants (Moa *et al.*, 2014). Therefore, the present study aimed to Compare the efficiency of different natural coagulants for reducing of waste water turbidity of Qanat al-Jaish (Army canal) and compare the performance and effectiveness of natural coagulants as a replacement to alum in treatment of water turbidity.

2. Materials and Methods

Collection of Wastewater samples

The wastewater sample was collected from Qanat al-Jaish in eastern of Baghdad city, about 50 cm below the surface water of the canal (The sample of 2 Liters), were measured to determine the values of Total dissolved solids (TDS), Total salinity (TS), Turbidity, pH and electrical conductivity (EC) by TDS meter, TS meter, turbidity meter, pH meter and EC meter respectively. All the chemical and physical parameters mentioned above were measured for wastewater samples before and after treatment by natural coagulants (plant wastes).

Preparation of natural coagulants

Four different plants wastes were used as natural coagulants that were: cactus leaves, okra fruit peels, okra seeds and fenugreek seeds (Figure1).These coagulants were selected for their cost effectiveness and ready availability. The plant wastes were obtained from locally Iraqi markets. These plants waste coagulants were prepared according to the following Batch system method (Renuk and Jadhav, 2013).

Fenugreek seeds were washed with deionized water by mixing in a shaker for 30 minutes. After that, the water was decanted, again the seeds shaken with D.W for another 30 minutes until apparent excess material and color were removed from the samples. The cleaned wet fenugreek seeds were placed in a large glass baking dish and dried in the ovenat50 C for 48 hrs. After drying, clean plants seeds were stored in pre-cleaned plastic container and kept tightly to avoid absorption of moisture from the atmosphere.

The cactus leaves, also washed twice with deionized water by mixing in a shaker for 30 minutes and cut into pieces at the size 5mm. then, the cleaned wet cactus leaves placed in a large glass baking dish and dried in the oven at50 C for 48 hrs. After that, dried clean leaves were stored in pre-cleaned plastic containers and kept air tight to avoid absorption of moisture from the atmosphere.

In the same time, the seeds of okra were removed from fruits and prepared with same procedure as the previously mentioned, while the peel of fruits were prepared like a procedure of cactus leaves preparation. These natural coagulants were used in the experiments.

Figure 1: Plant coagulants after configured for the experiment

Coagulation experimental studies

Twelve flasks with 200 ml of wastewater and pH = 6 were prepared for coagulation process. Different amounts of each plant coagulants (5gm, 10gm and 15gm) were added individually to each flask with shaking for 60 minutes for the treatment and coagulation of pollutants.

Then, the flasks were left for 30 minutes in order to decant the water. After that, the samples were taken to determine the values of Total dissolved solids (TDS), Total salinity (TS), Turbidity, pH and electrical conductivity (EC) after coagulation process.

The calculations

The efficiency of coagulation process was calculated according to the following equation (Fahad, 1994):

$$\textit{Efficiency of Coagulation(EC)\%} = \frac{C_0 - C_f}{C_0} \times 100$$

❖ *Where:* C_0 = *the initial concentration (UNT)*

C_f = *the final concentration (UNT)*

Statistical study

All data were studied and analyzed statistically by using statistical program, Anova test at (probability≤ 0.05).

3. The Results and Discussion

The physical and chemical characterization for sample of wastewater Table (1) shows the values of physical and chemical characterization for wastewater samples that taken from Qanat al-Jaish in eastern of Baghdad city before treatment (waste water of many factories pollutants). They were: 7.8, 50 UNT, 1750 ppm, 2734.37 µS/cm and1.7 % for pH, Turbidity, TDS, EC and TS respectively. These results showed higher chemical and physical values comparing to the Standard Specification (Standard values) of wastewater.

Table 1: The physical and chemical characterization for sample of wastewater before treatment

The Parameter	The Unit	Initial Value	Standard Value
pH Value	-	7.8	6-905
Turbidity	UNT	50	5
TDS	PPM	1750	933
Electrical Conductivity	µS/cm	2734.37	1400
Salinity	%%	1.7	0.8

Physical and chemical parameters after coagulation process

The turbidity

The values of turbidity for waste water samples after treatment by Cactus leaves, Okra fruit peels, Okra seeds and Fenugreek seeds additionally to Alum were illustrated in table 2 and 3. They were ranged from 11 to5250 UNT. The result showed that the cactus leaves coagulant give the best coagulation efficiency followed by Alum (Table 3). Coagulation efficiency of cactus leaves was 78% and for alum was 76% at weight of 5 gm.

