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A Study into the quality of inflowing sewage into Chaohu Lake

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ABSTRACT

Objective To offer a solution to govern the watercourses under pollution and improve the quality of outflowing water from inland rivers. Method This paper analyzes the water condition of Fengle River and, in pertinence to its pollution characteristics, studies the decontaminating effects of various coagulants and coagulant aid in both separate and combined use through indoor coagulation beaker experiments. Result The water environment around Fengle River is of overall poor quality, where the contents of TP, TN and COD have uniformly gone far beyond the standard on V-class water. Polyaluminum ferric chloride (PAFC) has the optimum removal effects on both turbidity and TP as well as good COD-removal efficiency without affecting the pH of the raw water. The four coagulants in combined use with the coagulant aid can all enhance the power of removing TP and COD from the raw water. Conclusion PAFC in combined with cationic polyacrylamide (CPAM) can achieve the optimal effect in raw water treatment, which lays a reliable theoretical basis for modern governance over river sewage.

KEYWORDS

Fengle river; Coagulation beaker experiment; Coagulant; Coagulant aid; PAFC; CPAM.

INTRODUCTION

Located in the central area of Hills of Yangtze River and Huai River in Anhui Province, Chaohu Lake is China's fifth largest freshwater lake. Expanding an area of 753 km^2 with a circumference of 172 km, Chaohu Lake neighbors four counties - Chao County, Lujiang, Feidong and Feixi - and one city - Hefei. There is a confluence of Fengle River, Hang Buhe River and more rivers into the lake, with an outflow from Yuxi River to Yangtze River. Located to the southwest of Chaohu Lake, Fengle River is the biggest tributary of it. Fengle River used to be in good water condition at the earlier stage of the last century. With the development in industrial and agricultural production in areas along the river, acceleration of urbanization progress as well as improvement of people's living standard over the recent years, however, sanitary sewage, industrial wastewater and chemical fertilizers and pesticides have been discharged into Fengle River in vast quantity, which has placed the water resources of Fengle River under unrecoverable destruction. According to investigations and statistics of related departments into Fengle River, there are 23 fishes, 32 species of zooplankton and 58 of floating algae in it at present. In the middle and downstream reaches where the pollution is severe, there basically exist no fishes and other bulky aquatic organisms. Another severe pollution goes to the bottom sediment under Fengle River, which contains a lot of organic matters. Moreover, the serious heavy metal pollution which is multiple times by the background value of river has become an underlying source of pollution. The water quality of Fengle River is ever-worsening, especially in terms of eutrophication of the water body as a result of nitrogen, phosphorus and other nutritive salts flowing into the water in vast quantity. At present the water quality of Fengle River is rated as the inferior V-class. The water body of Fengle River has received serious pollution, rendering a "black and odorous" phenomenon in summer; the ecosystem has been worsening, with its discharge capacity accounting for above 45% of the total amount of sewage in Chaohu Lake. Governance over it has been listed as a priority among priorities in governing the water environment around Chaohu Lake.

This paper begins with an investigation into the water condition of Fengle River, on which base a series of indoor coagulation beaker experiments are performed, so as to select the optimum coagulant that fits the water condition of Fengle River and determine the corresponding dosage and coagulant aid. By increasing the dosage of coagulants, changing their morphological match or adjusting pH, the end of enhancing coagulation and effluent quality is to be reached.

MATERIALS & METHODS

Key instruments & reagents

Key instruments: Multiparameter water quality monitor, six-up synchronous electric mixer, ultraviolet-visible spectrophotometer, pH meter, digital-readout thermostat water bath, precision electronic balance, etc.

Reagents: Coagulants: Polymeric aluminum chloride (PAC), polymerization ferric chloride (PFC), polymerization ferric sulfate (PFS) and polyaluminum ferric chloride (PAFC); coagulant aid: cationic polyacrylamide (CPAM).

Sample collection

In order to minimize the impact of artificial factors on the effect of test, in this test 8 sampling sites for water intaking are set in the middle and downstream of Fengle River (The smaller the serial number of sampling site, the more the sampling site approaches Chaohu Lake). Since August 1st 2013, the testing group have taken samples at all sampling sites once per 5 days, investigated and analyzed the water condition of each sampling site. The sampling has lasted 6 cycles, over which the mean of all sampling sites is taken as the recorded value.

