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*Original Research*

# Key Technologies for Purification of Suspended Solids in Turbid Surface Water under the Influence of Rainy Seasons

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## Abstract

The turbidity degree of surface water in the rainy season will change with the change in rainfall, and the predictability and flexibility of water sources lead to the difficulty of purifying suspended solids. Therefore, the key technologies for purifying suspended solids in turbid surface water under the influence of the rainy season are studied. Select a small pool in a certain area as the research object, test the basic water quality indicators of the water source, measure the particle size distribution of the raw water according to the characteristics of suspended particles in the raw water, prepare the flocculant organic solution with a concentration of inorganic to organic ratio of 10:1, measure the turbidity of the water sample, flocculate the suspended solids in the raw water, and use ultrafiltration technology to purify the suspended solids in the raw water in the study area. The Daphnia magna was separated and purified, and the purification test of suspended solids in turbid surface water in the study area was carried out according to the prepared flocculant. The test results show that the use of PAM-PAM composite flocculant can achieve a better purification effect of suspended solids in turbid surface water under the influence of the rainy season, and the flocculant is combined with ultrafiltration. When the dosage of flocculant is 4mg/L, the removal rate of suspended solids is better. For suspended solids with smaller particle sizes, the combination of flocculant ultrafiltration and Daphnia magna can purify a large number of suspended solids in surface water bodies. A good purification effect is achieved.

**Keywords:** rainy season effects, turbid surface water, suspended matter in water, flocculants, purification, ultrafiltration technology

## Introduction

During the rainy season, rainfall causes suspended substances such as soil, sediment, and organic matter in the water to be washed into the water, resulting in a large number of suspended turbidity particles in the water [1]. These suspended turbidity particles can reduce water transparency and affect water quality, which in turn has a negative impact on aquatic life and human health while disrupting ecosystem balance. Purification of turbid water can improve the aquatic ecological environment and protect the living environment of aquatic organisms [2]. Suspended substances in surface water mainly include sediment, clay, algae, bacteria, viruses, macromolecular organic matter, and other substances, which mainly come from sediment, microorganisms, and plankton

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in water [3]. These suspended substances will affect the transparency of the water body, resulting in the weakening of the self-purification ability of the water body [4], affecting the survival of aquatic organisms [5], and affecting human health and food [6]. Therefore, it is necessary to study and develop suitable technology to remove suspended substances in cloudy surface water during the rainy season.

There are various methods for the determination of suspended solids in water, such as weighing, spectrophotometry, centrifugal separation, membrane filtration, etc. Currently, the more widely used is the water quality suspended solids tester [7], which utilizes spectrophotometric measurements. Rainfall can lead to soil erosion and wash suspended matter into water bodies, especially intense runoff caused by heavy rainfall, which may wash more suspended matter into water bodies. This may be due to the fact that rainfall washes fine particles from the soil and surface during landfall and carries them into the runoff [8]. For the existing problems of suspended solids in turbid surface water, scholars will use more advanced suspended solids purification technology. The more common technology includes adsorption, crystallization, coagulation, air flotation, etc., of which coagulation, because of its simple, inexpensive, and efficient features, is the most widely used to remove suspended solids in water, dissolved solids, and colloids, as well as the organic matter of the method. Coagulation is divided into coagulation and flocculation of the two phases [9]. In the coagulation stage, the addition of positively charged flocculants neutralizes the negative charge on the surface of the suspended particles, so that the suspended particles are destabilized to form small flocs. In the flocculation stage, the polymer chains form bridges between the suspended particles to facilitate the flocs' settlement process. In coagulation, the choice of flocculant is the key factor affecting the final treatment effect. After using flocculants to purify the water, further purification of suspended phosphorus is needed, and aquatic plants and algae can play a good role in this process. Algal bloom is a difficult problem for the management of eutrophic water bodies containing suspended solids [10], and it is particularly important to find out countermeasures to effectively regulate phytoplankton abundance. At present, many scholars focus on the classical food chain and try to find out countermeasures from it while neglecting the close connection between the microfood ring and the classical aquatic food web and finding out the influence of algal plants on the microbial ring composition and structure, which may provide a better solution for the suspended particles as well as the suspended particles. This may bring some new ideas for the regulation of suspended particles and phytoplankton.

