

Enhanced Coagulation for the Different Mixture Ratio Raw Water of Yellow River Water and South-to-North Water Diversion Water

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Abstract. This study analysed the water quality of the mixed raw water of Yellow River Water (YW) and South-to-North Water Diversion Water (SNW) in the proportion of 2:1, 1:1, 1:2. According to the actual operation condition of most water treatment plant in Zheng Zhou, PAC was used as coagulant and activated silica acid as coagulant aid for enhanced coagulation. Finally, the removal efficiency of turbidity, UV_{254} , NH_3-N for different raw water was gave. The optimum coagulant and coagulant aid (activated silica acid) dose of enhanced coagulation were determined. The results of this study would provide guidelines to the optimization operation of the local water treatment plants which used the mixed raw water of YW and SNW.

1. Introduction

After the operation of the middle route of the South-to-North Water Diversion Project, the water quality of SNW is better than that of the YW in Zhengzhou. However, it is difficult to completely switch the water source from YW to SNW in a short term. As a result, the water treatment plants in Zhengzhou would adopt dual water source supply mode which combined use YW and SNW as raw water for a long time. The change of water source mode poses new challenge to the original water treatment processes of the local drinking water treatment plant. The designs and operating parameters of the original treatment process may not be the most effective for the treatment of the mixed raw water of YW and SNW.

Enhanced coagulation refers to dosing coagulant and coagulant aid to the raw water or control the pH value, thereby enhancing the removal of natural organic matter in conventional treatment. This study aimed to investigate optimum coagulant and coagulant aid and its dosage based on the result of pilot test for the raw water that YW and SNW mixed in different proportion.

2. Experimental Procedure

The pilot test processes were composed by coagulation, inclined tube sedimentation, sand filtration, and disinfection. The flow chart was shown in Figure 1.

During the experiment, the flow rate of each system was controlled at $1\text{ m}^3/\text{h}$. The coagulation process was carried out using the following conditions, rapid mixing ($t=30\text{ s}$, $G=500\text{ s}^{-1}$) and three-stage flocculation ($t_1=5\text{ min}$, $G_1=70\text{ s}^{-1}$, $t_2=5\text{ min}$, $G_2=40\text{ s}^{-1}$, $t_3=8\text{ min}$, $G_3=20\text{ s}^{-1}$). The sedimentation pond was equipped with a 60° inclined pipe and it is 1 m in length. The depth of the sand filtration bed was 0.95 m, and sand with diameter range 0.8-1.2 mm was used as filter media. The value of turbidity,



UV₂₅₄ and NH₃-N of filtration effluent were measured and the efficiencies were used to evaluate the treatment effect of enhanced coagulation.

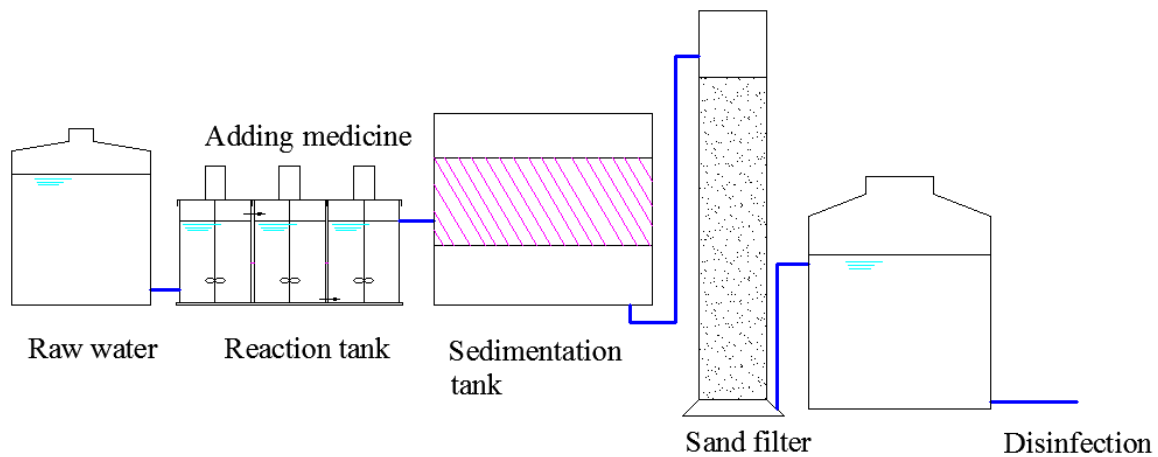


Figure 1. Flow chart of pilot treatment process.

3. Results and Discussion

The PAC dose of 15, 25 and 35 mg/L were used for coagulation, activated silica acid was dosed in the PAC and activated silica acid proportion of 5:1, and the raw water were the mixed water of YW and SNW in the ratio of 2:1, 1:1 and 1:2, respectively. The performance of PAC enhanced coagulation was investigated for three kinds of raw water.