Parametric measurement

The parameters to measure in this test include: turbidity, pH-value, total nitrogen (TN), total phosphorus (TP) and COD.

RESULT & DISCUSSION

Current water condition of fengle river

The basic water condition of Fengle River is shown as Table 1.

Table 1 : Basic water condition of fengle river

	Sampling Site 1	Sampling Site 2	Sampling Site 3	Sampling Site 4	Sampling Site 5	Sampling Site 6	Sampling Site 7	Sampling Site 8
Turbidity (NTU)	11.25	12.51	11.01	11.50	11.47	10.00	9.54	9.47
pH-value	7.8	7.7	8.2	7.9	7.5	8.1	7.7	8.3
TN (mg/L)	4.2	5.1	7.7	10.5	10.2	8.5	8.8	9.5
TP (mg/L)	0.44	0.61	0.34	1.31	0.87	1.69	0.72	0.65
COD (mg/L)	5.1	7.3	5.9	8.6	9.2	10.6	11.1	9.8

According to Table 1: (i) The mean of turbidity values at the 8 sampling sites over the 6 cycles ranges between 9.47 and 12.51 NTU, and the phenomenon that the turbidity values at the sampling sites render a descending tendency mainly reflects that Fengle River has quite strong aggregative effect on suspended solids in the water body and great input of substances into Chaohu Lake. (ii) The pH of the water body ranges between 7.5 and 8.3, which indicates the water body becomes slightly alkaline. Besides, the pH-values at NO. 2-3, 5-6 and 7-8 sampling sites ascend largely as a possible result of the photosynthesis of blue-green algae in the water body; meanwhile, this phenomenon also evinces there are blue-green algae gathering locally in Fengle River. (iii) The content of TN in the water body ranges between 4.2 and 10.5 mg/L, and the content of TP between 0.34 and 1.69 mg/L, both far exceeding the standard TN≤2mg/L, TP≤0.2mg/L as indicators of V-class water in "Environmental Quality Standards on Surface Water" (GB3838-2002); moreover, the maximums of TN and TP have exceeded above 5 times the standard on V-class water, which is indicative of the higher contents of total nitrogen and total phosphorus in the water body of Fengle River and serious water pollution. (iv) The COD value of the water body resides between 5.1 and 11.1 mg/L, and this indicator mainly reflects the total amount of organic pollutants in the water body. The COD values at a large portion of the sampling sites have far exceeded the indicator $COD_{Mn}\leq 6$ of III-class water specified in "Environmental Quality Standards on Surface Water" (GB3838-2002).

Turbidity removal of different coagulants & determination of coagulant aid

Take the mixed liquor from all sampling sites as a research object, and add PAC, PFC, PFS, PAFC, PAC + CPAM, PFC + CPAM, PFS + CPAM and PAFC + CPAM of different concentrations, respectively. Refer to Fig 1 for the result of turbidity measurement.