Table 2: Turbidity (UNT) of waste water sample after treatment by different coagulants

Type of Coagulant	Weight of Coagulants		
	5gm	10gm	15gm
Cactus Leaves	11	19	33
Okra fruits	83	134	193
Okra Seeds	1050	1600	5250
Fenugreek Seeds	110	875	1000
Alum	12	20	33.3

Table 3: The Efficiency of Coagulation process for Turbidity by Cactus leaves and Alum

Type of Coagulant	Weight of Coagulants		
	5gm	10gm	15gm
Cactus Leaves	78%	62%	34%
Okra fruits	-0.66%	-1.68%	-2.86%
Okra Seeds	-20%	-31%	-104%
Fenugreek Seeds	-1.2%	-16.5%	-19%
Alum	76%	60%	33.4%

It is obviously that the cactus leaves in the present study showed a high efficiency for reducing of waste water turbidity as coagulants. While the results of Okra fruits peels, Okra seeds and Fenugreek seeds showed increasing of turbidity in waste water (figure 2).These plant wastes do not have any coagulation efficiency for reducing of turbidity that ranged from – 1.2% up to – 104%, which belong to the increasing of liberalization of soluble organic compounds to the water (Crini and Badot, 2008) and then lead to the increasing the turbidity (Maria, *et al.*, 2014). These plant wastes need to chemical modification before they are used as natural coagulants in waste water treatment. Chemical Modification processing for the plant waste can decrease the soluble organic compounds of plant and increases the coagulation efficiency of plants (Hanafiah and Wan, 2008).And considered a one of the widely methods that used chemical treatment techniques for surface modification of plant wastes for improving its coagulation properties (Vadiveloo, *et al.*, 2009).

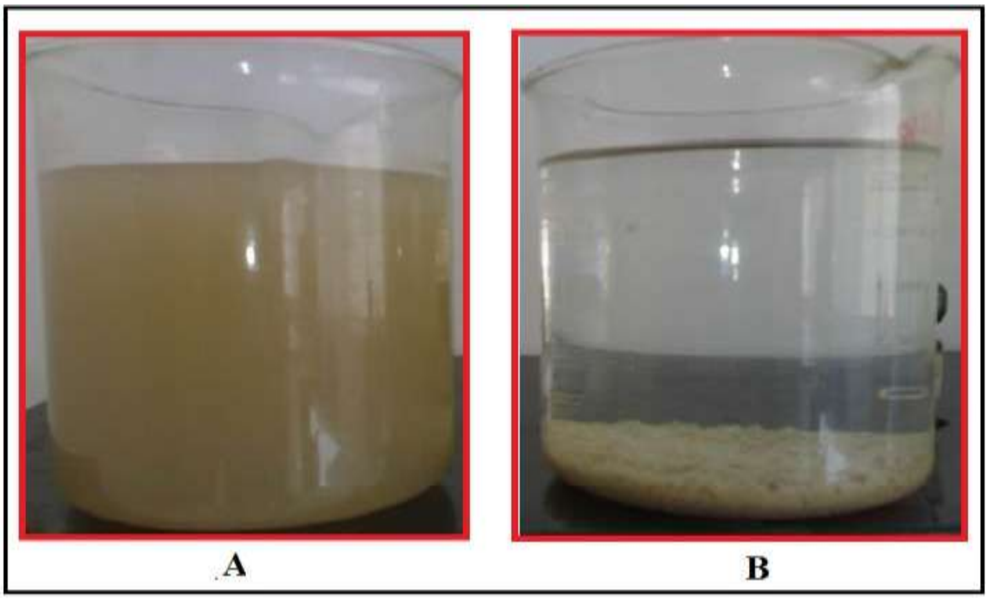

Figure 2: Reducing of turbidity for waste water sample by Cactus leaves (A: Before treatment. B: After treatment)

The Total Dissolved Solids (TDS)

According to the data in table 4, the values of TDS for the samples that treated by cactus leaves were 380, 665 and 1155 ppm for weight 5, 10 and 15gm respectively. Whereas the values of TDS for samples that treated by alum were 1800, 3500 and 6860 ppm for weight 5, 10 and 15gm respectively. For other coagulants, TDS values were arranged from 1915 to 6755 ppm.

It is clearly that the cactus leaves in the present study showed higher efficiency as coagulants for decreasing the TDS values and make it near to the standard value. Also, Okra fruit peels, Okra seeds and Fenugreek seeds are unable to reduce TDS value and need to be chemically modified.

Table 4: TDS (ppm) of waste water sample after treatment by different coagulants

Type of Coagulant	Weight of Coagulant		
	5gm	10gm	15gm
Cactus Leaves	380	665	1155
Okra fruits	2905	4690	6755
Okra Seeds	2325	2625	4125
Fenugreek Seeds	1915	2050	2500
Alum	1800	3500	6860

The Electrical Conductivity (EC)

From the results in table 5. Again, cactus leaves showed a best data for reducing EC values that were 593, 1039 and 1804μS/cm for weight 5, 10 and 15gm respectively. Then, came after it Fenugreek seeds, Okra seeds and Okra fruits at the weights 5gm, 10gm and 15gm respectively. While, the highest values (The worst result) were 2812.5, 5468.7 and 10718.7 μS/cm for alum at the weights 5gm, 10gm and 15gm respectively.

