Experimental Research on Removal of Turbidity and UV₂₅₄ by Poly-aluminum Chloride (PAC)

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Abstract: Through a static beaker test, it was analyzed the effect on the removal of turbidity and UV₂₅₄ by poly-aluminum chloride(PAC) under different dosages and pH values in the PI river, and discussed the relationship between the dosage of PAC and residual aluminum. The results showed that it has good effect on removing turbidity by adding PAC, but it was normal to UV₂₅₄, the removal rate was not exceed sixty percent ,with the increase of PAC dosage , the removal trend of the turbidity after precipitation was similar to that of UV₂₅₄, while residual aluminum first decreased and then slowly increased. For turbidity removal, the optimal dosage of PAC was 8.5 mg / L, and the optimal pH value range was 7.2-8.5. For removal of UV₂₅₄, the optimal pH value range was 6.5-7.2. The best experimental conditions for coagulation are PAC dosage of 8.5 mg/L, raw water pH value of 7.2.

1 Introduction

The PI river is the source of drinking water for a water plant ,in which the average of turbidity is less than 10 NTU,and organic pollutants are mainly natural organic matters(NOM),including humus, microbial secretions, dissolved plant tissue and animal wastes^[1].

At present, the removal of natural organic matter are mainly:enhanced coagulation, granular activated carbon adsorption and membrane filtration, in which the enhanced coagulation is recommended by the U.S. Environmental Protection Agency (USEPA) in water control^[2]. The poly aluminum chloride (PAC) is the most extensively used coagulant for water purification and eventually in waste water treatment plants throughout the world ^[3].In order to improve the aggregating capacity of PAC, several efforts have been made during the recent few years, towards the incorporation of silica in its structure.Hasegawa et al.^[4]noticed that by introducing metal ions into polymerized silicic acid solution, the molecular weight of the product was increased and the corresponding stability and coagulation performance were further improved.

For many years, it is used PAC as coagulant in a water plant.Due to less impurities in low turbidity source water, there is less chance of condensation and collision, and it is not easy to form flocs, although overdosed PAC can increase floc Formation, but it will lead to increased aluminum content in water, the body's excessive intake of aluminum may cause severe calcium deficiency, and the body's high residual aluminum may cause Parkinson's disease, Alzheimer's disease, hair loss and other diseases ^[5].UV₂₅₄ is an index to evaluate organic pollutants in water in 1970s. It is an important control parameter to measure organic matter index in water^[6].A

lot of literature at home and abroad shows that the UV_{254} value of water samples has some correlation with TOC, DOC, COD in water and so on, which can indirectly reflect the degree of pollution of organic matter in water ^[7-9]. Therefore, it is discussed the effect of coagulation treatment by the PAC coagulant for the PI river, which are used turbidity, UV_{254} , residual aluminum, etc. as the main measurement indicators. It is provided a certain reference to treat low turbidity and high organic water in a water plant.

2 Methods

The raw water is from the Jiefang south road bridge intake, the water quality as shown in Table 1.

Instruments:T6 new century UV spectrophotometer (Beijing Purkinje General instrument Co.Ltd.); MY3000-6F intelligent coagulation test mixing equipment (Wuhan Mei Yu instrument Co.Ltd.);WGZ-200 turbidity meter (Shanghai Xin Rui Instrument Co.Ltd.);portable pH meter (Zhejiang Li Chen instrument technology Co. Ltd.).

Reagents: poly-aluminum chloride, its performance parameters are shown in Table 2. Other reagents are analytical pure.

It is process used PAC as coagulant, and simulated hydraulic condition. The procedure for coagulation sedimentation test is shown in Table 3.

The superabundant is determined by WGZ-200 turbidimeter. UV_{254} in the water sample is measured by spectrophotometry. Aluminum ions is determined by aluminum reagent spectrophotometric, pH value is determined by portable pH meter determination.

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Table 1. Raw water quality in PI river.

temperature	pН	turbidity	UV ₂₅₄	
(°C)		(NTU)	(/cm ⁻¹)	
22.3~25.4	6.9~7.3	4~9	0.017~0.048	

Table 2. Performance parameters of poly-aluminum chloride.

project	poly-aluminum chloride		
place of origin	Gong Yi , Henan province, China		
character	solid		
alumina (AL ₂ O ₃)/%	30		
iron oxide (Fe ₂ O ₃)/%	0		
salt degree /%	40~90		
pH(1% aqueous solution)	3.5~5.0		

 Table 3. Coagulation test procedures.

segment number	Speed (r.min ⁻¹⁾	time (s)	dosing conditions	velocity gradient (G /s ⁻¹)	$\sum GT$
1	300	30	dosing	232.2	6966
2	150	300	no dosing	82.0	31596
3	80	600	no dosing	32.0	50796
4	00	1200	no dosing	0.0	sediment

3 Results and discussion

The dosage of poly-aluminum chloride (PAC) is 4.5, 5.5, 6.5, 7.5, 8.5, and 9.5 mg.L⁻¹ respectively, and the effect on the treatment effect is examined as shown in Figure 1.



