BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, December 2014. Vol. **11**(3), 1707-1711

Performance Comparison of Polymeric and inorganic Coagulants in Coagulation and Flocculation

Mojtaba Fazeli[1] and Mastaneh Safari[2]

[1]Faculty of Water and Environmental Engineering , Shahid Beheshti University, A.C., Tehran, Iran.
[2]Department of Environment and Energy Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran.

doi: http://dx.doi.org/10.13005/bbra/1573

(Received: 15 August 2014; accepted: 10 October 2014)

The most important steps in water treatment plants are coagulation and flocculation. Various researches have been done about the best coagulant for water treatment. The present study is aimed to the performance of polymeric coagulants (including: poly aluminum chloride, poly ferric sulfate and poly aluminum ferrous sulfate and minerals coagulants (e.g. ferric chloride and alum) on clot formation, turbidity and organic material removal. Aluminum ferrous chloride has been used for the first time in Iran for water treatment. The total poly ferric sulfate showed a better performance among all coagulants tested for turbidity removal and organic carbon.

Key words: Water treatment, Coagulation, Poly ferric sulfate, Poly aluminum ferrous chloride.

Increasing population growth, improvements of living standards, urbanization development, industrial and agricultural developments are among the factors increasing the community's water consumption and waste water production and causing environmental pollution[7].

The water that is contaminated naturally or by human must be treated through the various processes to be drinkable. These processes include: coagulation, flocculation , sedimentation, and disinfection. Coagulation is the process by which non-settled particles called colloids are attached to each other and form larger clumps. In water resources, turbidity is caused by chemical, biological or physical factors[7].

The size of colloidal particles in water is between 0.001 to 1 micron. However the spontaneous sedimentation rate of a particle with a diameter of 0.9 micron is about 3 meters in one million year.

Thus, filtration process of water is impossible without the use of substances increasing the rate of sedimentation of colloidal particles[5].

Vitriol (aluminum sulfate) consumption in murky waters dates back to Babylon and Assyria civilization .Indeed, this substance was used in water treatment in two thousand BC. Based on the investigations around the Ziggurat Temple in Iran ,100 miles south in settling ponds that used for water treatment in Karkheh River ,has been discovered[3].

* To whom all correspondence should be addressed.

Karkheh River is one of the rivers with very high turbidity in most of the time. It is doubtable that based on the background of using Vitriol by people around the Mediterranean Sea, vitriol is not used in these pools.

In the fifteenth century in the Mediterranean, alum has been widely produced and used.

In 1881 in the city of Boston in UK, vitriol was used officially for the first time in water treatment of cities. Afterward, coagulation practically was recognized and recommended as a prerequisite for filtration and sedimentation.

In half of the twentieth century, alum and ferric salts were used as only coagulants in water treatment and they were the required parameters for the treatment and removal of pathogenic bacteria causing cholera and typhoid. In the years of 20[t], coagulation technology advanced rapidly way polymeric materials were used in water treatment.

In light of the findings of research conducted in the 1980, inorganic polymer entered the market as coagulant.

The result of all these developments leads to further reduction of dark water and improvement of water quality[3].

Among these polymers, poly aluminum chloride and poly ferric sulfate can be mentioned. Poly aluminum chloride is with chemical formula $AL2(OH)CL_{6-n}$ as yellow powder ,its AL_2O_3 27 -30 %,PH of 1% solution is 3.5 - 5 and in case of hydrolysis in water strong cationic charge is created[1].

a) Improved turbidity removal
b) Improved color removal
c) Increased TOC (Total Organic Carbon) removal
d) Simplified operation (eliminating pH regulating materials, secondary polyelectrolyte)
e) Lower overall treatment costs

As it was stated, poly ferric sulfate is among the best materials to be used in water treatment and waste water clarification in the advanced industrial countries.

This material combined with water turns to yellow water solution, which consist of ferric sulfate polymers. Basic part of poly ferric sulfate solution is trivalent iron [4].

Another point that its role in making this changes from coagulation types aspect in technological systems should not be ignored is improvement and review of water quality standards , specially potable water that is done by responsible Health institutions once every few years in different countries at international level by and according to the latest data from the hygienic effects of different constituents and elements ,some quantities as guideline values or maximum permissible limit are recommended. It is obvious, efficiency and performance of different coagulation systems in achieving water to desired level of quality is not the same and application of an appropriate treatment system is mandatory.