3.1. Turbidity removal for Three Kinds of Raw Water

It was indicated that for different kinds of raw water, the optimum coagulant and coagulant aid dose varied greatly. It can be seen from Figure 2 that the turbidity removal efficiency for three kinds of source water all reached to 90% or even more regardless of the coagulant dosage. A highest turbidity removal efficiency of 96.5% could be achieved at the PAC dosage of 35 mg/L and activated silica acid dosage of 7 mg/L for the source water YW and SNW mixed in the ratio of 2:1. To get the 96.5% turbidity removal ratio, 25 mg/L PAC and 5 mg/L activated silica acid was needed for the source water YW and SNW mixed in the ratio of 1:1. Approximately 96.16% turbidity could be removed by PAC coagulation at the PAC and activated silica acid dosage of only 15 mg/L and 3 mg/L respectively for the source water YW and SNW mixed in the ratio of 1:2. The coagulant dosage needed to achieve the optimum turbidity removal became less with the increase of the proportion that SNW accounted for in raw water. The more of the SNW portion in raw water, the lower of raw water turbidity was.

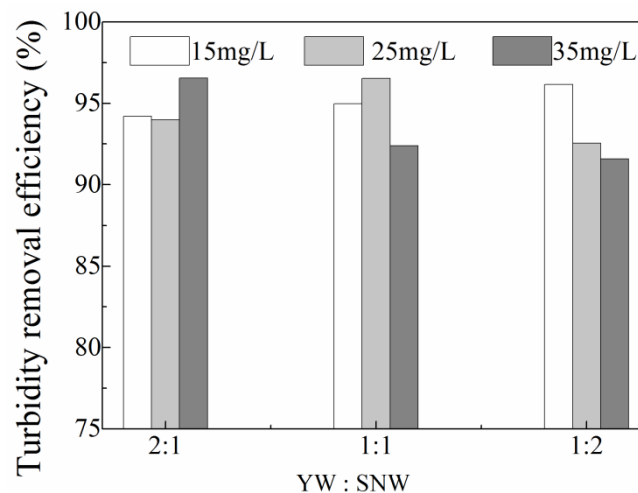


Figure 2. The turbidity removal by PAC enhanced coagulation for different kinds of raw water.

3.2. UV_{254} Removal for Three Kinds of Raw Water

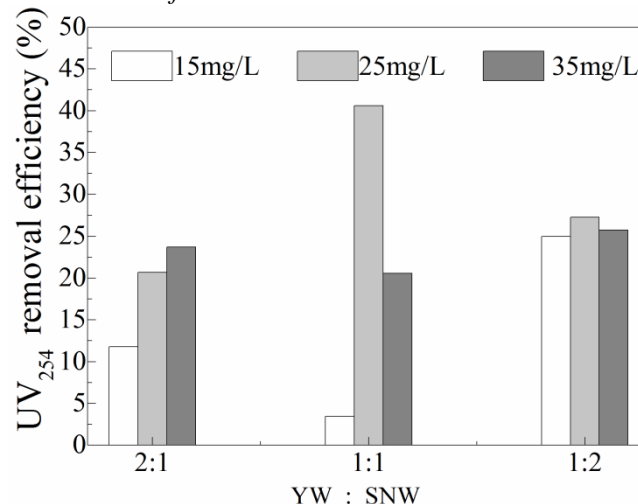


Figure 3. The UV_{254} removal by PAC enhanced coagulation for different kinds of raw water.

As shown in Figure 3, the UV_{254} removal behavior by PAC coagulation for three kinds of raw water did not follow the turbidity removal case. UV_{254} removal efficiency was relatively low in the PAC dose range of 15-35 mg/L. For the raw water YW and SNW mixed in the ratio of 2:1, UV_{254} removal efficiency increased with the increase of PAC dosage. The highest removal efficiency was achieved at PAC dosage of 35 mg/L and activated silica acid dosage of 7 mg/L. The removal of UV_{254} is positively correlated to the coagulant dosage. However, the highest UV_{254} removal efficiency was only 23.68%, which was extremely low relative to the high turbidity removal efficiency 96.55% at this PAC and activated silica acid dosage. The mechanisms involved in colloidal particle and Natural organic matter (NOM) removal could be significantly different, colloidal particle could be removed by charge neutralization and sweep flocculation, but formation of insoluble complexes between NOM and coagulant species as well as the adsorption of NOM onto freshly formed hydroxide precipitate could be the removal mechanisms of NOM^[1]. Coagulation of humic acid might not follow the same charge neutralization rules associated with coagulation of mineral colloids. Due to the differences between coagulation of mineral colloids and NOM, the designs and operating procedures that are effective for removing turbidity may not be the most effective for removing NOM. Preformed polymeric Al coagulants are efficient in removing mineral colloids, but not in removing dissolved organic matter^[2]. For the raw water YW and SNW mixed in the ratio of 1:1, it was observed that the

UV₂₅₄ removal sharply increased with the increase of PAC dosage from 15 to 25 mg/L but decreased when PAC dosage increased from 25 to 35 mg/L. 40% UV₂₅₄ could be removed by 25 mg/L PAC and 5 mg/L activated silica acid. The PAC and activated silica acid dosage for optimum turbidity removal could also remove UV₂₅₄ efficiently, so the recommended PAC and activated silica acid dosage were 25 and 5 mg/L. For the raw water YW and SNW mixed in the ratio of 1:2, UV₂₅₄ removal efficiency varied little with the increase of PAC dosage. The maximum UV₂₅₄ removal efficiency was approximate 25%, and the recommended PAC and activated silica acid dosage were 15 and 3 mg/L, respectively.