Many researchers have conducted analyses on the purification of suspended solids in turbid surface water. Garud studied polyacrylamide grafted waste sand particles (PAGSPs) as an effective adsorbent to adsorb organic and inorganic pollutants in water to achieve the purification of pollutants in water. The composite particles were characterized by various methods. The results show that the size of the composite particles is in the range of micrometers, the specific surface area of the composite particles is 10 m~2 g~(-1), and the average pore diameter is 1.22 nm. Due to their good regeneration capacity, functional polymer based composite particles show great potential in removing organic and inorganic pollutants from wastewater and can obtain a good water purification effect, but this research has not been applied to natural water bodies [11]. The composite particles are affected by environmental factors, changes in water composition, and repeated utilization, and their adsorption capacity and regeneration effect are uncertain. Rashid and other scholars use a semiconducting photocatalyst that is magnetic, recyclable, active under visible light, stable under high temperatures and high conductivity, can achieve efficient purification, and has a high economy [12]. Semiconductor catalysts are active under visible light and can generate photogenerated electrons and hole pairs to catalyze the degradation of pollutants. However, its photoelectric conversion efficiency is limited by the energy and intensity of the light source. If the lighting conditions are not ideal or the photoelectric conversion efficiency is low, it will take longer to complete the purification process. Akamatsu and other scholars studied the characteristics of grafting poly (2-methoxyethylacrylate) (PMEA) onto the surface and pore wall of the membrane through plasma graft polymerization (PGP) and surface initiated atom transfer radical polymerization (SI-ATRP) to keep the membrane surface free of dirt. The modified membrane was used to filter raw water for 10 hours, and no flux decline was found. It shows that the modified membrane has an effective ability to inhibit pollution and can purify polluted raw water containing suspended solids [13]. Due to their graft modification of the membrane surface and pore wall, the stability and service life of the membrane are key issues. In the process of long-term operation, the graft layer may be affected by chemical substances, pressure, temperature, and other factors leading to degradation, thus affecting the purification performance and life of the membrane. Kitamura and other scholars tried to support useful microorganisms on the surface of a crystalline phosphorus removal agent composed of gypsum and calcium carbonate, so that it has the ability to remove organics. This material shows a high ability to remove organics. Research found that activated sludge, as a type of microorganism, can more effectively prepare water purification materials that can remove both phosphorus and organics than culture liquid [14]. In practical applications, microorganisms are affected by environmental conditions, temperature, pH value, and other factors, resulting in a decrease in microbial activity, making the purification result less than ideal.

On the basis of the above research methods, the key technologies for purifying suspended matter in turbid surface water under the influence of the rainy season are put forward. Organic solution flocculant is selected to have a better flocculation effect and higher purification efficiency. Ultrafiltration technology is used to separate and purify suspended solids. The application of ultrafiltration technology can effectively separate larger daphnia particles and further improve the purification effect of water. The experimental results show that the research method is more comprehensive and efficient and provides a new idea and solution for the purification of suspended matter in turbid surface water.

## Research on the Purification Technology of Suspended Solids in Turbid Surface Water Bodies

### Water Body Context

(1) General water indicators

This paper selects a small pool in a certain area that is connected to two large river systems and is rich in water resources. Due to the impact of surrounding factory production and crop growth, this water source contains high organic matter, ammonia nitrogen, odor substances, suspended particles, dissolved oxygen, and other characteristics below national standards, which will also produce a series of related water quality problems [15]. The pollutants in this water source are jointly affected by domestic wastewater and industrial wastewater, and the seasonal difference is large, so the situation is complex. The basic water quality indicators of the water source are tested, including the pH value of raw water, concentration of suspended solids and particle size distribution, Zeta potential, turbidity, ammonia nitrogen, organic matter, and other contents. The basic parameters are routine detection indicators of raw drinking water, which can objectively and accurately reflect the characteristics of the water body and its pollution degree. The test results are shown in Table 1.

