

Study on Potassium Permanganate Enhanced DAFF Combination's Treatment Effect

based on Yellow River Reservoir Water

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Abstract. Yellow River reservoir water, which is slightly polluted and owns a high content of suspended particles, is studied as raw water in this paper. Online particle counting instrument is used to detect and track the particle content of raw water. Potassium permanganate pre-oxidation process combined with DAFF(dissolved air flotation filtration) is studied to examine the effect of removing contaminants. The results showed that the particles with the size of 2 μ m,3 μ m and 5 μ m take up the major part, and the ratio reduce with the increase of the size. As the water treatment proceed, the concentration changes and the changing law differs from size to size. The effect of removing suspended particles is obvious, with the removal ratio over 90%. The outflow's NPOC is 1.388 mg / L on average, and the average removal rates is 49.1%. The combined process also improved the effect on water taste and disinfection byproducts significantly.

Introduction

As Yellow River reservoir has features such as low temperature , low turbidity, high algae content and high organic matter content, traditional purification process's ability to remove pollutants is limited. Pre-treatment process should be used to strengthen the treatment effect on the basis of traditional purification process. The pre-treatment technologies used to deal with slightly polluted water source of drinking water include adding chemical oxidant, adding the adsorbent material and the biological oxidation method. Chemical oxidant potassium permanganate method mainly contains using potassium permanganate, using hydrogen preoxide, using sodium precarbonate, and oxidation coupling flocculants method ^[1]. Potassium permanganate preoxidation method combined with floating filter technology, based on the Yellow River reservoir water is studied in this paper to check out the treatment effect.

According to the study of researchers of American, the Giardia lamblia and cryptozoite (two worms for short) is related to the amount of particles ^[2]. The existence of the two worms is much more frequent when the content of the particle of 2 μ m over 100 no./L. As the content of the suspended particles in the Yellow River reservoir water is high, deep study is needed to discuss the threat to the drinking water safety^[3].

Material and method

Test Overview. This combination treatment process's raw water is Yellow River reservoir water, the water filter combination process design flow rate Q is 5 m³ / h, PAFC dosing quantity is optimized to 3 mg/L, the oxidant(KMnO₄)quantity is optimized to 0.3 mg/L, back flow ratio is 8%. Under the same conditions, 12 samples are collected in 6 days, 2samples per day, and they are marked from 1 to 12. The water samples are collected from the raw water, the effluent of pre-oxidation and the effluent of filter water. Conventional index, such as the suspended particle size and concentration, NPOC as

well as the non conventional index, such as smelling, 2-Methylisoborneol and disinfection by-products(DBP_s) are detected.

Online particle counting instrument is used to detect and track the particle content of raw water and the effluent of DAFF.

Items and Methods.particle: WPCS V2.0 online particle counting instrument; geosmin and 2-Methylisoborneol: TRACE-DSQ; gas chromatography-mass spectrometer; DBP_s:Agilent6890N gas chromatograph; odor: FPA stink analytic hierarchy process (ahp).

Results and Discussion

Distribution of suspended particles in Yellow River reservoir Water. Online particle counting instrument can monitor the distribution of the particles all the time, and it has the characteristic of high accuracy. Yanling Yang and Xing Li's researches show that the Online particle counting instrument is much more accurate compared with the turbidity meter, when the particle bigger than 1 μm particles takes the major part. So it can reflect the content of suspended particles in water reaction, and provide reference basis for optimal operation of the water plant management. [4]

WPCS V2.0 online particle counting instrument is used in this test to monitor the total gross of the particles and the distribution, timing from the end of the back flush. The result of the total gross of the particles and the distribution in raw water is shown in Fig. 1.

