Current Clinical and Medical Education

Received 19 Mar 2024 | Revised 20 Mar 2024 | Accepted 18 May 2024 | Published Online 20 May 2024

vision publisher
Medical Journals
ISSN 2942-0792

Published By: Vision Publisher

CCME 02 (5), 340-353

Treatment of Water by Direct Filtration

Faten Latif Obaid Takhakh [1], Shandroy Sirwan Mahmoud Kaka [2], Mustafa Jabbar Falih Al-Jubouri [3], Tuqa Karim Hussein Mansour [4]

[1]University of Babylon, College of Engineering, Department of Environmental Engineering, Iraq.

[2]Kirkuk University, College of Science, Department of Chemistry, Iraq.

[3] University of Kufa/ College of Science, Department of Environmental Sciences and Pollution, Iraq.

[4]University of Babylon, College of Engineering, Department of Environmental Engineering, Iraq.

Abstract: The present study was performed in a pilot treatment system for synthetic turbid water with the all characterization and process. The parameters of the pilot unit were justified in the optimum conditions through the experimental work. For water treatment plants, filters are the most critical devices; so many studies have focused on improving these units ' quality. This can increase present plants ' capacity to meet the water consumption of the user. This work is therefore an attempt to improve the efficiency of filter operation by using pre-filtration coagulation and flocculation basins as it helps remove colloidal and thus improves the ability of the sand filter. This study is aimed to investigate the influence of adding coagulant aids with alum on the performance of rapid sand filter , through experimented process by using pilot plant (direct filtration) for operation condition of turbidity (150 NTU) and used different dose from alum alone and with coagulant aid (cationic polymer) another one . Standard jar tests studies were conducted in order to determine the optimum doses of alum and polyelectrolyte It was found that the dose of alum (40 mg/l) and (0.8 mg/l) of polyelectrolyte at a pH of (7.52) are most appropriate.

Has been measurement influent and effluent turbidity from filter by using turbidity meters in order to determine efficiency of removal turbidity for all test and compared between the test for using alum alone and using alum with cationic polymer .The results indicated that that the maximum removal efficiency of turbidity 98% at filtration time (14hr) using coagulant (alum +polymer) and flocculation with direct filtration was the most efficient in term of turbidity.

Keyword: Water treatment, Direct filtration, Raw water, Coagulation, Filtration.

Corresponding Author: Faten Latif Obaid Takhakh†, University of Babylon, College of Engineering, Department of Environmental Engineering, Iraq.

Supplementary information The online version of this article (https://doi.org/xx.xxx/xxx.xx) contains supplementary material,which is available to autho-rized users.

Introduction:

Selection of the water treatment system is a complex task that requires taking into account several variables. The choice of water treatment processes to be used on a given source of water supply, determined by the need to deliver a) appropriate finished water quality and b) at the most attractive overall cost. Choosing a treatment system for water depends on[1]:

• Value of source water supply

• Quality of finished water.

• Processing equipment quality.

• Flexibility in coping with changing water quality and equipment malfunctions • Operational specifications and staff strength.

• Limited land for the construction of waste disposal facilities.

• Investment and production costs (including availability of chemical products)Water treatment unit processes are interrelated such that modifications in one unit process may affect other unit processes and the overall treatment objective. For example, the degree of chemical mixing or flocculation may affect performance of the filtration process. Water treatment processes can be grouped according to their general function in the water treatment scheme. However, each water source is unique, and process modifications to fit a particular treatment objective must be considered on a case-by-case basis [1].

Given the bacteriological content, turbidity, and total organic concentrations, the value of groundwater is usually higher than that of surface water. On the other side, groundwater may have a lower content of minerals (hardness, iron, manganese) and may require it additional care. Groundwater sources are often injected with inadequate care into the distribution system [1]. Table (1) lists these sources and provides general comments on each of them [2].

Increasingly, low-quality surface water needs to be treated to produce drinking quality water that meets the conditions of consent. Water percolating through a granular media bed (filtration) is commonly used to explain condensed liquids of particles of a broad range of sizes in municipal water treatment.

Table (1): Different sources of water [2]**.**

Source of water	Comments
Surface water	Low streams, easy to contaminate, relatively high SS, turbidity, and pathogens. Rivers and streams are drying up in some parts of the world during the dry season.
Groundwater	Fifty percent of the U.S. population is using groundwater as a drinking water source. Higher flows but have a natural filtering ability that prevents SS and turbidity. The total dissolved solids (TDS) may be high, including Fe, Mn, Ca and Mg (hardness). Impossible to scrub after pollution.
Ocean	Intensive energy; too expensive compared to other sources. Desalination may occur through distillation, reverse osmosis, electrodialysis, freezing, and exchange of ions. Of these, the two most widely used technologies are multi-stage distillation and reverse osmosis (they account for about 87% of the worldwide desalination capacity). There are more plants in the wold for reverse osmosis, but they are typically smaller in ability than plants for distillation.
Reclaimed water	Technically possible. The public will be more likely to be inappropriate.

Slow Sand Filters (SSF) and Rapid Sand Filters (RSF) are widely used in surface water filtration for removal of solids in surface waters, precipitation of lime soft water hardness, and precipitation of iron and manganese. Both of these types (SSF and RSF) are deep granular filters, often grading silica sand into the filter press. The precoat filter is activated using diatomous, activated carbon etc. is another form of filter as the filter media, [3].

Filtration

Filtration is a system generally used to extract particulate matter from air. Nearly all surface water and some wastewater treatment facilities use certain filtration types as they contain algae, mud, clay and other organic and inorganic particulate matter. Through eliminating these molecules, filtration increases the purity of air. In addition, all surface waters contain microorganisms that can cause waterborne disease, so filtration is almost always required in tandem with chemical disinfection to ensure that water is free from these pathogens[4][5].

