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Evaluation of common coagulants and polymeric coagulant aid in the removal of suspended particles and colloidal turbidity of raw water of Gavoshan dam

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ABSTRACT

Background: In water treatment plants coagulation and flocculation are special process and always trying is to achieve high efficient in the removal of colloidal and suspended solids by low cost. So this study aimed to determine the efficacy of conventional coagulants and polymeric coagulant aid in the clarification of raw water of Gavoshan dam.

Methods: The study was conducted in laboratory scale using a jar test. The efficiency of coagulants, aluminum sulfate (5, 10, 15 and 20 mg/l), ferric chloride (4, 6, 8 and 10 mg/l) and cation and polymeric coagulant aid (0.25, 0.5, 0.75 and 1 mg/l) were evaluated separately and in combination. Rapid mixing stage with 120 rpm in 1 minute and slow mixing with 30 rpm in 20 minutes was carried out, then to sedimentation samples were placed in stasis for 30 minutes.

Results: Ferric chloride at 10 mg/l and anionic polymer at 1 mg /l concentration are the best coagulant and coagulant aid respectively with 82.61% and 87.57% turbidity removal efficiency. There was a direct relationship between system efficiency and coagulants dose. In coagulants and coagulant aid combination, the optimum concentration of 20 mg/l aluminum sulfate and 1 mg/l anionic and cationic polymer removal efficiency were 92.61% and 90.9 % and10 mg/l ferric chloride with 1 mg/l anionic and cationic polymers 90.62 % and 93.21% removal efficiency respectively obtained.

Conclusion: The use of a coagulant aid increases removal efficiency. So coagulation process by using a coagulant aid can be applied as an efficient method for the removal of turbidity from Gavoshan dam water.

KEY WORDS: ferric chloride, aluminum sulfate, anionic polymer, cationic polymer Gavoshan dam.

1. INTRODUCTION

Surface waters are the most important sources of water supply in different societies that rapid population growth, industrial and agricultural activities and urbanization have played an important role in increasing the pollution of these sources in recent decades (Pathan Mohsinkhan, 2016). As the presence of suspended solids such as sand particles, bacteria, algae, organic materials, etc. in this resources is possible so this leads to an increase in turbidity (Lee, 2007). One of the key indicators of surface water quality is turbidity that indicates the presence of water contamination is inevitable (Ukiwe, 2016).Generally, the turbidity in three aspects of aesthetics, blocking filters and disinfection is important. Due to the relationship between turbidity and some biological characteristics such as *Giardia lamblia* cyst, turbidity can considered as an indirectly indicator to determine the removal or the presence of these factors (Divakaran and Pillai, 2001). Turbidity while create the undesirable appearance can be a haven for microorganisms before disinfection (Engineers, 1985). An important health problem of turbidity is chlorination process disorder and production of toxic component. Chlorine reacts with organic matter that causing water turbidity and produce toxic byproducts such as Haloacetic Acids and Trihalomethanes. Trihalomethanes by European Union and Trihalomethanes and Halloacetic Acids by United States are classified as hazardous material and are regularly monitored (Jung and Son, 2008).Several methods such as coagulation and flocculation are used for the removal of turbidity from surface water sources (Silva, 2013).Coagulation is used to destabilizing colloidal particles and flocculation is clotting unstable colloidal particles that are removed by sedimentation from water (Pathan Mohsinkhan, 2016). The process success depends on understanding the interaction between the factors influencing soluble and suspended solids and water molecules. Surface charge of particles has an important role in particles stabilization. Most of the particles in water and wastewater has a negative charge and repel each other when contact (Tripathy and De, 2006). So selection of the appropriate coagulant to neutralize the repulsive force between particles is very important and should be based on the following principles: The appropriate coagulant effect, non-toxicity, low cost, providing health standards and compatibility with a wide range of pH (Ukiwe, 2016).

Minerals such as alumina and ferric salts and synthetic organic polymers are coagulants that their performance to destabilizing particles and clotting them are well proven (Antov, 2012). Alum and ferric sulfate can be used in combination with each other and reduce turbidity and COD successfully (Pirsaheb, 2011). Since the Gavshan dam water turbidity is caused by soluble and colloidal, so coagulation process by selecting an appropriate coagulant will be able to remove significant amounts of pollutants. The aim of this study was to evaluate the effectiveness of coagulation and flocculation process to removal of turbidity from raw water of Gavoshan dam in the Kurdistan Province, Iran.