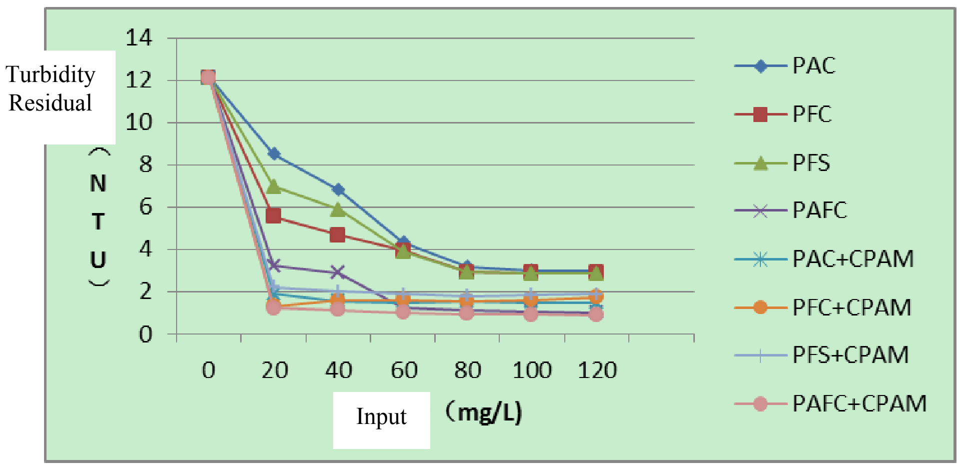

Fig 1 Turbidity removal Conditions of Different Coagulants

According to Fig 1, when all coagulants are in separate use and when the input of the four coagulants ranges between 0 and 40 mg/L, the turbidity of sewage drops rapidly with a remarkable effect of turbidity removal on the sewage; when the input exceeds 60mg/L, the turbidity residual varies gently. Besides, PAFC has the best effect of turbidity removal, followed by PFC and PFS, whereas PAC has the poorest effect of turbidity removal. As the input of coagulants increases, the gap of effect of turbidity removal among all coagulants diminishes gradually. When the input of coagulants is 20 mg/L, the removing rates of PAFC, PFC, PFS and PAC on turbidity are 79.5%, 64.8%, 56.0% and 49.7%, respectively. When the input of coagulants reaches 60 mg/L, the removing rates are 91.2%, 75.3%, 75.6% and 71.1%, respectively.

After being jointly input along with the 1 mg/L CPAM, the four coagulants turn out to have basically similar effects of turbidity removal, and the effects of turbidity removal of PAFC, PFC, PAC and PFS in combined use with CPAM have all enhanced. When the input of the coagulants ranges between 0 and 20 mg/L, the removing rates rise perpendicularly; when the input of the coagulants exceeds 20 mg/L, the turbidity residual varies gently, and the rates of turbidity removal are all above 75%. Besides, Fig 1 also indicates PAFC and CPAM in combined use can achieve the optimum effect of turbidity removal.

Effects of different coagulants on the ph of fengle river water

Take the mixed liquor from all sampling sites as a research object, and add PAC, PFC, PFS, PAFC, PAC + CPAM, PFC + CPAM, PFS + CPAM and PAFC + CPAM of different concentrations, respectively. Refer to Fig 2 for the result of pH-value measurement.

When the four coagulants are in separate use, PAC and PAFC basically make no difference to the pH-value of the sewage, whereas PFS and PFC can significantly lower down the pH-value as they are input increasingly. When the input of PFC exceeds 60 mg/L, the sewage becomes acidic, so does it when the input of PFS exceeds 80 mg/L. When the four coagulants are input in combined use with the 1 mg/L CPAM, the effect of variation of pH bears basic similarity to that of all coagulants in separate use. PFC has the optimum effect on the variation of pH of the water body.

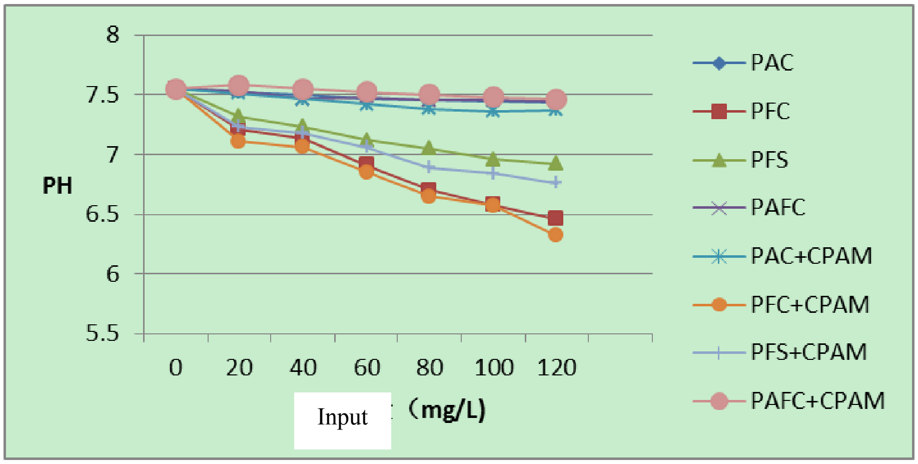

Fig 2 Effects of Different Coagulants on the pH of Fengle River Water

Removal effects of different coagulants on TP in fengle river water

Take the mixed liquor from all sampling sites as a research object, and add PAC, PFC, PFS, PAFC, PAC + CPAM, PFC + CPAM, PFS + CPAM and PAFC + CPAM of different concentrations, respectively. Refer to Fig 3 for the result of TP value measurement.