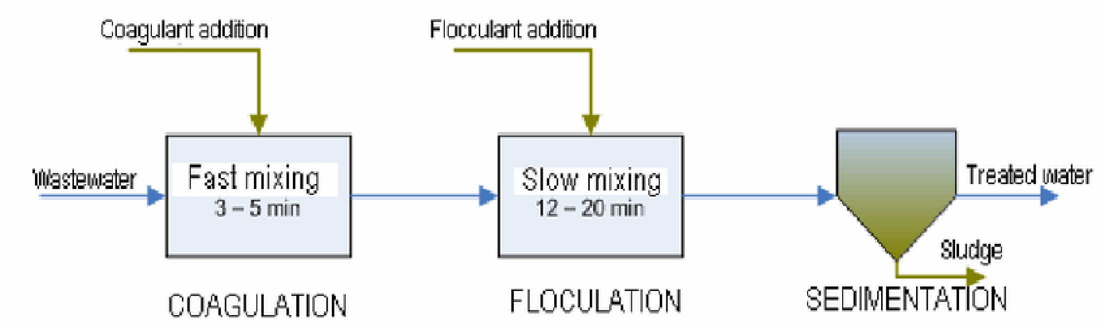
Particles are separated in granular filtration as the powerful water passes through a submerged granular or filter medium. Some of the particles present in it, as it flows through the medium, move towards and deposit on the surface of the granular medium due to the different forces acting on it. Generally speaking, the degree of deposition throughout the medium cannot be uniform; nevertheless, the whole medium is intended for the selection of particles[5][6].

Processes Precede Filtration

Coagulation, flocculation, and sedimentation are usually preceded by traditional filtration processes. Both coagulation and flocculation precede direct filtration procedures, the floc is extracted directly by the filters. One or all of the following procedures may include pretreatment processes:

1-Coagulation and flocculation

Coagulation ; flocculation are two processes that are widely used in water treatment to get rid of unwanted liquid suspended content. Coagulation requires the use of a coagulant that can de-stabilize the charged particles previously contained in the suspension. In flocculation, on the other hand, de-stabilization is caused by physical methods such as mixing the solution, and also by adding polymers often. This is the coagulation and flocculation main difference[5]. Coagulation has the advantage of reducing the time needed to remove suspended solids and is very effective in removing fine particles which are otherwise very hard to remove. Coagulation can also help most protozoa, bacteria and viruses to be removed. The main drawbacks of using coagulants for small supply treatment are the cost and the need for accurate dosage and frequent monitoring. To function efficiently, coagulants need specific dosing equipment, and the dose needed depends on the nature of the raw water that can differ rapidly. The success of the coagulation system depends on the properties of the raw water, the coagulant used and operational variables including mixing conditions, dose level of coagulant and pH quality. Bench-scale coagulation tests(' jar tests') should assess the selection of coagulant and the determination of optimal operating conditions for particular raw water. Therefore, while coagulation and flocculation are the most effective treatment for removing color and turbidity, due to the level of control needed and the need to dispose of large volumes of thin sludge, they may not be appropriate for small water supplies[7]. Figure(1) Coagulation status-flowchart process flocculation



. **Figure(1)** : Coagulation - flocculation flowchart system [7]

A -What is Coagulation?

As described above, coagulation is a chemical process in which it is necessary to change the chemistry of a suspension to cause particle settling. It therefore needs a coagulant to be applied. The coagulant interacts in the suspension with the particles or colloids and distorts the chemical charge. Alum ($Al_2(SO4)_3.14H2O$) is one of the most widely used coagulants.

Coagulation is an important blood coagulation phenomenon. Therefore, coagulation is commonly referred to as coagulation. By using an anti-coagulant, the effects of a coagulant can be reversed. To stop blockage of the artery, these anti-coagulants are often used to relieve blood clots. Figure (2) demonstrates the workings of coagulation [7].

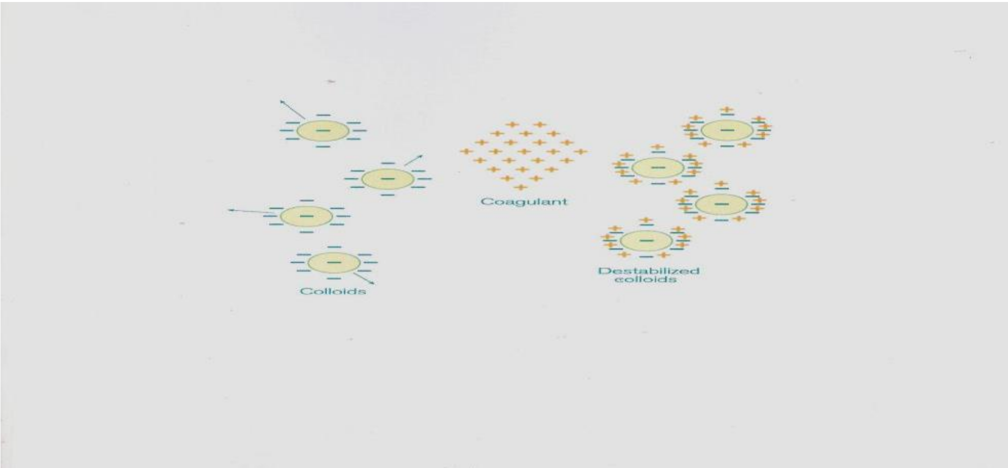


Figure (2): Coagulation work

B. What is Flocculation?

Flocculation is the neutralized colloid's agglomeration. Which result of attraction forces acting between the particles brought into contact by (Brownian motion)[5].

A polymeric bridging coagulant aggregates the molecules similarly. It makes particles small enough to separate them for sedimentation , filtration process. Definition of how to see a polymer bridge in Figure (3),[5].