3.3. NH₃-N Removal for Three Kinds of Raw Water

The NH₃-N removal performance of PAC coagulation for three kinds of raw water is shown in Figure 4.

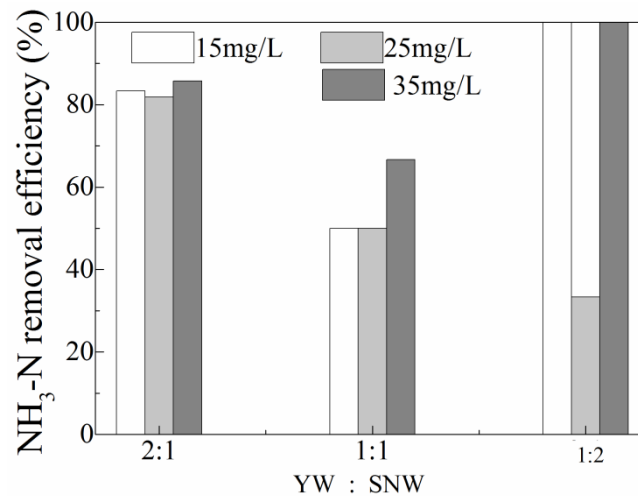


Figure 4. The NH₃-N removal by PAC enhanced coagulation for different kinds of raw water.

For the raw water YW and SNW mixed in the ratio of 2:1, PAC dosage of 35 mg/L and activated silica acid dosage of 7 mg/L, which gave the maximum NH₃-N removal efficiency of 85.71%, was the optimum conditions for turbidity removal, PAC dosage had little influence in NH₃-N removal, it might because that the initial NH₃-N was relatively low (0.18 mg N /L), it was difficult to improve the NH₃-N removal in the coagulant dosage range applied in this study. NH₃-N removal efficiency was only used as a reference indicator for the optimization of PAC and activated silica acid dosage. For the raw water YW and SNW mixed in the ratio of 1:1, 50% NH₃-N could be removed by 25 mg/L PAC and 5 mg/L activated silica acid. It was 20% lower than the NH₃-N removal at the PAC and activated silica acid dosage of 35 and 7 mg/L. However, given the maximum turbidity removal achieved by 25 mg/L PAC and 5 mg/L activated silica acid, the recommended PAC and activated silica acid dosage for the raw water YW and SNW mixed in the ratio of 1:1 was 25 mg/L and 5 mg/L, respectively. For the raw water YW and SNW mixed in the ratio of 1:2, when PAC and activated silica acid were dosed at 15 mg/L and 3 mg/L respectively, NH₃-N could be almost 100% removed, moreover, the turbidity removal efficiency was high up to 96.16%. 15 mg/L PAC and 3 mg/L activated silica acid were recommended to be the optimum coagulation conditions for the treatment of the raw water YW and SNW mixed in the ratio of 1:2.

4. Conclusions

In this study, the optimum enhanced coagulation conditions were investigated by pilot test for the raw water that Yellow River water and South-to-North Diversion Water mixed in the proportion of 2:1, 1:1, 1:2, respectively. The main conclusions drawn are as follows:

(1) The turbidity removal efficiency of PAC enhanced coagulation all reached to 90% and more for three kinds of raw water. For the raw water YW and SNW mixed in the proportion of 2:1, the recommended PAC and activated silica acid dose was 35 and 7 mg/L, respectively. For the raw water

YW and SNW mixed in the proportion of 1:1, the recommended PAC and activated silica acid dose was 25 and 5 mg/L, respectively. For the raw water YW and SNW mixed in the proportion of 1:2, the recommended PAC and activated silica acid dose was 15 and 3 mg/L, respectively. The optimum PAC and activated silica acid dosage decreased with the increase of the SNW portion of raw water. Replacing YW with SNW partially would be significant to cost saving for the local water treatment plants.

(2) The UV_{254} removal efficiency of PAC enhanced coagulation was all less than 40% for three kinds of raw water in the PAC dose range of 15-35 mg/L, and UV_{254} removal varied significantly for different raw water. The NH_3-N removal efficiency was during the range of 80-100%, the PAC and activated silica acid dose had little influence on NH_3-N removal.

5. References

- [1] Lu X, Chen Z and Yang X 1999 Spectroscopic study of aluminum speciation in removing humic substances by Al coagulation *J. Water Research*. 33 3271-80.
- [2] Shi B, Wei Q and Wang D 2007 Coagulation of humic acid: the performance of preformed and non-preformed Al species *J. Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 296 141-8.

Acknowledgments

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