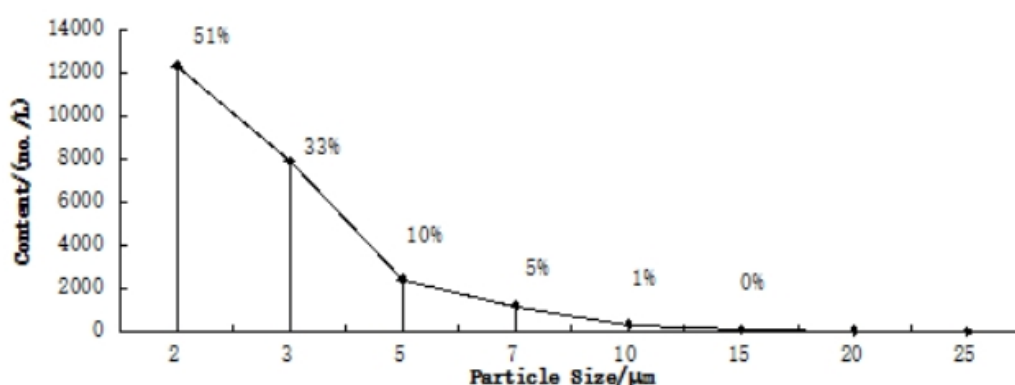


Fig1. Total gross of the particles and the distribution in raw water

Figure 1 shows that the average total particulate content in the Yellow River reservoir water is 3027 no./ml; the particles with the size of 2 μm , 3 μm and 5 μm , accounting for 94%, make the largest proportion, and the content of the particle move inversely to size. Yellow River diversion reservoir water particle concentration is strongly influenced by the Yellow River water. when the rainy season come, the particle concentration rise rapidly as the water scoured and the Yellow River water stirred. It is necessary to purify the water before the reservoir to improve the water quality of the Yellow River reservoir water.

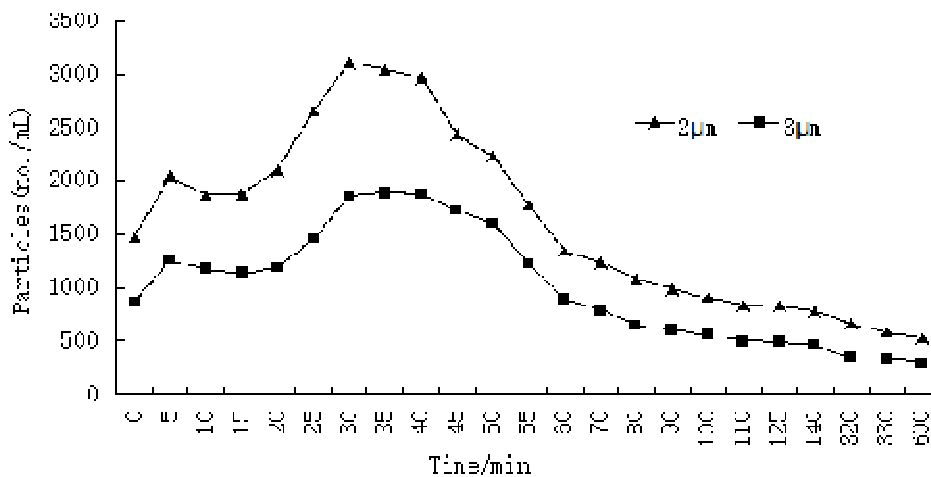
Analysis of particles removal. The USA *Surface Water Treatment Regulations* require that the *Giardia lamblia* should be removed 99.9% by reducing the particle content in the effluent of the water treatment plant. In order to ensure the water quality, most water treatment plants in the United States control the average content of particle with the size over 2 μm t under 50 no./ ml. Pennsylvania dictate that the particles between 3 to 18 μm should be less than than no./ mL [5]. Table 1 shows the particle concentration of the influent and effluent of the DAFF.

Table 1 Removal effect of particles of DAFF

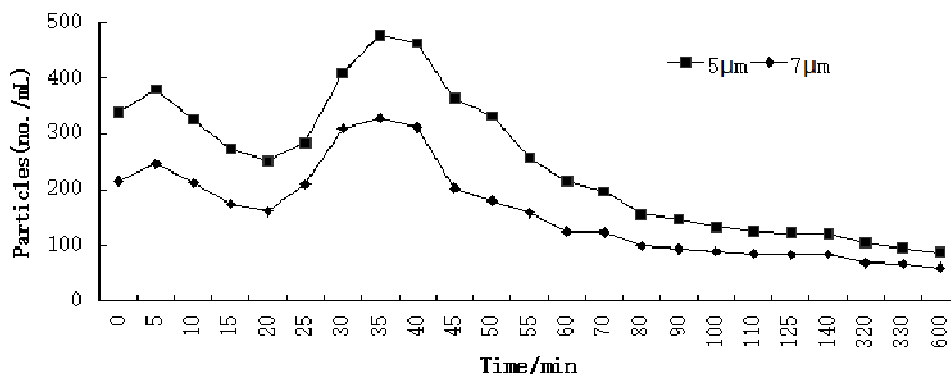
Size (μm)	2	3	5	7	10	15	20	25
Influent (no./mL)	12300	7886	2417	1169	315	92	26	12
Effluent (no./mL)	335	241	66	27	12	5	1	1
Removal Rate (%)	97.3	96.9	97.3	97.7	96.2	94.6	96.2	91.7

Table 1 shows that the particle removal efficiency of DAFF, exceeding 90%, is significant. The removal efficiency get the maximum at the size of 3 μm , the minimum at the size of 25 μm , and the average removal rate is 96.0%. The average amount of particles bigger than 2 μm is 52.2 no./ mL, slightly higher than the American waterworks request (50 no./ mL).