It can be seen from Table 1 that the pH value of raw water is within the normal range of the surface water value (6.5-8.5), but for the purification experiment, this pH value is relatively high. The turbidity of raw water is high. The influence substances of turbidity are mainly insoluble suspended particles and colloidal particles. High turbidity water not only seriously affects the senses of the water body, but also causes harm to human health. The proportion of people who drink high turbidity water for a long time, suffering from gastrointestinal diseases and lithiasis, increases. Through observation, it is found that the raw water has good self-sedimentation, and the turbidity has significantly decreased after standing, which can be reduced to below. The content of soluble organic carbon (DOC) in raw water is 4.87mg/L.

Table 1. Basic indicators of surface water bodies.

| Basic index of water source | Numerical value |
|---|---|
| pH value | 7.92 |
| Suspended matter content/(mg/L) | 94.8 |
| Turbidity | 79.8 |
| $UV_{254}$ | 0.089 |
| $NH_3$-N/(mg/L) | 0.596 |
| DOC/(mg/L) | 4.87 |

(2) Raw water suspended particle size

The size distribution of suspended particles can provide important information about the properties and sources of suspended matter in water bodies. The behavior of suspended particles of different sizes is different in the processes of deposition, precipitation, and filtration. Larger suspended particles are more easily removed by physical or chemical methods, while smaller particles require more detailed treatment means to achieve good purification effects. After understanding the particle size range of suspended turbidity in raw water, appropriate purification methods can be selected and optimized, including flocculation, precipitation, filtration, etc., to achieve the goal of efficient removal of specific particle size suspended turbidity. Therefore, the particle size of raw water suspended particles is described to provide basic data for the subsequent purification process and equipment selection.

The laser particle size analyzer is used to measure the particle size through light scattering. The average particle size is expressed by the average volume particle size, which is generally expressed as d (0.5); that is, when the floc particle size is less than or greater than d50, the floc volume accounts for half of the total volume. By analyzing the characteristics of suspended particles in raw water, parameters such as particle types and particle size range can be directly reflected, which can guide the determination of coagulation test conditions. The experiment takes ultrapure water as the background, and the particle size distribution of raw water measured by a laser particle size analyzer shows that the particle size is mainly concentrated in a certain range. Raw water contains granular suspended solids that are obviously visible to the naked eye, most of which are clay particles and colloidal suspended solids, which is the main reason for the high turbidity value of raw water.

### Key Technologies for the Purification of Suspended Solids in Water Bodies

In order to realize the purification of suspended solids in turbid surface water under the influence of the rainy season in the study area, flocculants were used to initially purify the surface water in the study area [16], then ultrafiltration technology was used to realize further purification, and algal plants were used to realize the final purification of fine suspended solids and nitrogen and phosphorus pollution that still existed. The combination of the three purification technologies realized the comprehensive purification of turbid surface water under the influence of the rainy season through the use of the key technologies. Suspended matter.

### *Analysis of Flocculant Preparation and Purification Technology*

(1) Materials

The materials used in the preparation of the flocculants and the details of each material are shown in Table 2.

(2) Instrumentation

The instrumentation used in the preparation of flocculants is shown in Table 3.