Table 3-5: EC (μS/cm) of waste water sample after treatment by different coagulants

Type of Coagulant	Weight of Coagulant		
	5gm	10gm	15gm
Cactus Leaves	593	1039	1804
Okra fruits	4539	7328	10554
Okra Seeds	3632	4101	6445
Fenugreek Seeds	2992	3203	3906
Alum	2812.5	5468.7	10718.7

The TDS is meaning all solids (usually mineral salts) that are dissolved in water. TDS and EC are connected in a strong relationship. Most of the organic and inorganic salts can dissolved in water, and this status lead to increasing of the electrical conductivity value. The most of solids that stay in the water after filtration by sand are dissolved ionic salts (Vasile,*et al.*, 2011).The TDS is meaning all solids (usually mineral salts) that are dissolved in water. TDS and EC are connected in a strong relationship. Most of the organic and inorganic salts can dissolved in water, and this status lead to increasing of the electrical conductivity value. The most of solids that stay in the water after filtration by sand are dissolved ionic salts (Vasile,*et al.*, 2011).At same time, the electrical conductivity is considered a suitable indicator for determination of the total salinity, for that, the electrical conductivity used as criteria for measurement of water capacity to conduct electrical current, and directly related with the concentration of salts that dissolved in water, and therefore with the TDS value. These salts are dissolved into ions that have positive and negative charges and possess ability to conduct electricity (Figure 3) (Iyasele and David, 2015).

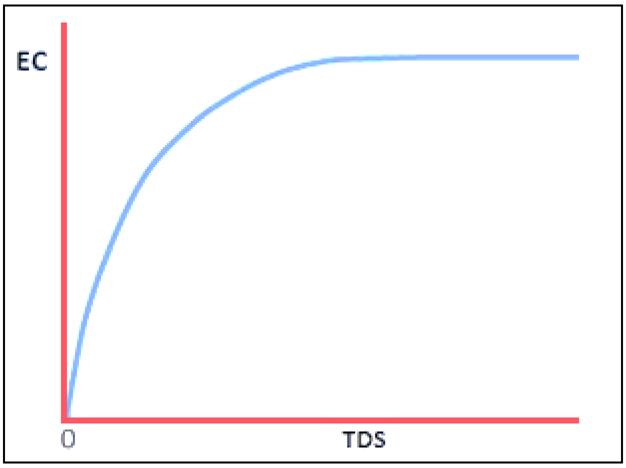

Figure 3: The relationship between TDS and EC values

The Salinity (S)

Finally, the salinity values of waste water samples that treated by Cactus leaves, Okra fruits, Okra seeds and Fenugreek seeds additionally to Alum were ranged from 0.3 to6.7%. These data showed that the cactus leaves coagulant showed best coagulation efficiency for chemical and physical parameters tested and was the best followed by Alum (Table 6), The value of cactus leaves for reducing and decreasing the salinity were0.3, 0.6 and 1.1% and for alum were1.8, 3.4 and 6.7% with weight of 5, 10 and 15 gm respectively. While, other coagulants were arranged from 1.8 to 6.6%.

Table 6: Salinity (%) of waste water sample after treatment by different coagulants

Type of Coagulant	Weight of Coagulant		
	5gm	10gm	15gm
Cactus Leaves	0.3	0.6	1.1
Okra fruits	2.8	4.6	6.6
Okra Seeds	2.2	2.5	4
Fenugreek Seeds	1.8	2	2.4
Alum	1.8	3.4	6.7

Salinity is similar to TDS concerning the estimation of the salt level in the water sample and it is derived from the value of EC that is obtained by using the conversion factor (usually 0.5). It is typically expressed as parts per thousand (ppt) or g/Land also as percentage ratio (%). Salinity readings are typically used by industries such as agriculture, pool and spa monitoring, and hydroponics (Johnson, *et al*. 1999).

4. Conclusion

Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environmental friendly and multifunction in water purification. In this study, a low cost coagulant has been prepared and used as an alternative to Alum in the removal of waste water turbidity in addition to other chemical and physical parameters such as**: pH**, **S**, **TDS** and **EC**. It was found that from all of the results that mentioned recently and among the natural coagulants used in this study, It is obviously that the cactus leaves showed high efficiency for waste water treatment and decreasing all the parameters as best natural coagulants and make it near to the standard values.