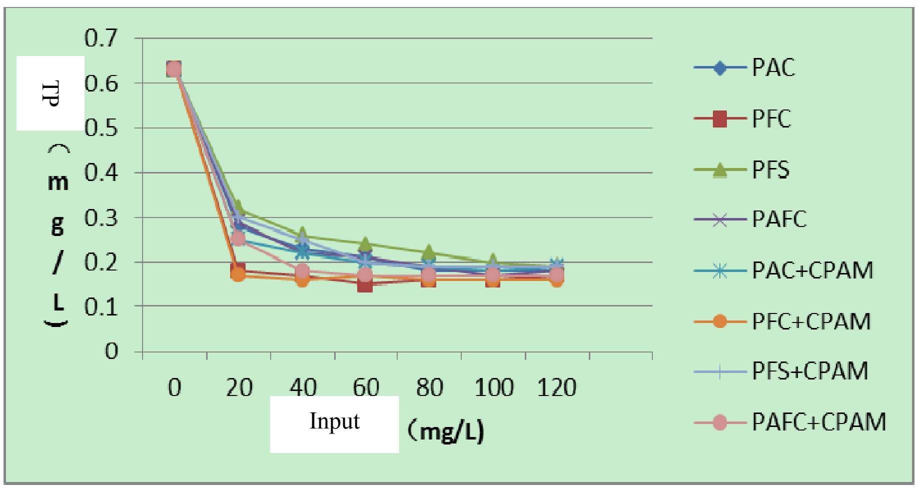

Fig 3 Removal Effects of Different Coagulants on TP in Fengle River Water

According to Fig 3, the four coagulants in separate use can all significantly diminish the content of TP in the sewage with noticeable phosphorous removal effect. The phosphorous removal efficiency in proper order is: PAFC>PAC>PFC>PFS. When the input exceeds 60 mg/L, the four coagulants can all make the sewage up to the III-class standard in "Environmental Quality Standards on Surface Water" (GB3838-2002). The PAC, PFC and PFS coagulants can enhance the phosphorous removal effect when added to the 1 mg/L CPAM coagulant, as compared with each in separate use. However, PAFC and CPAM input in combined use cannot achieve the effect of enhancing phosphorus removal.

Removal effects of different coagulants on tn in fengle river water

Fig 4 shows the removal effects of different coagulants on TN in Fengle River water.

According to Fig 4, the four coagulants have uniformly insignificant removal effects on TN in the sewage. Among them PFS basically has no nitrogen-removal effect, whereas the other three coagulants have limited ability of nitrogen removal. PAFC has the best nitrogen-removal effect in relative terms, but its nitrogen-removal efficiency is only 10% or so. Besides, the four coagulants to which the coagulant aid is added fail to enhance their separate TN-removal effect, which may bear a relation to the chemical property of nitrogen and its existence form in the water body. Nitrogen exists in the water body mainly in the dissolved form, rarely absorbed by suspended particulate matters, but coagulants eliminate pollutants in the water body primarily by removing suspended matters in the water.