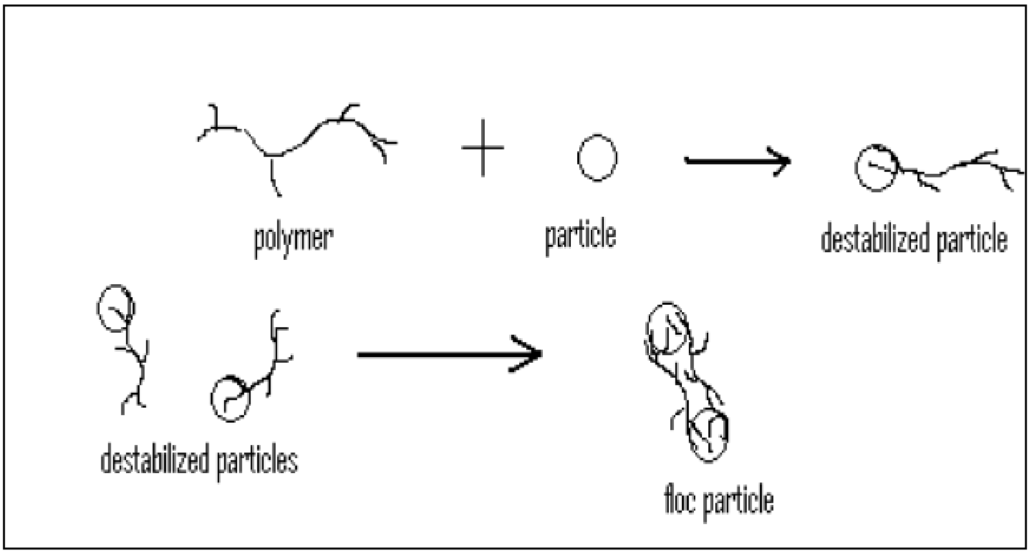


Figure. (3): Coagulation and Flocculation process

It is essentially a physical mixing process until they achieve a size of approximately 0.1 micron and then get the flock to the required size by "internal mechanical agitation." some of the aggregates should settle after enough flocculation during the sedimentation process. It is therefore water conditioning to form flocks that can be easily removed by either settling process or filtration unites [5]. In addition, mixing speed, mixing time, etc. can influence flocculation process efficiency. How does Flocculation function in Figure (4)

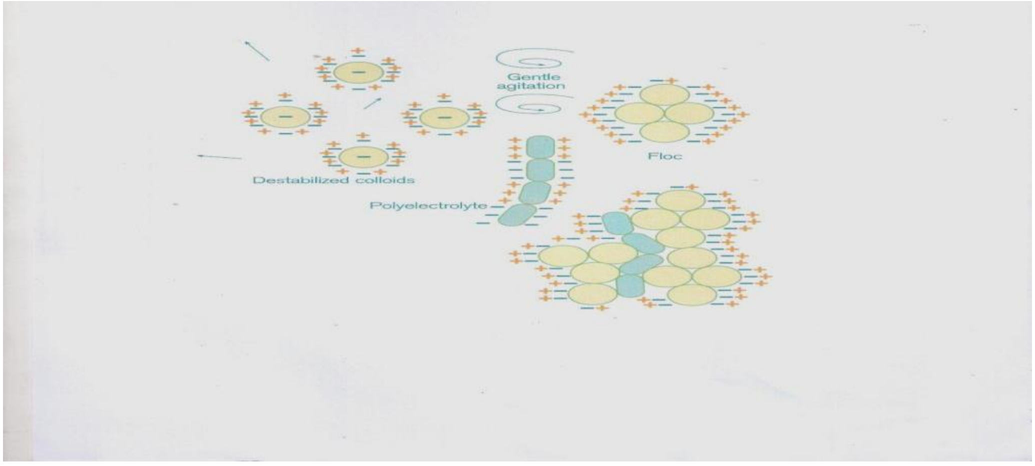


Figure (4): Flocculation work

C- Sedimentation

Sedimentation is the unit system in which the (S.S) are isolated by gravity settling from the liquid phase requires the particular use of sedimentation in water treatment.

1. Until modern water treatment, surface water pretreatment.

2. Settling until filtration of coagulated and flocculated waters.

3. Settling in chemical water softening of coagulated flocculated waters.

4. Liquid settling treated for removal of iron and manganese.

Settlement in dilute suspension of flocculent particles after chemical coagulation and flocculation has been reported in which non-discrete particles are chemically coagulated. Flocculent particles are those particles that are chemically supported to join, shape and settle large particles. During the settling process, the particles are also flocculating and thus increase in size and weight [9].

Filtration mechanisms

Four basic filtration mechanisms are available[5][6]:.

1-Sedimentation: The sedimentation process is due to the gravity force and the resulting settling speed of the sample, which allows the particle to cross the streamlines, and then enter the collector. .
2- Interception: Particle interception is common with large particles.

3-Brownian Diffusion: For very small particles, such as bacteria, diffusion in media granules occurs. Due to thermal gradients, particles travel about randomly within the liquid. For particles with diameters < 1 micron, this mechanism is only essential.

4- Inertia: Inertia connection happens as larger particles move quickly enough to travel off their streamlines and crash into media grains.**Filer Materials**

1-Sand: Sand is usually used as filter material, whether fine or fine. The sand size is measured and represented through the word "effective size." The effective size, that is to say. D10 can be described as the sieve size in mm by which 10% of the sand sample passes by weight. The size or degree of uniformity of particle size differences is measured and expressed by the term "uniformity coefficient." The uniformity coefficient, i.e. (D60/D10), can be defined as the sieve size ratio in mm through which 60% of the sand sample passes to the effective sand size.

2-Gravel: The sand sheets can be placed on gravel, enabling the filtered water to move freely to the underground drains and allowing the washing water to flow uniformly upwards.

3-Other materials: Anthrafilt is sometimes used as a filter media instead of using sand. Anthrafilt is made of anthracite, a form of coal-stone that burns without flames or smoke. It is cheaper and has given a high filtration rate[7]

Types of Filters

1-Slow sand filter: made up of fine gravel-backed soil They capture particles on the surface of the bed and are usually cleaned by removing the particles from the top layer of sand.

2-Rapid-sand filter: consist of smaller grains of sand backed by gravel, collecting particles throughout the surface. By running water through the pad, they are washed to ' kick off ' the particles.

3-Multimedia filters: two or more layers of various granular materials of different densities. Anthracite is commonly used in coal, salt, and gravel. The different layers combined can make selection more flexible than a single layer of sand. The layers remain neatly divided due to differences in thickness, even after[10][5] has been washed away.

Direct filtration

Direct filtration is used to treat water supplies of high quality. It includes coagulant addition, quick mixing, flocculation, and filtration. The major difference between the application of coagulant and filtration is the lack of a separation process, such as sedimentation or flotation, compared to conventional therapy. Pre-oxidation, accompanied by the addition of powdered activated carbon (PAC) and in some cases followed by the adsorption of granular activated carbon (GAC) may be preceded by direct filtration. It may be identical to other processes[12][13] at the same time.