(3) Flocculant preparation

Due to the different chemical compositions and physical properties of different flocculants, their effects on the purification process and the removal ability of specific suspended turbidity will vary. In order to evaluate which flocculants are more suitable for the purification of raw water suspended matter in the study area, a variety of flocculants are prepared and tested separately. By preparing and testing a variety of flocculants, it is possible to compare their effectiveness in purifying suspended turbidity in cloudy surface water under the influence of the rainy season, so as to determine the best flocculant formulation to improve purification efficiency and optimize the treatment process. The specific preparation of several flocculants is as follows:

Flocculant①(PFC): according to the relevant literature [17], take FeCl3·6H2O as raw material, take 4g of FeCl3·6H2O solid into a beaker, add about 200ml of distilled water and stir until completely dissolved, slowly add 0.78g of Na2CO3 powder for a small number of times to the predetermined alkalinity, and after the foam disappears, add the stabilizer NaHPO4·12H2O according to the ratio of phosphorus to iron mole ratio of 0.08, Continue to stir until it is completely dissolved, put it into an oven at 60°C for drying after curing for a certain time, cool it to room temperature, and grind it to obtain a polymer ferric chloride solid with relatively stable performance.

Flocculant②(PAFC): referring to the relevant literature [18], FeCl3·6H2O and AlCl3·6H2O are added into the beaker at the molar ratio of 5:2 aluminum to iron, a certain amount of distilled water is added and stirred until completely dissolved, a small amount of Na2CO3 powder is slowly added several times to the predetermined alkalinity, and after the foam disappears, a certain amount of NaHPO4·12H2O is added at the molar ratio of 0.08; continue stirring until completely dissolved. After stirring is stopped, it is naturally cooled to room temperature. After curing for a certain time, it

Table 2. Details of test materials.

| Material name | Manufacturer | Details |
|---|---|---|
| Ferric chloride hexahydrate ($FeCl_3·6H_2O$) | Jining three stone biotechnology Co., LTD | A relatively common inorganic compound with yellowish crystals, soluble in water and ethanol, and having a strong pungent odor |
| Sodium carbonate ($Na_2CO_3$) | Huanghua Chentai Chemical Products Co., LTD | White powder, can be 200 mesh sieve, easily soluble in water, melting point 851°C |
| Disodium phosphate dodecahydrate ($NaHPO_4·12H_2O$) | Wuhan Kemike Biomedical Technology Co., LTD | Industrial grade, colorless transparent crystal, compatible with water-compatible salts, density 1.53g/cm$^3$, melting point 34.5°C |
| Crystalline aluminum chloride ($AlCl_3·6H_2O$) | Hubei Xingyan New Material Technology Co., LTD | Industrial grade white to light yellow crystalline solid Soluble in water, ethanol, ether and glycerol, the aqueous solution is acidic, slightly soluble in hydrochloric acid, melting point 100°C, density 2.39g/cm$^3$ |
| Polyacrylamide | Foshan Hantu environmental protection Technology Co., LTD | Mainly used for wastewater flocculation settlement, mesh number is 40-60, density is 1.302g/cm$^3$,pH value is 5-12 |
| Acetic acid solution | Shandong Huayu Chemical Technology Co., LTD | Industrial grade, colorless transparent liquid, soluble in water, density 1.05g/cm$^3$, boiling point 117.9°C, melting point -10°C |
| Polyaluminum chloride | Henan Yihua purification material Co., LTD | Industrial grade, pH 3.5-5, water insoluble matter less than 0.5%, base degree 40%-90% |

Table 3. Device details.

| Device name | Manufacturer | Model number | Details |
|---|---|---|---|
| Oven | Changzhou Glide drying equipment Co., LTD | CT-C | Power is 1500W, hot air circulation drying, heat dissipation area 100m2, steam consumption 72kg/h, drying capacity 480kg Temperature difference 2°C |
| Magnetic stirrer | Shanghai Binglin Electronic Technology Co., LTD | BCL-100U | Stirring power 45W, voltage 220V-230V, heating power 500W, speed range 50r/ min-1800R /min, temperature range room temperature -380°C |
| Desktop turbidity meter | | | |

is transferred to a 60°C oven for drying, cooled to room temperature, and ground to obtain a polyaluminium ferric chloride solid with relatively stable performance.