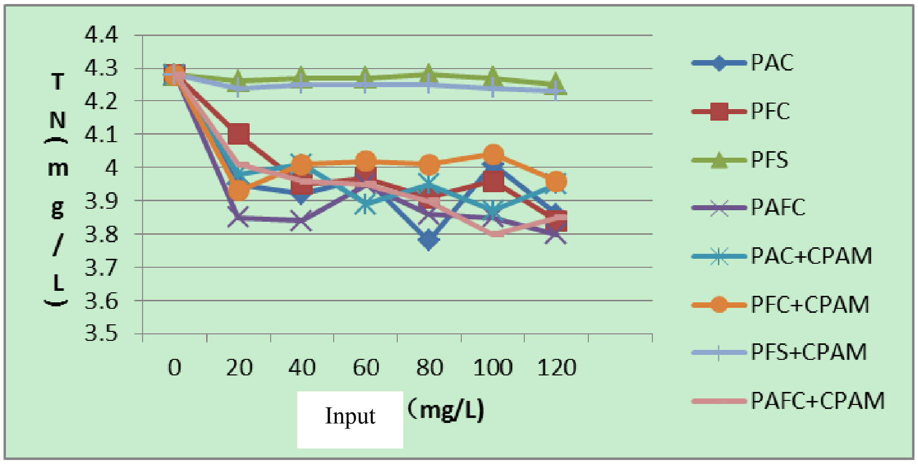

Fig 4 Removal Effects of Different Coagulants on TN in Fengle River Water

Removal effects of different coagulants on cod in fengle river water

Fig 5 shows the removal effects of different coagulants on COD in Fengle River water.

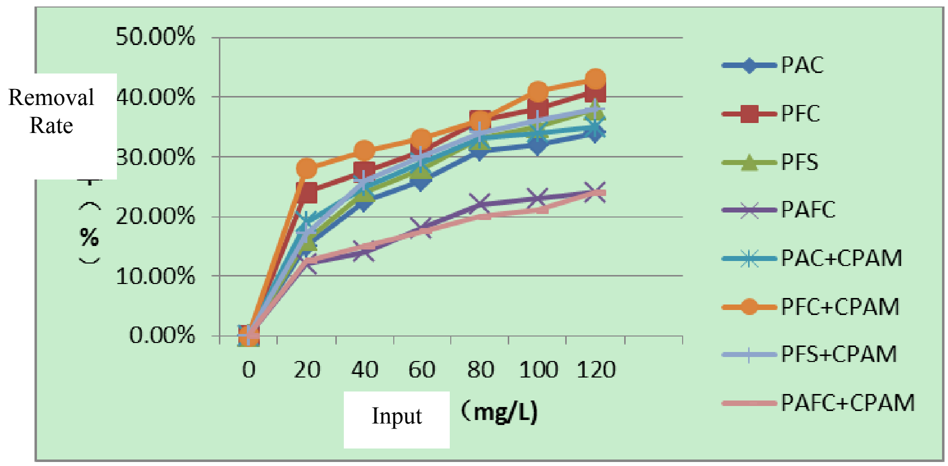

Fig 5 Removal Effects of Different Coagulants on COD in Fengle River Water

The four coagulants in separate use have quite significant removal effects on COD in the water body, which are enhanced as their additive amount increases. The efficiency in proper order is PFC>PFS>PAC>PAFC. The four coagulants have a respective maximum removal rate of 41%, 38%, 34% and 24% on COD. This shows PFC and PFS outperform PAC and PAFC in removing COD from Fengle River. The four coagulants in combined use with CPAM have slightly higher rate of removing COD from Fengle River water than any of these in separate use. The respective maximum rate of COD removal is 43%, 38%, 35% and 24.5%. The result evinces the addition of coagulant aid CPAM fails to significantly enhance the removal effect of the four coagulants on COD.

CONCLUSION

This paper begins with an analysis on the current water condition of Fengle River, followed by a study and analysis on the turbidity, nitrogen- and phosphorus-removal effects of different coagulants and their effects on pH-value through beaker experiments at lab. The conclusions are made as the following: (1) Nutrient pollution such as TN and TP is very serious in the water body of Fengle River. The contents of TP and TN have far exceeded the standard value on V-class water in “Environmental Quality Standards on Surface Water” (GB3838-2002). (2) Among the four coagulants when in separate use, PAFC has the best turbidity removal and TP-removal effects as well as good removal effect on COD without affecting the pH of the raw water; whereas PFC and PFS in separate use can significantly reduce the pH of the raw water; the four coagulants in separate use have uniformly insignificant effects on TN. (3) PAFC in combined use with CPAM achieves the best turbidity removal effect, significantly better than the effects of any other coagulants in either combined or separate use. (4) The coagulants in combined use with CPAM can enhance their turbidity removal and TP-removal abilities, but cannot significantly improve their COD-removal effect, with the same effects on pH and TN as in separate use.

The coagulants in combined use with coagulant aid can effectively remove the turbidity of and pollutants like TP in the water body, and have a good removal effect on COD, but limited removal effect on TN in the water body. Therefore, TN-removal methods of coagulants and coagulant aids worth studying in a further step.

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