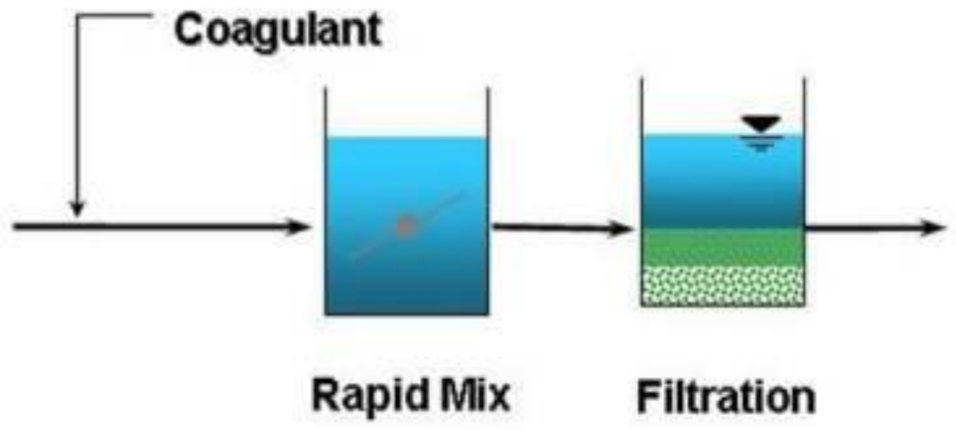


Figure (5): Direct filtration

Advantages of Direct filtration

Direct filtration has several benefits over conventional treatment: (1) lower chemical costs due to lower coagulant dosages used in direct filtration, (2) lower capital costs since the sedimentation (and sometimes flocculation) tank is not needed and (3) lower operational and maintenance costs due to the lack of control of the sedimentation (and sometimes flocculation) tank.

Disadvantages of Direct filtration

Direct filtration also has drawbacks, including: (1) it can not handle high turbidity and/or color water supplies, (2) operators have limited response time to adapt treatment to changes in source water quality and (3) less detention time to manage seasonal taste and odor problems[13].

Materials and Method:

1. Kaolinite is a clay mineral with the chemical composition Al2Si2O5(OH)4, part of the group of industrial minerals. It is a layered mineral silicate, with one tetrahedral sheet connected to one octahedral sheet of octahedral alumina through oxygen atoms. General gravity: as shown in figure (6) 2.6[15].

Figure (6) :kaolin clay used in this study

2. The coagulant: the coagulant used was Aluminum Sulfate $AL(SO_4)_2.16H2O$, from which an aluminum solution was prepared at a strength of 1% and used in various doses with coagulant support (cations polymer) and aluminum alone[1] as shown in figure (7).

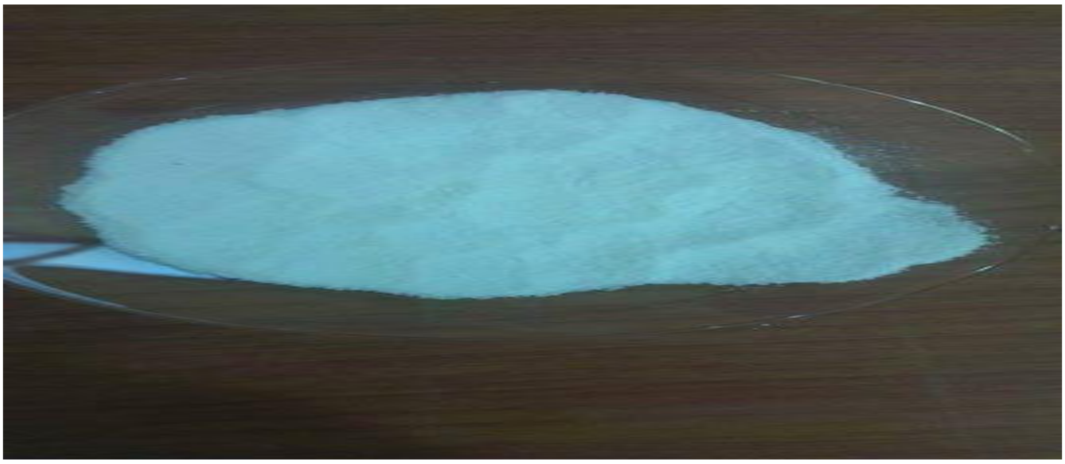


Figure (7)*:* Alum used in this study

Apparatus:

1- Jar test apparatus

The optimum coagulant concentration for alum and with coagulant support (cations polymer) can be calculated using jar check and applied to the water solution contaminated with kaolinitic clay as shown in Figure (8) .

Figure (8): Jar test apparatus

2- Turbidity

Turbidity is a measure of the ability of water to scatter light, depending on the form, volume, number, and refractive index of the suspended particles. The turbid meter is a tool used to measure water turbidity by balancing the dispersed and transmitted light intensities for a defined illumination condition using closed glasses containing standard suspensions formalized polymers as shown in figure (9).

Figure (9): turbidity apparatus

3- pH Meter

The pH value was calculated as shown in fig.(10) using the pH meter.

Figure (10): pH Meter used in this study

.

3-3 Pilot Filtration Unit

To check the efficiency of the filter proposed in this report, a pilot filtration system was installed. Figure (11) shows a schematic representation of the filtration unit built for the pilot. A image of this pilot plant unit is shown in Figure (12). It is made up of the following parts:

1- Coagulation Tank : h= 50cm, w= 20cm l=20cm.

2- Flocculation Tank : h= 50cm, w= 20cm l=20cm.

3-Filter dimension : h=60 cm, w=20cm l=20cm.

4- Sand filters media (5cm gravel+30cm sand)

Figure (13) shows the filter materials.

