Comparative study between aluminum sulfate and ferric chloride in water treatment: turbidity removal

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Abstract:

The objective of the study is to improve the reduction of turbidity and dissolved solids in water by the coagulation-flocculation process by comparing two coagulants in the presence of polymer. The obtained results show that the uses of aluminum sulphate in combination with ferric chloride gave the maximum turbidity removal.

The Jar Test were performed in the laboratory, and several parameters such as pH, coagulant dose, polymer dose, were optimized in order to maximize the turbidity removal.

Keywords: *coagulation, flocculation, turbidity, coagulant dose, organic matter.*

1-Introduction:

Coagulation flocculation is a very effective treatment of clarification whose vital objective is the elimination of the non decantable portion of the suspended matter. This category of substances is represented primarily by colloids, characterized by their great stability.

The purpose of the operation of coagulation-flocculation is the growth of the particles (which are primarily colloidal) by destabilization of the suspended particles then formation of the flocs by absorption and aggregation [1].

The destabilization of the entities in suspension goes through adsorption phenomena [2], explained by the theory of the double layer. It explains how the colloids are treated with clotting.

Coagulation is an operation simple to carry out but the concerned mechanisms are very complex and do not cease occupying a broad place in recent research [3-5]. The comprehension of this phenomenon requires a thorough knowledge of the colloidal state and the chemical structure of the coagulants used like their mode of action.

The experimental study of the coagulation-flocculation aims to determine the choice a reagent and the optimum concentrations required for maximum reduction of the turbidity after simple sedimentation.

In order to satisfy this objective, the experimental gravel bank-test like technique was chosen.

2-Materials and methods:

2-1- Reagents used:

The metal salts used during the tests in Jar tests are the aluminum sulfate ($Al_2 (SO_4)_3$, $18H_2O$), ferric chloride ($FeCl_3$);

The metal salt solutions are prepared daily with a concentration of 1g/l.

The flocculants used is the polymer.

The polymer is prepared with concentrations of 0.1g/l.

2-2-other reactive:

Soda and sulphuric acid used to adjust the pH. The solutions of these reagents are prepared in distilled water.

2-3- Experimental Protocol:

The Jar-test was used to determine the optimum values of:

- Coagulants dose
- Polymer dose
- pH and organic mater
- Conductivity, alkalinity and salinity.

Different dose of coagulant were added to raw water in 06 beakers of 1 liter of water volume. The samples are mixed at high speed of 160 rpm, the of pH adjustment were performed by adding a base solution (sodium hydroxide 1 N) or an acid solution (sulfuric acid at 10 g / l), then poured coagulant. The rapid mixing agitation was maintained for 4min, followed by slow phase (30 rpm) for 20 minutes. Finally all parameters such as, turbidity, pH, organic matter, etc. were measured.

The result of turbidity is expressed according to the percentage as:

$$\textbf{Abatement\%} = \frac{\boldsymbol{initial\ value - value\ résidualo}}{\boldsymbol{initial\ value}}$$

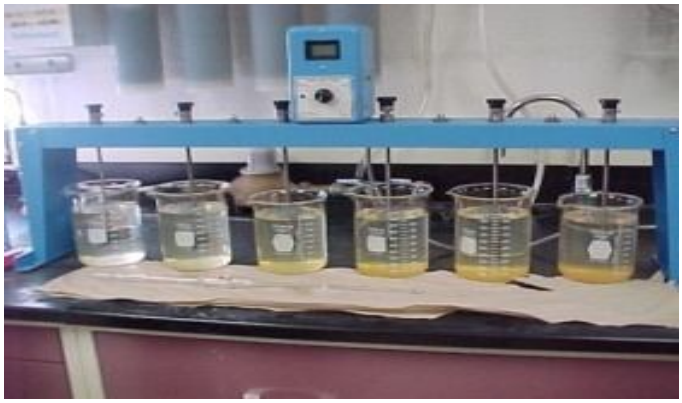

Figure 1: Jar Test

3-Results:

3-1-Optimization of pH:

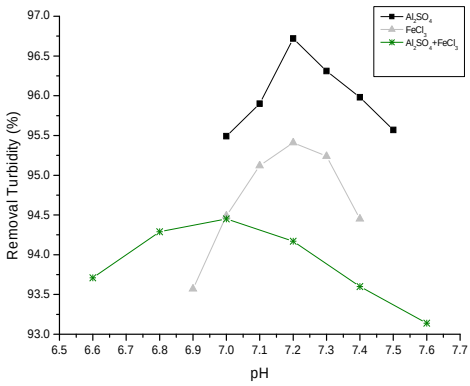

Figure 2: Effects of pH on turbidity removal

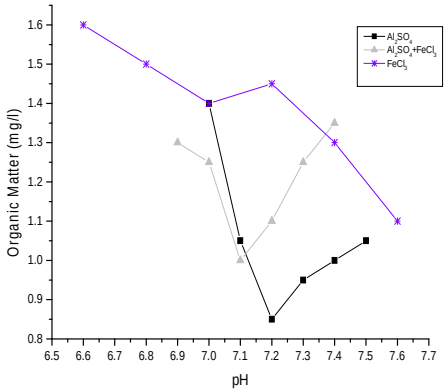

Figure 3: Effects of pH on organic matter

3-2 Optimization of the coagulant dose:

It is noticed well that the addition of coagulant caused the reduction in the value of turbidity with the increase in the concentration of the coagulant.

The particles of the coagulant destabilize colloids negatively charged present in water to be treated, by neutralizing the loads which generate the forces of repulsion enter colloids.
The overdose in coagulant causes the destabilization of the colloidal particles and prevents the formation of the intraparticle bridges and there will be thus water very charged in coagulant with a bad clarification.