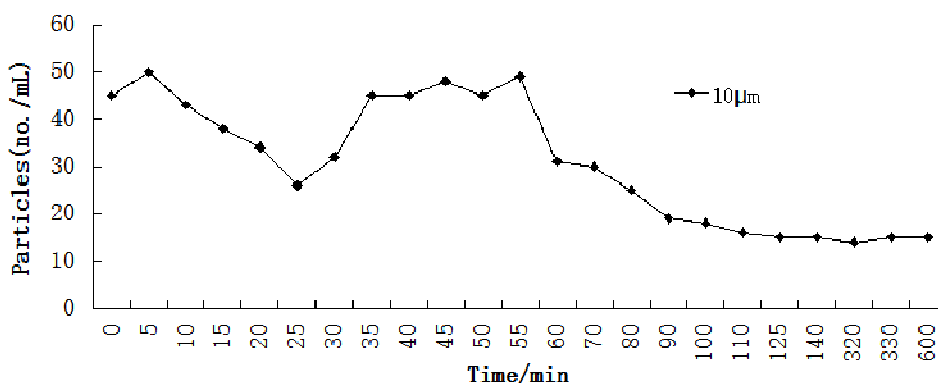
The particulate matters' amount differ from time to time. Filter's operating time should be defined from the quality of the effluent, especially controlled by turbidity or particle concentration. Fig 2 shows the data of particle amounts monitored from the beginning of the filter cycle.



a 2 μm and 3 μm



b 5 μm and 7 μm



c 10 μm

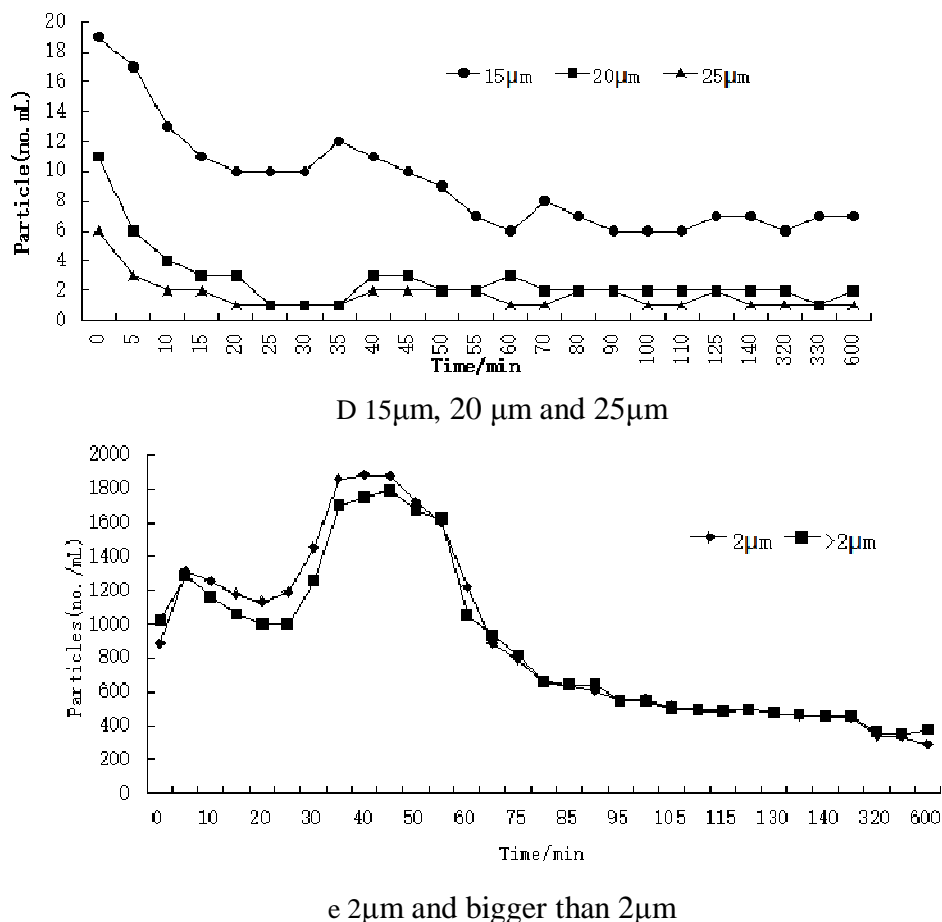


Fig 2. The amount of particles with different size in effluent during the initial filtering stages

Many conclusions can be obtained from Fig.2. Firstly, a downward trend experienced in all particulate matters with different sizes as the process advanced, and the trend is much more similar as the size is similar, such as the trend between 2µm and 3µm, 5µm and 7µm, 15µm,20µm and 25µm, as shown from a to d. Secondly, the curve of the particles of 2µm is almost the same to the particles of all bigger than 2µm, as shown in e. Thirdly, microscopic particulate matter fed to a filter with excess coagulate carry-over from chemical treatment produce clogging of the bed pores at the surface. Optimum filtration occurs when impurities in the water(60minutes after the beginning) and coagulant concentration cause “in-depth”filtration, and the concentration of the particle stays at a low level.