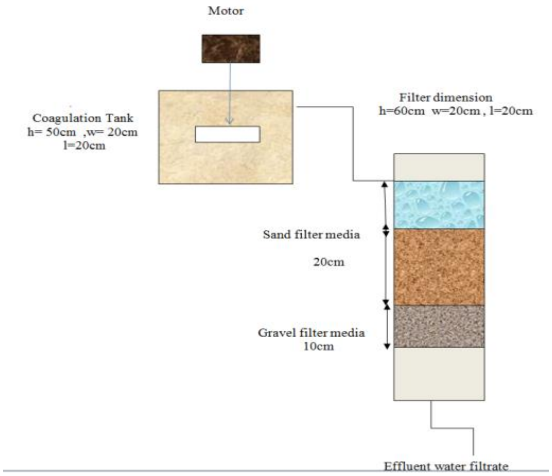


Figure (11): Design of pilot plant unit

Figure (12): Picture of pilot plant unit .

Figure (13): Filter materials

Results and Discussion

Optimum doses

1-Optimum alum dose

Jar tests were performed on calibrated specimens from (1.0 L) at the initial turbidity concentration (150 mg / L) for each of six water solution stirrers contaminated with kaolinitic clay. The Jar experiment was carried out as follows: The preparation of 10,000 ppm of alum solution for testing was performed at alum solution concentration (0, 10, 20, 30, 40, and 50 ppm) and flash mixed at 100 rpm for 1 minute, followed by flocculation at 42 rpm for 15 minutes. The specimens were then allowed to settle for 15 minutes until all the flock had settled down completely. Before and after treatment specimens were assessed turbidity, pH. The purpose of the experiment was to establish only the optimal alum coagulant concentration and to be applied to the water solution with coagulant support (cations polymer). Results showed the optimal coagulant concentration for alum is (40 ppm) at pH equal to (7.52) as in the figure (14).

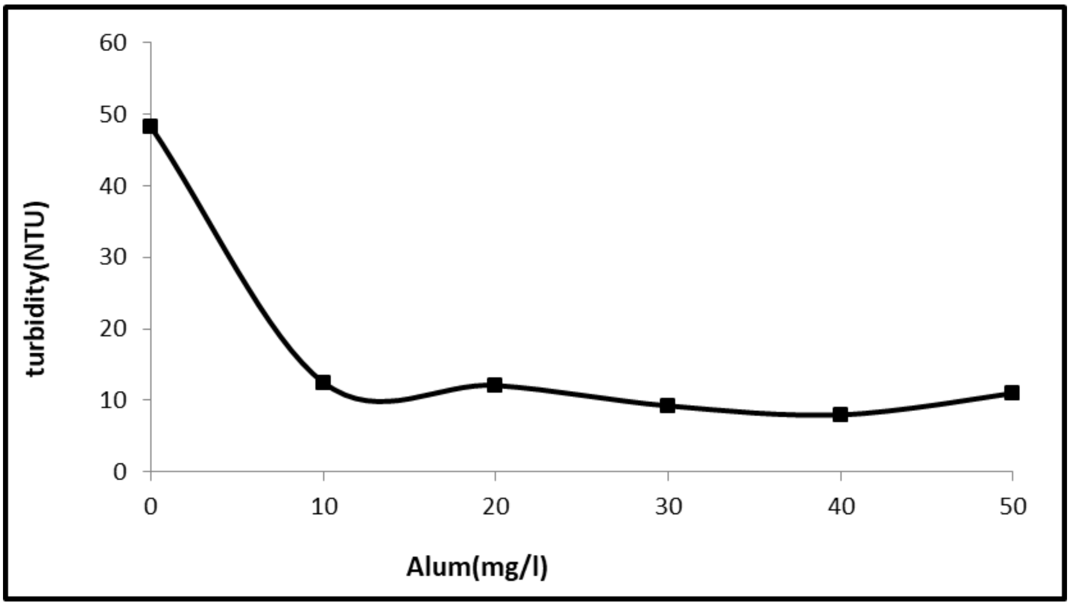


Figure (14): the optimum dose of alum

2- Optimum (alum + coagulant aid) dose:

Results showed that the ideal aluminum coagulant support concentration (40 ppm) was 0.8 mg / l

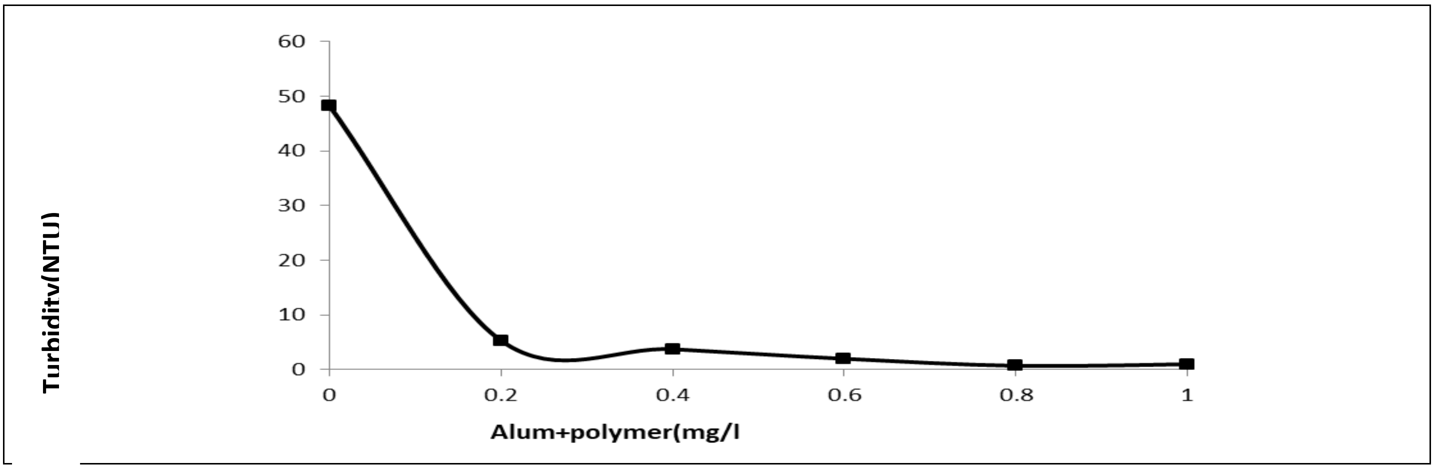


Figure (15): the optimum dose of (alum+cationic polymer)

Filter media

1- Sand

In the experiments conducted in this study, sand samples were used as a porous medium. Table (2) summarizes this sand's composition and properties. The particle size distribution was calculated in the Babylon Department of Environmental Engineering as shown in Figure (16).