2. MATERIAL AND METHODS

This is experimental study on laboratory scale that was conducted on raw water of Gavoshan damin spring. To determine the coagulants efficiency for the removal of turbidity, experiments were conducted based on coagulants concentrations such as aluminum sulfate (5, 10, 15 and20mg/l), ferric chloride (4, 6, 8, 10mg/l) and anionic and cationic polymer coagulant aids (0.25, 0.5, 0.75,1mg/l).Reagents and chemicals of Merck Germany with the purity of %99/99 were used in this study. All stages of sampling, sample storage and experiments were conducted in accordance with the instructions provided on standard methods for water and wastewater (APHA., 1976). After transferring the samples to the laboratory, using a turbidity meter HACH-2100 Made in America (based on the principle of light scattering) turbidity of samples were determined. Before the jar test, pH, temperature, alkalinity and turbidity parameters were measured, then in accordance with the objectives of the study the optimum concentration of coagulants and coagulant aid separately and in combination were added to the Container with a volume of one liter. Coagulation and flocculation have conducted in this way, first, rapid mixing was done in a minute at 120 rpm then clots were formed on 20 minutes while mixing with a 30 rpm speed and finally time of 30 minutes was considered to settling clots, thus the best coagulants concentration in the desired turbidity were determined. After the jar test, samples turbidity was determined again. PH and alkalinity were measured by the pH meter (HANNA model) and titration method respectively. It should be mentioned in order to obtain appropriate accuracy, all experiments were repeated three times and the results were reported as mean ± SD. It should be mentioned Gavsohan dam placed on the Gavroud river in 40 kilometers from south of the Sanandaj city in Kurdistan province, Iran, with geographic coordinates N 46°59′40″E and a total capacity of 550 million cubic meters (Rasolabadi, 2015). Dam height is 123 meters, the length 620 meters and its volume is 10 million cubic meters. About 63 million cubic meters of dam water annually are used for drinking water purposes in Kermanshah city (Tunnel, 2011).

3. RESULTS

This study was conducted to evaluate the efficiency of aluminum sulfate and ferric chloride coagulants and polymeric anion and caution coagulant aids in the turbidity removal of Gavoshan dam raw water and the following results were obtained: Process efficiency was directly related to the amount of coagulants and coagulant aids. So that according to Figure 1 using aluminum sulfate least (46.69%) and the highest (64.74%) removal efficiency was at 5 mg / l and 20 mg / l concentrations respectively. Using Ferric chloride coagulant sulfate the least and the highest removal efficiency was at 4 mg / l (60.36%) and 10 mg/l (82.61%), concentrations respectively (Figure 2).

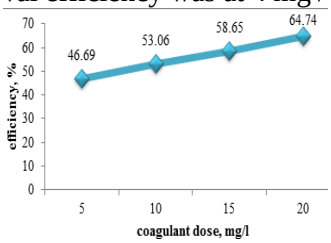

Fig.1. Efficiency of Sulfate Aluminum coagulant in the removal of turbidity of raw water of Gavoshan dam

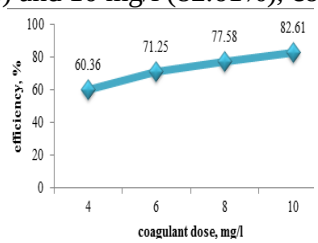

Fig.2. Efficiency of Chloric Ferric coagulant in the removal of turbidity of raw water of Gavoshan dam

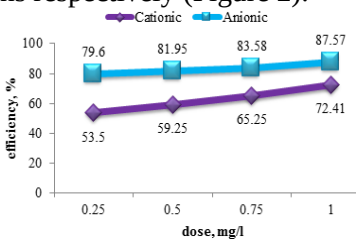

Fig.3. Efficiency of coagulant aid in the removal of turbidity of raw water of Gavoshan dam

In the study of anionic polymer effectiveness on the removal of turbidity, the least turbidity removal efficiency was 79.6% in 0.25mg/l concentration and the highest removal efficiency at concentration of 1 mg / l was 87.57 %. Also achieved a similar trend in turbidity removal using cationic polymers that the least removal efficiency was 53.5% in 0.25mg/l concentration and the highest removal efficiency was 87.57 % at concentration of 1 mg / l. Generally ferric chloride was more efficient than Alum in less concentrations and anionic polymer coagulant aid performance was better than cationic type. In evaluation of turbidity removal by combination of aluminum sulfate and anionic polymer coagulant aid the least removal efficiency (74.2%) was at a base concentration of aluminum sulfate and anionic polymer coagulants. As shows in Fig. 2 and 3turbidity removal efficiency is directly related to the concentration of coagulants, so that highest efficiency in combination used coagulants was 92.61% at 20 mg / l concentration of Aluminum sulfate in combination with 1 mg / l anionic polymer. Cationic polymer coagulant aid in

combination with aluminum sulfate had less efficiency so that the initial turbidity decreased about 82.9% (Fig. 3).In study the effectiveness of ferric chloride and anionic and cationic polymer coagulant aids combination on turbidity removal, the least removal efficiency was at the lowest concentration (Table 2). Generally, removal efficiency increased by coagulant aids, for instance, turbidity removal at concentration of 10 mg/l Ferric chloride was about 82.61% but by using cationic and anionic polymer coagulant aids removal of turbidity increased to 93.21% and 90.62% respectively.