Analysis of NPOC removal. When the samples come from clean raw water, such as surface water , tap water and lake, non-purgeable organic carbon (NPOC) is measured directly as the organic carbon after acidated. The result is relatively accurate as the deviation is much smaller. Fig. 5 shows the NPOC test results of the procedure effluent.

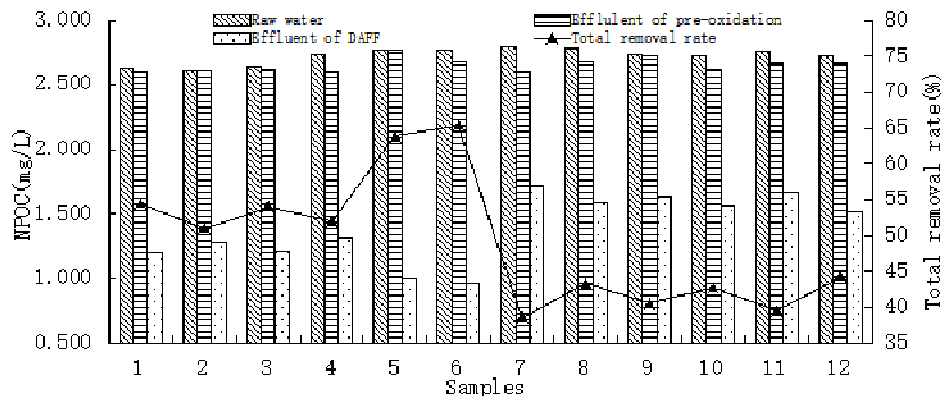


Fig 3. Removal rate of NPOC by pre-oxidation

NPOC reduce slightly after pre-oxidized and rapidly after DAFF. The maximum removal ratio is 65.3% and the average ratio is 49.1%. The efficiency is much higher than process without pre-oxidation owing to the potassium permanganate. The potassium permanganate can oxidize large molecules to smaller ones, so it is easier to be adsorbed and intercepted by filter.

Analysis of unconventional pollutants removal. The odor and smell in the water source is often due to the algae and its secretion. Chemical reactions occurred between the chemicals and water substances in the process of water treatment produce odor and DBPs. The odor and DBPs in raw water and effluent of filter are detected in this research, and the results are shown in table 2.

Table 2 Result of the removal of the unconventional pollutants mg/L

Process	Odor Level	Geosmin	2-Methylisoborneol	CHCl ₃	CHBrCl ₂	CHBr ₂ Cl	CHBr ₃
Influent of the DAFF	Earthy Taste , level 4	6×10^{-6}	1.5×10^{-5}	0.032	0.0303	0.0228	0.0031
Effluent of the DAFF	Odorless	$< 5 \times 10^{-6}$	$< 5 \times 10^{-6}$	0.01	0.0128	< 0.0177	0.0076
National Standard	Odorless	0.00001	0.00001	0.02	0.06	0.01	0.01

According to the results from table 2, this combined process perform well in deal with odor compounds. The removal efficiency of CHCl₃, CHBrCl₂ and CHBr₃ is about 60%, higher than of CHBr₂Cl. Owing to the excellent adsorption characteristics and the degradation of the activated carbon surface, the efficiency is much higher than of conventional process. The study of Zhonglin Chen and Lining Wang's also prove that the enhanced preoxidation by using PPC or potassium permanganate both work well in reducing algae and odor, it can reduce the by-products produced by chloride.^[6]

Conclusions

According to the test of the potassium permanganate enhanced DAFF combination's purification effect, the following conclusions are drawn.

Particles of 2 μ m, 3 μ m, and 5 μ m take the major part of the Yellow River reservoir water, the concentration vary inversely to the size. The concentration trend is different as the size changes, and particles with similar size owns similar trend. The removal efficiency of particles is obvious, up to 96.0%

The removal ratio of suspended particulate matter and NPOC by potassium permanganate in enhanced coagulation is higher than that of the floating filter.

The combined process has a good purification effect on the odor and taste substances.

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