Table (2): Composition and sand properties used in this study

Property	Value
Particle size distribution (ASTM D 422) Sand (%) Silt and Clay (%)	 99 1
pH	7.9
Bulk density (g/cm^3)	1.1
Porosity	42%
Soil classification	Sand

Partial size diameter (mm)

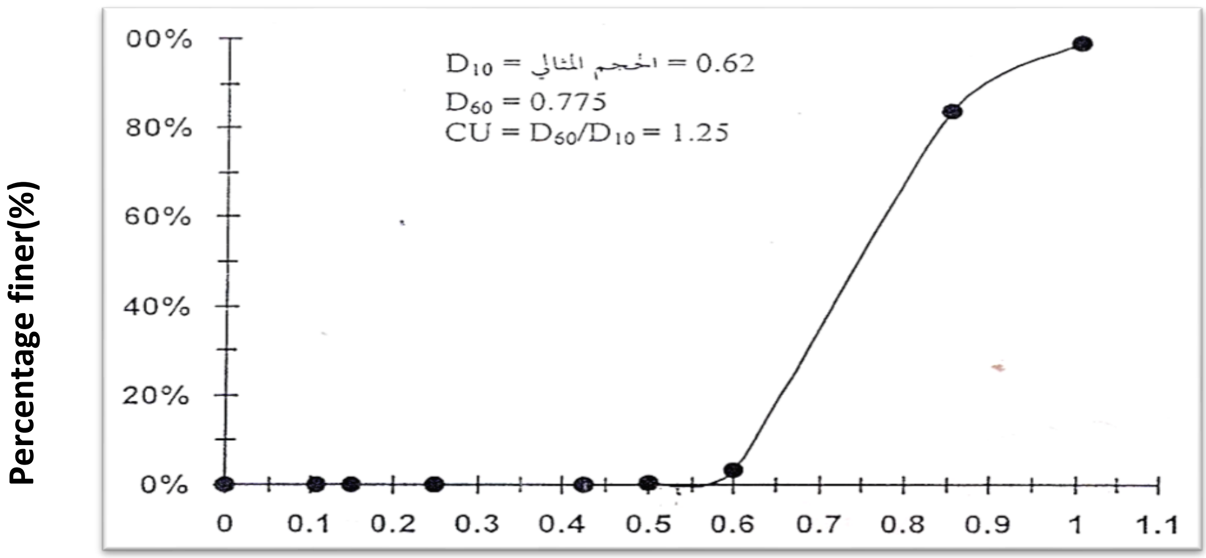


Figure (16): Particle size distribution of sand utilized in the present

Basic Factors in Pilot Plant Work

Several parameter effects as shown in table (3) in the layout of the pilot plant study:**Table (3):** Effect variable in the design of pilot plant study

Variable	condition variables
Raw water	Turbidity (150 NTU)
Temperature	(20 ºC)
alum dose poloyelectrolyte dose	40 mg/l 0.8 mg/l
Filter media	d10= 0.62, d60= 0.775 , CU=1.25
PH	7 .52
Q(m^3/sec)	Using constant head method (50 ml /15min)

Experimental Results:

A- Coagulant (alum)+filtration

The total turbidity removal efficiency at filtration time (9hr) is 80 percent, as shown in figure (17)

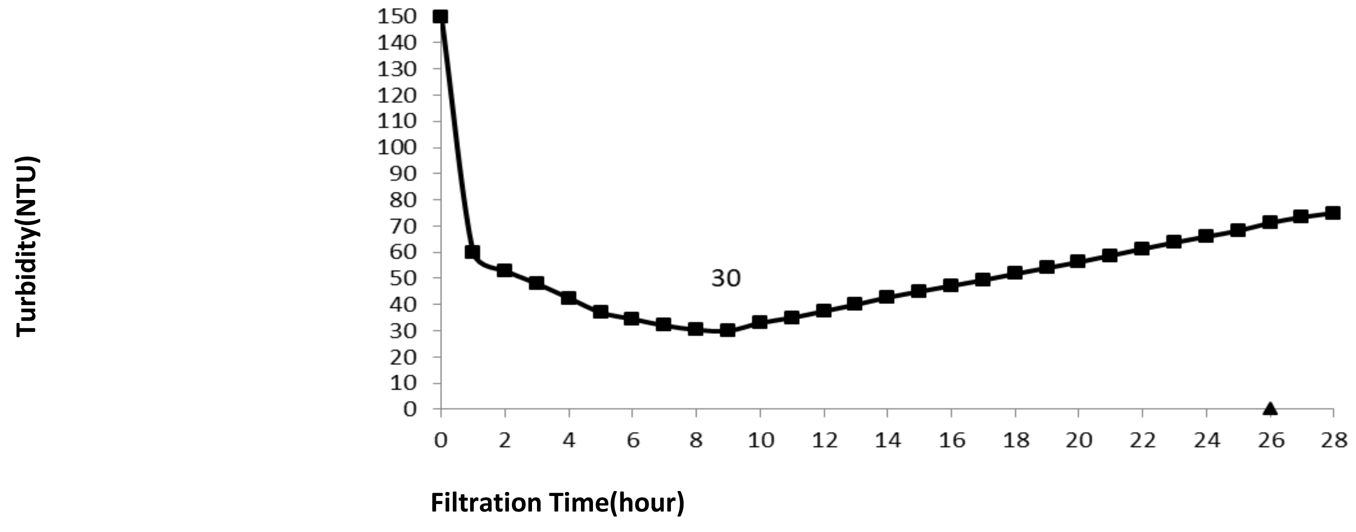


Figure (17): Variation of turbidity with filtration time at (coagulant(alum)+filtration)

B-Coagulant (alum+ polymer)+filtration

The maximum removal efficiency of turbidity is 90% at filtration time (14hr) as shown in figure (18)