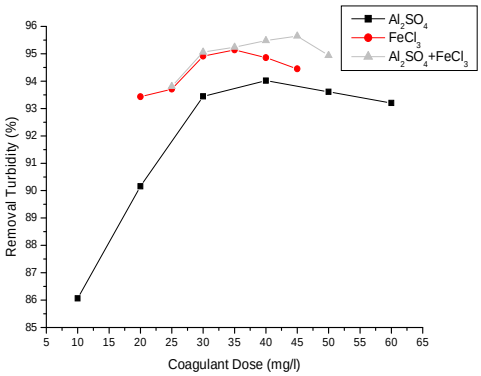

Figure 4: Effects of coagulant dose on removal turbidity

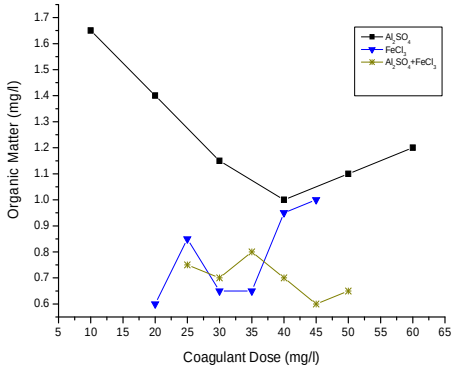

Figure 5: Effects of coagulant dose on organic matter

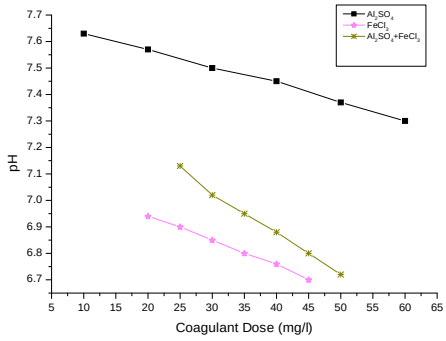

Figure 6: Effects of coagulant dose on pH

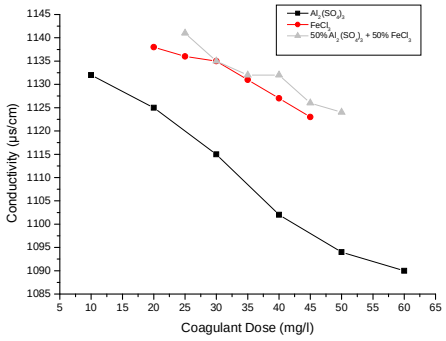

Figure 7: Effects of coagulant dose on conductivity

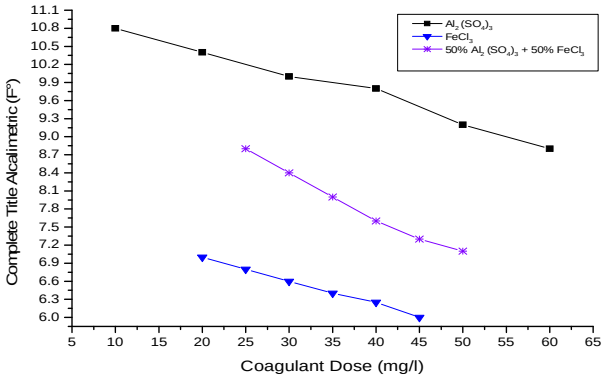

Figure 8: Effects of coagulant dose on Complete Title Alkalimetric

3-3 Optimization of the polymer dose:

It is well noticed that the waning of the curves until the optimal dose in the presence of the flocculating agent.

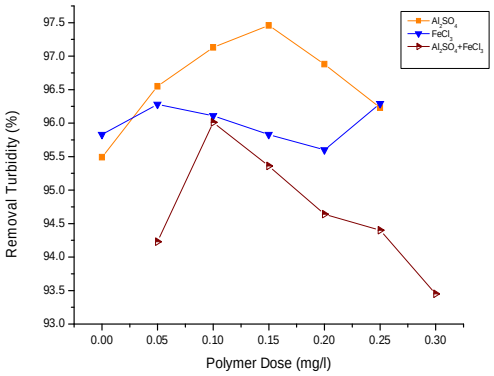

Figure 9: Effects of polymer dose on removal turbidity

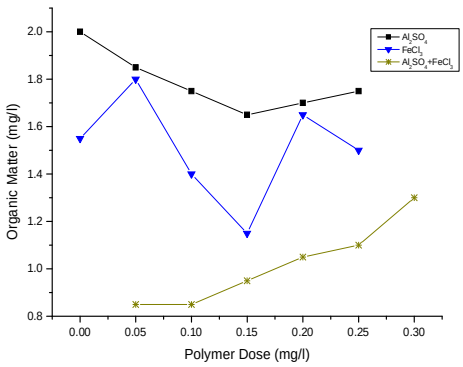

Figure 10: Effects of polymer dose on organic matter

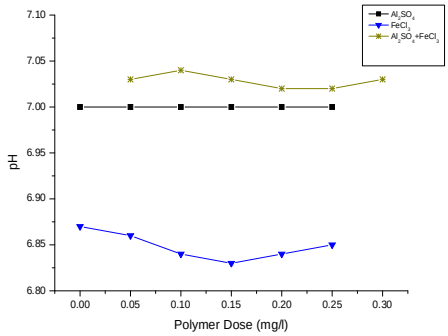

Figure 11: Effects of polymer dose on pH

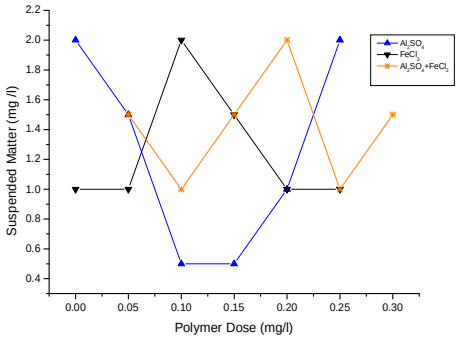

Figure 12: Effects of polymer dose on suspended matter

4-Discusions:

4-1-Optimization of pH:

The pH 7.2, 7.0, 7.2 represent the optimal values corresponding to the greatest value of reduction of the turbidity (96.72, 94.45, 95.41) of sulfate (Al_2 $(SO_4)_3$, $18H_2O$), $FeCl_3$, and mixes it respectively where the curves are decreasing before increasing;

Figure 3 represents the effect of the pH on the elimination of the organic matter where one can see that the optimal pH 7.2,7.0,7.2 gives a content of organic matter 0.85,1.4,1.1 for (Al_2 $(SO_4)_3$, $18H_2O$), $FeCl_3$, and mixes it respectively.