Table.1. Efficiency of sulfate Aluminum combined with polymeric coagulant aid in the removal of turbidity of raw water of Gavoshan dam

Type of polymeric coagulant aid	Conc. of polymeric coagulant aid (mg/l)	Conc. of sulfate Aluminum (mg/l)	Mean ± SD of turbidity removal
Anionic	0.25	5	10.05±74.2
	0.5	10	12.47±74.41
	0.75	15	89.89±6.97
	1	20	92.61±4.27
Cationic	0.25	5	73.5±7.76
	0.5	10	81.18±4.7
	0.75	15	84.41±4.55
	1	20	90.9±8.7

Table.2. Efficiency of Chloric ferric combined with polymeric coagulant aid in the removal of turbidity of raw water of Gavoshan dam

Type of polymeric coagulant aid	Conc. of polymeric coagulant aid (mg/l)	Conc. of Chloric ferric (mg/l)	Mean ± SD of turbidity removal
Anionic	0.25	4	76.3±12.34
	0.5	6	84.27±8.2
	0.75	8	88.8±8.71
	1	10	90.62±3.34
Cationic	0.25	4	80.31±5.12
	0.5	6	83.59±5.61
	0.75	8	84.79±7.32
	1	10	93.21±2.28

DISCUSSION

In this study coagulant efficiency individually and in combination with a coagulant aids to removal of turbidity of Gavoshan dam raw water was evaluated. According to the study results the best coagulant is ferric chloride in combination with a cationic polymer coagulant aid. Also considering that for removal of equal turbidity, Ferric chloride coagulant consumption is less than Aluminum sulfate, so the volume of sludge produce will be far less. This would reduce the cost of coagulant consumption per cubic meter of treated water and cost of facilities (Mahvi, 2003).Since the financing is one of the major factors influencing the selection of chemical coagulants for water treatment, therefore, the results of this study suggest that ferric chloride will be better than aluminum sulfate in economic aspects, so it is more suitable to use this coagulant for turbidity removal. Coagulant aids by bridging between fine particles clot result of using coagulants causing clots be larger and heavy, speed up their sedimentation and reduce the amount of coagulant (Mousa and Hadi, 2016).

Noorimotlagh and colleagues study showed that coagulant aid increase the turbidity removal efficiency of the textile wastewater (Zahra, 2014) and study results is in accordance with this study. In evaluating the effectiveness of cationic polymers should be mentioned that the optimum concentration of anionic polymer for about 83% removal efficiency is 0.5 mg/l While the optimum concentration for ferric chloride is 10 mg/l in the same case and aluminum sulfate even at a concentration of 20 mg/l did not achieve this efficiency. This result indicates the superiority of anionic polymers to ferric chloride and aluminum sulfate as inorganic coagulants in terms of efficiency and economic costs (Pillai, 2009). In general, the results show that the optimum concentration of polymers is much less than the aluminum sulfate and ferric chloride coagulants. Reducing the amount of coagulant in water purification is one of the polymer premier than conventional coagulants. In Pirsaheb and colleagues study it was found that increasing the concentration of aluminum sulfate from 10 to 30 mg / l turbidity removal rate would increase, so that in concentration of 20 to 30 mg / l turbidity removal rate achieve to 100 % (Pirsaheb, 2011).In this study, removal efficiency achieve to 64% using aluminum sulfate at a concentration of 20 mg/l that removal efficiency was less than the Pirsaheb study results.

Kurd Mostafapoor and colleagues study (2008) showed that at concentration of 10 and 20 mg of aluminum sulfate, turbidity removal efficiency was about 99.9% and highest removal efficiency was 96% at 20 mg / l concentration for ferric chloride coagulant. In addition also with increasing coagulant dose turbidity removal efficiency increased that is in accordance with this study results (Mostafapoor, 2008). Also in accordance with this study in Dargahi and colleagues study it was found turbidity removal efficiency is directly related to the concentration of aluminum sulfate and ferric chloride coagulants (Dargahi, 2015).According to studies, can make a change in the water industry by selecting and use of a suitable coagulant in water treatment.

4. CONCLUSION

Based on the results it can be concluded that in the optimum dosage, ferric chloride coagulant and anionic polymer coagulant aids are most effective in turbidity removal. Given that Gavshan dam suppliers part of the drinking water of Kermanshah city, water treatment seems essential. By conclusion of this study and comparison with other studies is recommended regarding to the high efficiency, low cost and no need for advanced technology, this method be used as proper solution for water treatment of Gavoshan dam.

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