In this study poly aluminum ferrous chloride is tested in Iran for the first time for water treatment. It is a chemical polymer that ferric polymer is formed based on poly aluminum chloride. These practices increase the molecular structure and improve coagulation and sedimentation. This material has ability to treat raw water with low temperature and high turbidity or low turbidity

MATERIALS AND METHODS

For the experiments, the samples of Tehran city water were applied. The turbidity and organic materials were obtained artificially by adding clay passed through the sieve no.200 and natural organic materials (the rotten leaves of trees). The experiments were carried out in laboratory scales and by using jar test apparatus with five coagulants including: poly ferric sulfate, ferric chloride , alum poly aluminum chloride and poly aluminum ferrous chloride .

The studied variables in turbidity removal included concentration of coagulant, PH(6,7,8,9,10,11,12) and turbidity (NTU 300,150,100,10).

Hydrochloride acid and sodium hydroxide with concentration of (0.5, 0.1 Mm) and PH meter were used to adjust the PH. Temperature of laboratory environment was averagely 20°C and water temperature was averagely 12. . After preparing the samples by using 1 L glass breakers containing 900ml of water, jar test was conducted. The samples in jar apparatus underwent rapid mixing with speed of 120rpm(revolution per minute) for 1 min and slow mixing speed of 25rpm for 20 min ,then allow the samples in the beakers to settle for 30 minutes, then the residual turbidity of the samples was measured by turbidity meter and efficiency of each coagulant was determined in turbidity removal and the charts were plotted. After jar test and achieving to optimum dose and PH of tested coagulant in turbidity removal, in later experiments, the PH of all breakers was set in optimum PH ,but dose of tested coagulant set in higher ,equal, or lower than the optimum dose of turbidity removal were added to breaker to obtain the removal percentage of organic carbon after coagulation, flocculation and sedimentation process.

Finally, dose and optimum PH of all tested coagulants and flake were formed and diameter of each was measured by Particle Size Experiment.

RESULTS

The result of this study on the performance of five coagulant (poly ferric sulfate ,ferric chloride ,alum ,poly aluminum chloride and Poly aluminum ferrous chloride) in turbidity and organic materials removal from drinking water are:

Figure 1 to 4 tested coagulants on turbidity removal efficiency and in tables 1 to 4 the removal efficiency of coagulant in dose and optimum PH of the test are compared together .As shown in tables and charts, in the input turbidity NTU300(table 1 and figure 1) removal efficiency of five coagulants is closer together and in all cases turbidity removal efficiency is above 90 percent , the best turbidity removal efficiency is for poly

Table 1. Turbudity removal efficiency of coagulant in turbidity of (300NUT)

Poly aluminum ferrous chloride	Poly ferric sulfate	Poly aluminum chloride	Ferric chloride	Alum	Coagulant matter Description
7	7	8	8	8	Optimum PH
16	14	14	14	20	Optimum dose(mg/L)
98.25	97.48	95.70	91.22	94.09	Removal efficiency(percent)

Table 2. Turbudity removal efficiency of coagulant in turbidity of (150NUT)

Poly aluminum ferrous chloride	Poly ferric sulfate	Poly aluminum chloride	Ferric chloride	Alum	Coagulant matter Description
7	7	8	8	8	Optimum PH
12	12	12	14	18	Optimum dose(mg/L)
96.24	98.66	94.63	95.11	93.62	Removal efficiency(percent)

Table 3. Turbudity removal efficiency of coagulant in turbidity of (100NUT)

Poly aluminum ferrous chloride	Poly ferric sulfate	Poly aluminum chloride	Ferric chloride	Alum	Coagulant matter Description
7	7	8	8	8	Optimum PH
10	10	12	12	16	Optimum dose(mg/L)
95.03	98.87	94.82	93.99	91.92	Removal efficiency(percent)

Table 4. Turbudity removal efficiency of coagulant in turbidity of (10NUT)

Poly aluminum ferrous chloride	Poly ferric sulfate	Poly aluminum chloride	Ferric chloride	Alum	Coagulant matter Description
7	7	8	8	8	Optimum PH
8	8	8	12	16	Optimum dose(mg/L)
94.56	95.27	94.43	89.83	63.60	Removal efficiency(percent)

aluminum ferrous chloride with an efficiency of 98/ 25 percent.