4-2 -Optimization of the coagulant dose:

According to the diagram of our experimental results, we got better results for 40, 35 and 45 doses (Al_2 $(SO_4)_3$, $18H_2O$), $FeCl_3$, and the mixture respectively,
these values represent the optimal dose because are the points corresponding to best the reduction of turbidity 94.02, 95.14, 95.65 respectively where the curves are increasing before this dose then becomes decreasing, The conductivity is reduced with increasing the dose of aluminum sulphate, ferric chloride and mixing, this reduction due to the reaction between the ionic charges in water and the coagulant used;

From the jar test experiments, it was found that the initial pH values for the water withdrawn is greater than 7 for the water to be treated and is basic because of the negative charges of the colloids.

The pH values have progressively reduced by increasing the concentrations of coagulant, coagulant each pH and concentrations of different coagulants, such as the pH value reached 7.30 aluminum sulfate has a concentration 60 mg/l;

Concerning the addition of the coagulant which involves the formation of hydroxide of metal with release of certain acidity (hydrolysis) what explains the reduction in the value of the pH.

$$M^{x+} + x\,H_2O \rightarrow M(OH)_x + xH^+$$

The particles of the coagulant bring also positive loads what also contributes to the reduction in the value of the pH and Complete Title Alkalimetric of water;

Figure 5 shows well that the effect of the dose of the coagulant on the content of organic matter, the dose of 40,20,45 gives the low value of organic matter 1.0,0.6,0.6 of $Al_2(SO_4)_3$, $FeCl_3$, mixture respectively, the abatement of the organic matter can be explained by simultaneous adsorption on the flocs of hydroxide of metal.

4-3 -Optimization of the polymer dose:

The flocculant used in our study is a polymer as a coagulant aid, which promotes agglomeration and floc formation.

The microphone-flocs formed by agglomeration of the particles discharged beforehand by the effect of the added mineral coagulant, are reinforced by the macromolecules of the polyelectrolytes or added flocculating agent. In this stage known as flocculation, these microphone-flocs are incorporated forming flakes which thus hold more suspended particles and consequently become bulkier what facilitates their decantation.

It is noticed well that the waning of the curves until the optimal dose in the presence of the flocculating agent.

The dose of 0.15, 0.05, 0.1 mg/l of polymer gives maximum reduction of turbidity 97.46, 96.28, 96.01%, and organic matter 0. 5, 1.0, 1.0 of $Al_2(SO_4)_3$, $18H_2O$), $FeCl_3$, mixture of 50%.

According to the comparison between aluminum sulfate, the ferric chloride and the mixture, one can conclude that aluminum sulfate with polymer is most effective that the others;

The absence off the ionic loads in the formulated of polymer explains the stabilization of pH with the variation of the polymer dose;

The increase in the organic matter by polymer is explained by the organic polymer formulated.

According to the experimental results one can also conclude:

The measurement of title alkalimetric is of only one limited interest, as for the determination of free CO_2 title alkalimetric is cancelled when

$$[CO_3^{-2}] + [OH^-] = [H_2CO_3] + [H_3O^+];$$

In the majority of the cases the pH of turn is close to 8.3, Thus water having a pH lower than 8.3 has a title alkalimetric which is null;

We noticed that the variation of salinity in our experiment independent of variation of pH and the amounts of coagulant and polymer, and a constant value of 0.3%.

5-Conclusion:

- PH, coagulant and polymer dosage are very important parameters;
- Aluminum sulfate combined with ferric chloride give a good result for turbidity removal;
- The polymer contributes also to turbidity removal;
- pH is a very important parameter for an optimal working of used coagulant;
- The overdose in coagulant causes the restabilisation of the colloidal particles and prevents the formation of the interarticular bridges and there will be thus water very charged in coagulant with a bad clarification;

- In coagulation-flocculation, the measurement of salinity is not a true reference mark to obtain information nor to judge the reliability of the process, nevertheless its variation can say to us on the salt reaction of dissolved during the treatment;
- The coagulant by a coagulant containing iron gives a better reduction of the organic matter than of coagulant containing aluminum.

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