Flocculant③(PAM): add 1g of polyacrylamide into the beaker, add 500ml of distilled water, and stir in a magnetic stirrer until it is completely dissolved to obtain 2g/L polyacrylamide solution.

Flocculant④(Cellulose) cellulose solutions are the same as above.

Flocculant⑤(chitosan CTS): add 1g of chitosan into a beaker, add 500ml of distilled water and 5ml of 1% acetic acid solution, stir with a magnetic stirrer until completely dissolved, and obtain 2g/L of chitosan solution.

Flocculant⑥(PAM-CTS): add the same amount of polyacrylamide solution and chitosan solution into the beaker, respectively, mix them with a magnetic stirrer until they are completely mixed, and obtain the polyacrylamide chitosan solution with a content of 1:1.

Flocculant⑦(PAC-PAM): Take the polyaluminum chloride polyacrylamide mixture as an example, mix a certain amount of polyaluminum chloride solution with polyacrylamide solution, and mix it completely under the stirring of a magnetic stirrer to obtain the polyaluminum chloride polyacrylamide solution with a concentration ratio of 10:1. The preparation steps for other inorganic organic compound solutions are the same as above. The inorganic organic solution has a concentration ratio of 10:1, and the preparation of flocculant is complete.

(4) Flocculant purification of raw water

In order to make the test results more accurate, raw water samples were collected from the study area and tested in an indoor environment. Add the flocculant into the raw water sample after accurate quantification according to the test settings, adjust it to a certain pH value, mix it for 2min with a magnetic stirrer at a speed of 300r/min, settle for 30min after reaction, and take the supernatant at a certain height to measure relevant water quality indicators. The flocculation test shall be conducted at room temperature, and each group of tests shall be repeated 3 times to make the test results more accurate. Use a desktop turbidimeter to measure the turbidity of water samples and judge the purification of suspended solids in surface water in the study area according to the turbidity value.

*Ultrafiltration Purification Process Flow*

The use of flocculant treatment of raw water can flocculate the suspended solids in the raw water, so that part of the large particle size suspended solids precipitation, to achieve the purpose of purification, but flocculation purification for the smaller particle size suspended solids purification effect is not ideal, so in the use of flocculants and then of ultrafiltration technology, further purification of suspended solids in the raw water in the study area [19]. Ultrafiltration is a membrane separation technology that can purify, separate, or concentrate solutions. The main role of the ultrafiltration membrane in water purification is solid-liquid separation. Ultrafiltration is a membrane filtration technology between microfiltration and nanofiltration. How to remove the impurities to be removed, especially dissolved impurities in the form of solid phase removal, is the key to giving full play to the role of membrane separation.

(1) Instructions for the use of ultrafiltration

The ultrafiltration membrane shall be shut down for cleaning once every certain period of use. The ultrafiltration membrane cleaning time is minutes, the positive flushing time is 5min, and the backwashing time is 5min. The ultrafiltration membrane needs to be backwashed when the following conditions occur. The water yield is 10%-15% less than that after the last cleaning, and the inlet pressure and water side pressure are 10%-15% more than that after the last cleaning. The cleaning water quality is sterile ultrafiltration water. If necessary, add disinfectant to the clean water. The disinfectant is hydrogen peroxide. The sand filter tank is cleaned every hour of use, including washing and backwashing. The washing time is 15min, and the backwashing time is 15min.