In input turbidity NTU150 (table and figure 2),the highest turbidity removal efficiency of tested coagulants is obtained as Poly ferric sulfate (98.66%), poly aluminum ferrous sulfate (96.24%) , ferric chloride (11.95%).poly aluminum chloride (63.94%) and alum (62.93%), respectively.

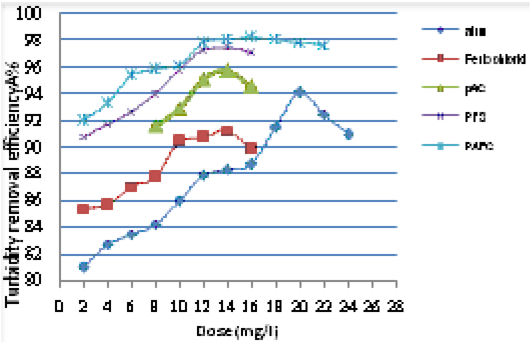

Fig. 1. Turbudity removal efficiency of coagulant in turbidity of (300NUT)

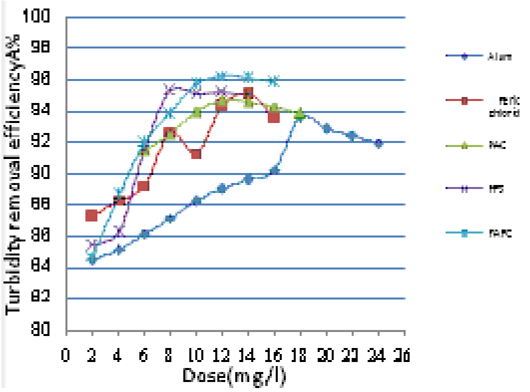

Fig. 2. Turbudity removal efficiency of coagulant in turbidity of (150NUT)

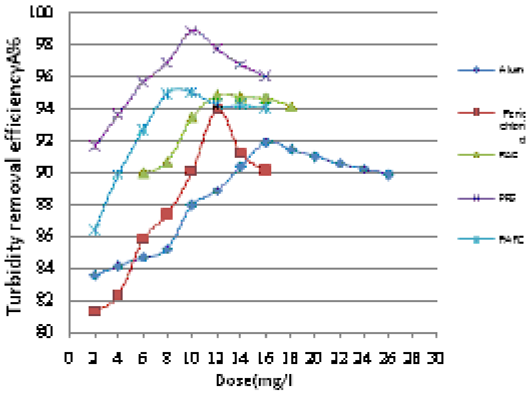

Fig. 3. Turbudity removal efficiency of coagulant in turbidity of (100NUT)

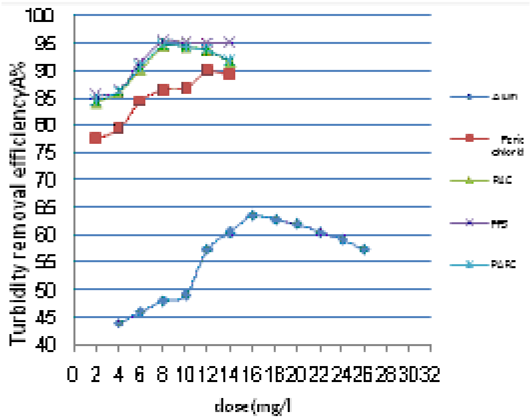

Fig. 4. Turbudity removal efficiency of coagulant in turbidity of (10NUT)