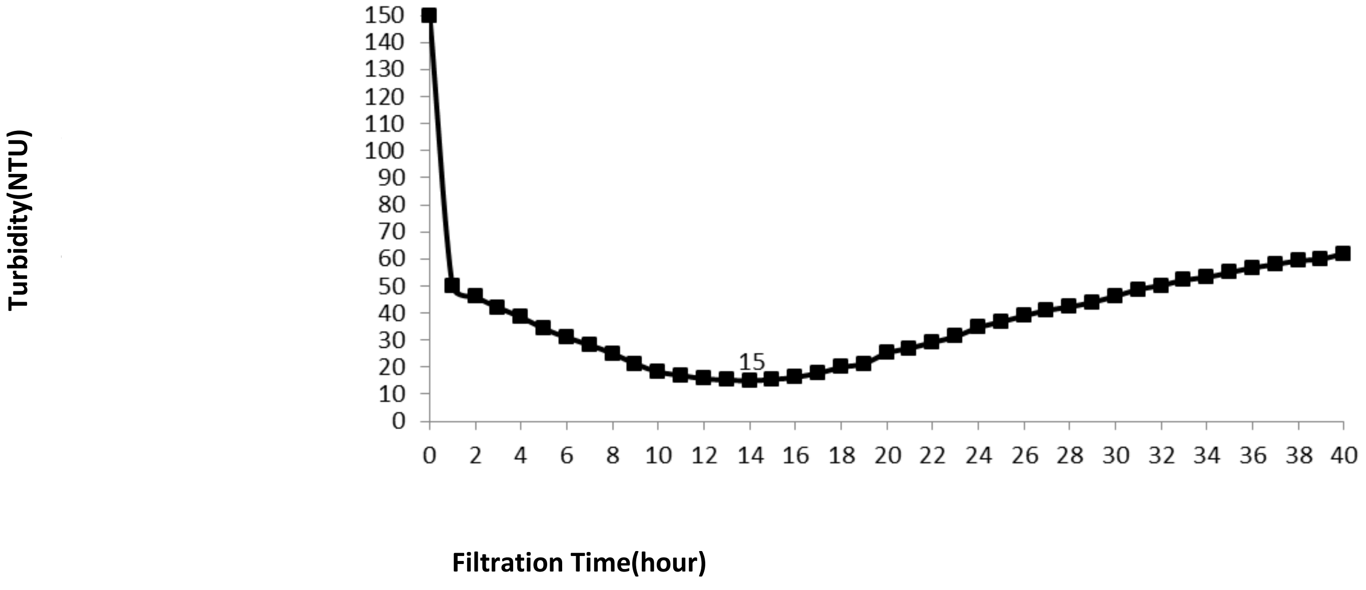


Figure (18): Variation of turbidity with filtration time at (Coagulant(alum+ polymer)+filtration

C-Coagulant (alum) +filtration

The maximum removal efficiency of turbidity is 86% at filtration time (9hr) as shown in figure (19)

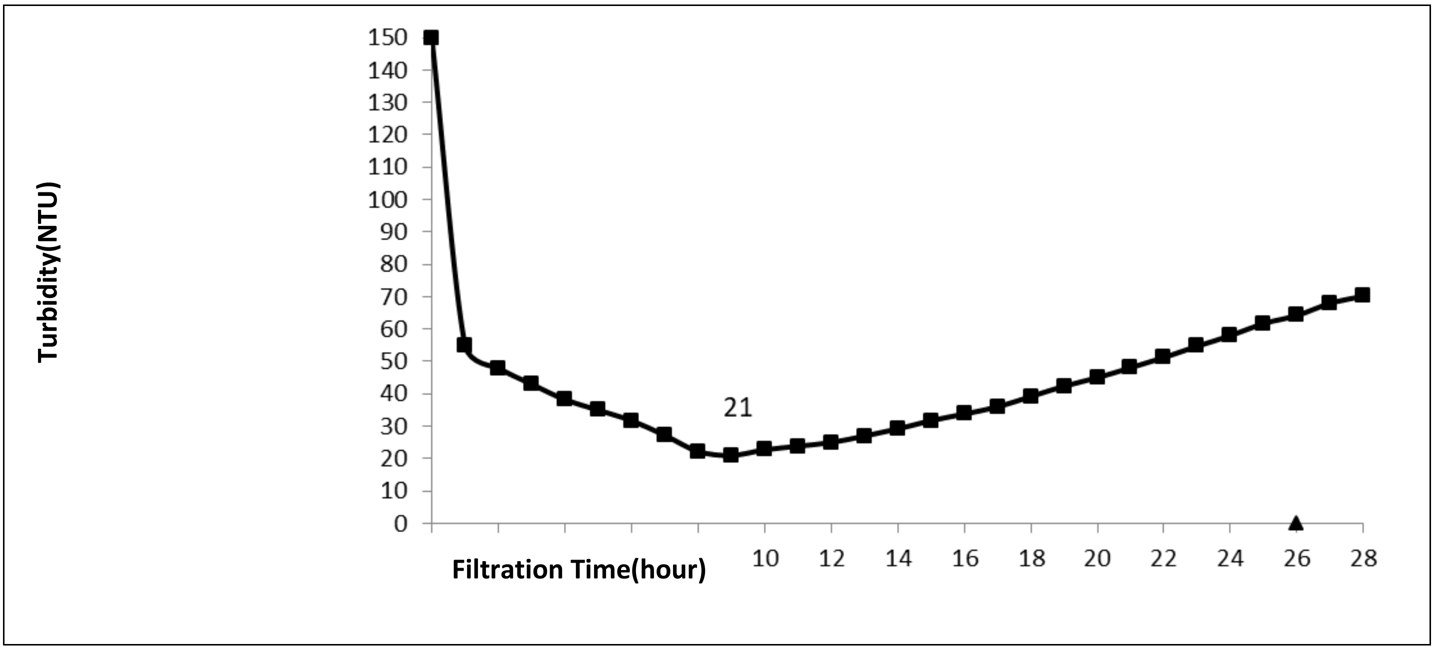


Figure (19): Variation of turbidity with filtration time at (Coagulant (alum) +flocculation +filtration)