Figure 1 Determination of the optimal dosage of PAC

Figure 1 shows that with the increase of PAC dose, the turbidity and UV_{254} removal rate after precipitation

are continuously increased. They have a similar removal tendency. When the dosage is ≤ 6 mg.L⁻¹, the removal rate of UV₂₅₄ is very low. the dosage was 8.5 mg.L⁻¹, at this time, the remaining turbidity of the supernatant and the UV₂₅₄ removal effect are the best, reaching 92% and 57% respectively. When the dosage is more than 8.5 mg.L⁻¹,the removal rate of UV₂₅₄ still increases slowly, and the removal rate of turbidity tends to decrease. It is showed that the initial increase in the amount of coagulant dosage can increase the chance of particulates participating in the adsorption bridging and sweeping operations, and is conducive to the destruction of colloidal aggregation stability. However, when the dosage of coagulant exceeds a certain limit, it will produce "colloidal protection" phenomenon, which reduces the removal rate of turbidity. Adding too much coagulant also brings problems of increased water treatment costs and difficulty in sludge treatment^[10,11].As can be seen from Figure1, with the increase in the amount of PAC, aluminum residue first decreased and then slowly increased, when the PAC dose is 8.5 mg.L⁻¹, the aluminum residue is 0.079mg.L⁻¹,lower than the requirements.The aluminum residue decreased first and then increased, indicating that PAC, as an inorganic polymer coagulant, can be hydrolyzed and precipitated even when the amount of PAC is less, and the residual aluminum concentration gradually decreases with the removal of turbidity, when it is high, the content of non-hydrolyzed coagulant increases, making the residual aluminum show an upward trend ^[12].Consider the cost of coagulation treatment and the treatment effect of water quality. In the follow-up experiment, the dosage of PAC is 8.5 mg.L⁻¹.

In the experiment, it is adjusted the pH values of the water sample with 0.1 mol/L hydrochloric acid solution and 0.1 mol/L sodium hydroxide solution, and added 8.5mg.L⁻¹ dosage of PAC. The results of the experiment are shown in Table 4.

Table 4 Effect of pH on PAC Coagulation

raw water quality		pН	supernat ant	supernata nt	removal rate of	removal rate of		
ty /NTU	ure ℃	pН	4/cm ⁻		/NTU	-1	(%)	(%)
	5.37 24.8	7.3 0.	0.030	6	3.25	0.014	39.48	53.35
				6.3	3.42	0.017	36.31	43.41
5.27				6.8	0.86	0.020	83.99	33.50
5.57				7.1	0.6	0.023	88.83	23.39
			8.2	0.74	0.025	86.22	16.67	
				8.8	1.14	0.027	78.77	10.00
8.05 22.9	22.0	22.9 7.2	7.2 0.029	6	4.88	0.016	39.38	44.83
	22.9			6.7	4.67	0.019	41.99	34.48

		7.2	1.69	0.021	79.01	27.59
		7.5	1.21	0.020	84.97	31.03
		7.9	0.96	0.025	88.07	13.79
		8.1	1.41	0.026	82.48	10.34

As we can see from Table 4, when pH is 7.2~6, with the decrease of pH, the removal rate of turbidity is reduced from 80% to 40%. At the same time, it is found that the turbidity will increase obviously, the color of the supernatant is more and more aggravating, and it is difficult to stratification. This is due to the aluminum hydroxide colloid which is mainly coagulating in water. Aluminum hydroxide is a amphoteric compound, when the original water tends to neutrality, it mainly exists in the form of precipitation^[13].For UV₂₅₄, the removal effect is different from the turbidity.With the decrease of pH value, the removal rate increases from 23% to 50%. The main reason is that low pH condition will affect the degree of humic acid dissociation, can change the existence of humic acid in water, increase the protonation of humic acid, reduce the charge density, and then reduce its solubility and hydrophilicity, and become easier to be adsorbed. morphologically, co-precipitates onto large amounts of existing flocculate particles, this will increase the removal rate of dissolved organics in water. When pH value is 7.2~8.5, the turbidity removal rate increases slowly, and UV_{254} is reduced from 27% to 10%. So it is clear that high or low pH values are not conducive to the removal of turbidity and UV₂₅₄, and the best pH value range is 6.5~7.2. It is because under acidic conditions, the hydrolysates of positive iron salts and the hydrolysates of aluminum salts are easy to combine with organic compounds in water, which is beneficial to the removal of turbidity and organic matter.

4 Conclusions

For turbidity removal, the optimal dosage of PAC is 8.5mg.L^{-1} , and the optimal pH value range is 7.2-8.5. For the removal of UV₂₅₄, the optimal pH value range is 6.5-7.2. The best experimental conditions for coagulation are PAC dosage of 8.5mg.L^{-1} , water pH value is 7.2.

It has good effect on removing turbidity by adding PAC,but it is normal to UV_{254} ,the removal rate is not exceed sixty percent,with the increase of PAC dosage,the removal trend of the turbidity after precipitation is similar to that of UV_{254} ,while residual aluminum first decreases and then slowly increases. At the optimal PAC dose, the residual aluminium is as low as 0.079 mg.L⁻¹.

In summary, it can be seen that PAC is an effective inorganic polymer coagulant and it is provided a scientific reference basis for a water plant to deal with low turbidity, high natural organic matter raw water.

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