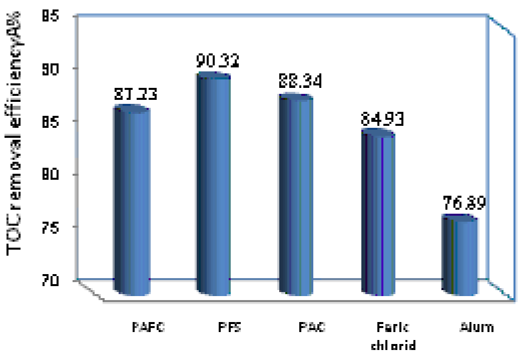

Fig. 5.TOC removal efficiency of TOC=10mg/L

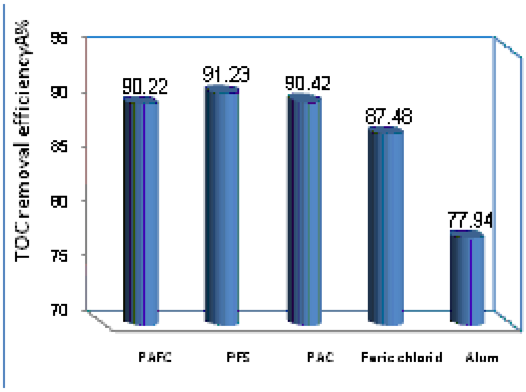

Fig. 6. TOC removal efficiency of TOC=20mg/L

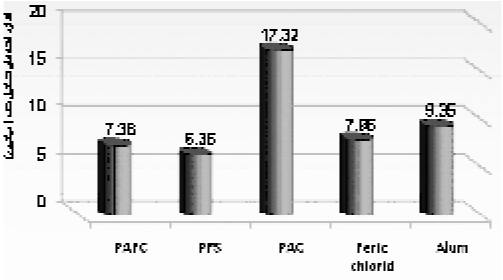

Fig. 7. Comparison of the diameter of fluke that is formed by the coagulants in coagulation and flocculation process

In input turbidity 100 NTU (table and figure 3) the highest turbidity removal efficiency is for poly ferric sulfate with 87.98%, and the input turbidity NTU10 (Table and Figure 4), as could be expected polymeric coagulant have better removal efficiency than alum and ferric chloride ,while the consumable dose was lower too and poly ferric sulfate with 27.95% had the highest removal percent.

In Figure 5 (TOC=10mg/L) and Figure 6 (TOC=20mg/L) , TOC removal efficiency of five tested coagulant is shown. With regard to the result of figures 5,6, poly ferric sulfate has the highest TOC removal efficiency .

In figure 7, diameter of fluke that formed in each of tested coagulants in dose and optimum PH of turbidity removal is shown.

As the result shows, fluke that is formed by poly aluminum chloride has a larger diameter than the other coagulants.

DISCUSSION

The results of study revealed that the efficiency of turbidity removal by different coagulants is affected by primary turbidity and all tested coagulants in turbidity of 300NTU had desirable removal efficiency .However, doses of poly ferric sulfate ,poly aluminum chloride and poly aluminum ferrous chloride are much lower than that of ferric chloride and alum.

In 10 NTU turbidity, poly ferric sulfate , poly aluminum chloride ,poly aluminum ferrous chloride, had very high removal efficiency too, while the consumable dose of these materials was low.

Since the raw water entering the water treatment plants was supplied more through surface waters in country , the use of coagulants with good performance in critical condition and the incidence of sudden pollution is very important ,and also this issue shows the technical and economic feasibility of replacing conventional coagulants with polymeric coagulants.

ACKNOWLEDGMENTS

Our gratitude goes to Zanjan water and wastewater Company ,all employees of water and wastewater chemistry lab and power and wastewater laboratory of power and water university of technology (Shahid Abbas pour), environment lab of Islamic Azad University – science and research Branch and those who supported and helped us in this project.

REFERENCES

1. Shahmansouri M ,Neshat A., Comparison of poly aluminum chloride, Aluminum sulfate and ferric chloride in removing TOC,MPN ,in optimal concentration of turbidity removal from raw water in water treatment plants in Isfahan . Mazandaran University of medical sciences and health services. sixth national conference on environmental health 2002-2003; 2.
2. Safaeefar, M., Performance evaluation of poly aluminum chloride in comparison with ferric chloride in direct filtration process .M.A Thesis, Tehran university 2005; 22.
3. Kashkouli,H., Coagulation diagram and important notes about using coagulant material in surface water treatment. the first seminar about coagulant in water industry.Tehran. 1996; 22.
4. Yazdi,M., Optimization of coagulation and flocculation by using alternative coagulant material. M.A Thesis . power and water university of technology. 2008; 23-26.
5. Kent.D.K.”Water treatment Plant Operation”, Volume1,Chapter 4, Coagulation and Flocculation, by J:Beard.1992.
6. Montogomery,J.M. “Water treatment principles and design”,John Wiley and Sons Ins,1995.
7. PariZanganeh A, abedini Y, Ghadimi Y. “Effect of environmental factors on pollutionreduction and increase of autopurification of Abharrood river in Zanjan state”, The 6th national congress of environmental health, Mazandaran University of medical sciences, 2003; 4.