D-Coagulant (alum+polymer)+flocculation +filtration

The maximum removal efficiency of turbidity is 98% at filtration time (14hr) as shown in figure (20)

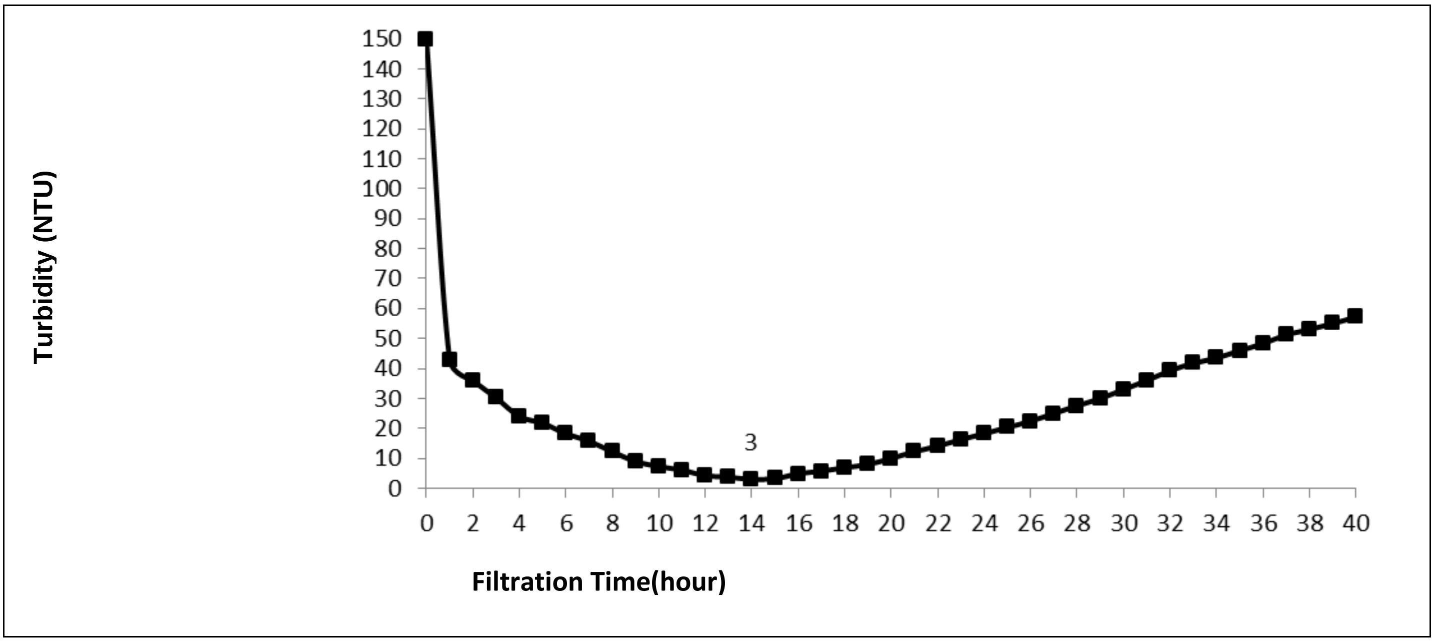


Figure (20): Variation of turbidity with filtration time at (Coagulant (alum+ polymer) +flocculation +filtration)

From figures above, the result indicted that the best removal turbidity efficiency using coagulant (alum polymer) + flocculation with filtration**.**

Conclusion:

1 - Improve the performance of sand filters by using coagulant aids with alum in order to increase their efficiency

2- The research confirms the necessity of using the coagulation and flocculation basins prior to filtration as it helps to remove colloidal thus leads to increase the efficiency of the sand filter.

3- The absence of a flocculation system and a sedimentation basin decreases construction costs, but raises the need for professional operators and high-quality instruments.

References:

1-. Cotruvo, J. A. and Vogt, C. D.; "Rational for Water Quality Standers and Goal in Water Quality and Treatment", A Handbook of Community Water Supplies, edited by Pontius, F. W.; American Water Works Association 4th edition, McGraw Hill Inc., New York, (1990).

2-Mihelcic, J. R. (Ed.). ;" Fundamentals of environmental engineering". New York: Wiley. Mihelcic, J. R., Urban, N. R., Perlinger, J. A., & Hand, D. W. (1999).

3- Sundarakumar, R. ; “Pilot Scale Study on Floating Media Filtration for Surface Water Treatment", M.Sc. Thesis, Asian Institute of Technology School of Environmental, and Resources Development Bangkok, Thailand. (1996)

4- Crittenden, J. C., Trussel, R.R., Hand, D.W., Howe, K.J., and Tchobanglous, G., “Water Treatment Principle and Design", John Wiley and Sons, Inc., MWH, (2005).

5-Al-Baidhani , J, H., Shubir, M.H.; "Study the ability of using crushed plastic solid wastes in water filtration" M.Sc. Thesis, College of Engineering , University of Babylon , Environmental Engineering.(2011).

6- Tien, C., and Ramarao, B. V., "Granular Filtration of Aerosols and Hydrosols", First edition, Elsevier Ltd, 2007,.

7- https://www.hach.com/asset-get.download(1999)

8- HDR Engineering Inc. ; Handbook of Public Water Systems. Second Edition; John Wiley &Sons, Inc.: New York.(2001).

9- Kiely, G.;" Environmental Engineering ".McGraw-Hill International (UK) Limited.(1997).

10-http://www.sswm.info/category/implementation-tools/water- purification/hardware/semi-centralised-drinking-water-treatme-14-(Internet, 2016)

11.https://www.mrwa.com/WaterWorksMnl/Chapter%2018%20Filtration.pdf . (Internet,2016) .

12-Babu,R. and Chaudhuri ,M.; "Home water treatment by direct filtration with natural coagulant" Journal of Water and Health (2005).

13- Aziz ,S.Q.;" treatment of greater-zab water by direct filtration' Department of Civil Engineering, College of Engineering, University of Salahaddin - Arbil, Kurdistan region, Iraq.(2009).

14-https://iaspub.epa.gov/tdb/pages/treatment/treatmentOverview. -(Internet, 2017).

15- https://en.wikipedia.org/wiki/Kaolinite(Intrnet 2016)