The Statistical study

Statistically, one-way analysis of variance (one-way ANOVA) is considered a suitable method for compare among the means of the values of samples through using F-distribution and depending on the numerical data only. However, one-way ANOVA is used for test of differences among at least three groups (Howell, 2002).

Results of ANOVA were carried out for determining the significant difference among the effects of coagulants on the turbidity reducing and other parameters in waste water samples (Table 7).

ANOVA statistical tests, the level of significance were $p \leq 0.05$ that suggesting the test is considered to be statistically significant (Zar, 1999).

According to Table (7) that consist of (turbidity, TDS, EC and salinity), showed significant difference between ability of the plant wastes coagulants and alum for coagulation process and reducing or changing of parameters in waste water samples.

Table 7: Statistical analysis of coagulants effect on parameters

Parameter	No. of group	F-Value	P-Value	Comment
Turbidity	5	3.427	0.052	Significant
TDS Value	5	3.297	0.057	Significant
EC Value	5	3.298	0.057	Significant
Salinity	5	3.372	0.054	Significant

At Level of Probability (P) $\leq$ 0.05

References

[1] Stumm, W.; Morgan, J.J. **(1996).** Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters, third edition. Wiley- Interscience. 1022 p.

[2] Rich,G.;Cherry,K.**(1987).**Hazardous Waste Treatment Technologies, Pudvan Publishers,New York.

[3] World Health Organization (WHO), **(2008)**.Water Supply, sanitation and hygiene development.

[4] Flaten, T.P**.(2001).**Aluminium as a risk factor in Alzheimer's disease, with emphasis on drinking water. Brain Research Bulletin.55 (2): 187-196.

[5] NRC (National Research Council).**(1979).** Iron.A Report of the Subcommittee on Iron, Committee on Medical and Biologic Effects of Environmental Pollutants, Division of Medical Sciences, Assembly of Life Sciences. University Park Press, Baltimore. 248 pp.

[6] Moa, Megersa; Abebe, Beyene1;Argaw,Ambelu;Bizuneh,Woldeab. **(2014)**. the use of indigenous plant species for drinking water treatment in developing countries: a review. J. Bio. & Env. Sci., Vol. 5, No. 3, pp. 269-281.

[7] RenukA, A. Binayki; Jadhav, M.V. **(2013).**Application of natural coagulants in water purification. International

Journal of Advanced Technology in Civil Engineering, Vol.2 (1), pp.: 118-123.

[8] Fahad, H. G. **(1994).**A study of efficiency of different microorganisms in thorium sorption from aqueous solutions.M.Sc. Thesis. College of Science, Baghdad University, Iraq.

[9] Crini, G.P.; Badot, M. **(2008)**. Application of chitosan, a natural amino polysaccharide, for dye removal from aqueous solutions by adsorption processes using batch studies: a review of recent literature, Prog.Polym.Sci.33399–447.

[10] Maria,Khishdoost; Bijan, Bina; Mohammad, Mehdi; Ensiyeh, Taheri; Akbar, Hassanzadeh; Mohammad, Modarresi. **(2014).** Optimization of treatment process of Bushigan treatment plant in respect of turbidity and total organic carbon reduction. Int J Env Health Eng., vol.2 (5):p. 1-6.

[11] Hanafiah, M. A. K. M. and Wan Ngah. **(2008).**Removal of heavy metals ions from wastewater by chemically modified plant wastes as adsorbents :A review . Bioresour. Technol., 99: 3935-3948.

[12] Vadiveloo, J.; Nurfariza, B.; Fadel, J.G**. (2009)**. Nutritional improvement of rice husks, Anim.FeedSci.Technol.151299–305.

[13] Vasile, Ovidiu ; Ion, V. ; Cristiana, Radulescu; Claudia, Stihi; Gh., Valerica ; Anca, Irina ; Ioana. DanielaDulama. **(2011).** Valuation of potop river quality, preliminary investigation and risk assessment of polluted degree. Journal of Science and Arts, Vol. 2(15), pp. 207-216.

[14] Iyasele, J.U. and David J. Idiata, D. **(2015).** Investigation of the Relationship between Electrical Conductivity and Total Dissolved Solids. International Journal of Engineering Research and Reviews. Vol. 3, Issue 1, pp: (40-48).

[15] Johnson, R.L.; Holman, S.;Holmquist, D.D.**(1999).** Water Quality with CBL Vernier Software, Oregon.

[16] Howell, D**. (2002).**Statistical Methods for Psychology. Duxbury. pp. 324–325. ISBN 0-534-37770-X.

[17] Zar, J**. (1999).** Biostatistical Analysis, 4th ed. Prentice Hall, Upper Saddle River, NJ. Englewood Cliffs, pp.950- 929.