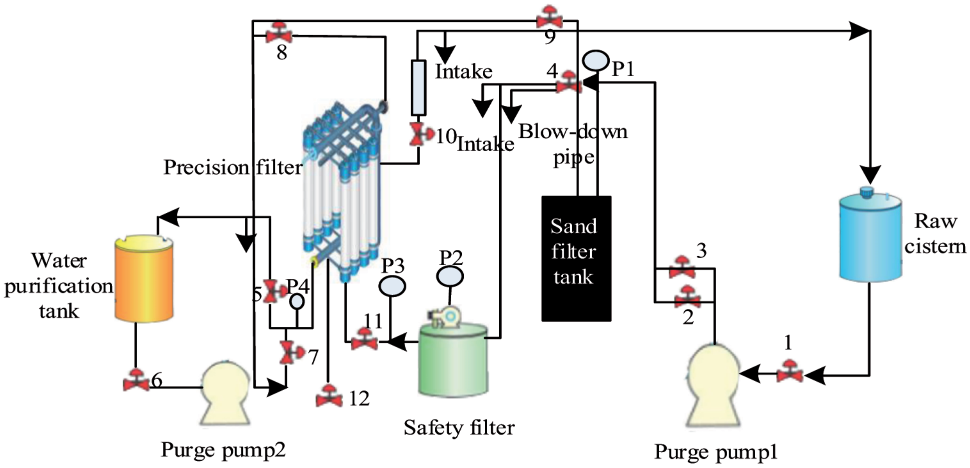



Fig. 1. Ultrafiltration purification details.

(2) Ultrafiltration process flow

The detailed process flow of purification by ultrafiltration technology is shown in Fig. 1.

The individual numbers in Fig. 1 indicate valve numbers. The ultrafiltration technology operates as follows:

Raw water into the booster pump 1 transfer to the sand filter tank, the sand filter tank after treatment transfer to the precision filter, the ultrafiltration membrane final filtration, and transmission to the final water purification tank. The process of opening the valves 1, 5, and 11, and valve 4 to the operating state. The cleaning process for the equipment is as follows:

The liquid from the water purification tank is transferred to cleaning pump 2 and then to the ultrafiltration membrane. During operation, stop the pump 1 operation, close the valves 1, 5, and 11, open the valves 6, 7, and 12 for backwash, and then open the valves 6, 8, and 12 for positive flushing. Water purification tank liquid is transferred to the cleaning pump 2 transmission in the sand filter tank to pass the rinse. The flushing process stops until pump 1 is in operation. Close the valves 1, 5, and 11, open the valves 6, 9, and 4 three-way valve positive rinsing, and adjust the positive rinsing backwash when adjusted to the backwash.

Process description: coagulant using metering pumps, through the pipeline to add most of the suspended solids in the water and part of the organic matter through the coagulation of the formation of microflocs. In the original water tank for a short period of time after the booster pump pressurized into the sand filter tank to intercept the coagulation after the formation of large particles of flocs so as to remove most of the suspended solids in the water and macromolecules of organic matter to improve the membrane flux [20]. And then, through the ultrafiltration membrane, to retain small flocs in the water, remove the residual suspended solids and organic matter in the water to further improve water quality.

### *Large-Scale Water Purification of Suspended Solids in Surface Waters*

Due to the high turbidity of surface water under the influence of the rainy season, ultrafiltration technology can effectively remove fine suspended particles, but it may not be able to treat water bodies containing large amounts of suspended particles. The large daphnia, through its internal agitation and sedimentation, can promote a larger volume of suspended matter to form a precipitate and rapid settlement in the water, so as to achieve a more thorough purification effect. Therefore, after the ultrafiltration technique is used to purify the suspended matter in the raw water in the study area, the daphnia macrosum is used to purify the suspended matter in the surface water.

① Selection of Daphnia magna: Daphnia magna for the experiment was collected from northwest China, isolated and purified in the laboratory, and cultivated and domesticated with baker's yeast as bait. Before the test, it was purified in pure water in the laboratory, and the intestinal tract was emptied for 48 hours for standby.

② Adjust the temperature of the laboratory to 8°C-10°C, divide 15 barrels of raw water after ultrafiltration into 5 groups, and repeat 3 times for each group. Then add different amounts of Daphnia magna in each group, so that the density of each group is 0ind/ L(T0)、5ind./ L(T1)、15ind./ L(T2)、25ind./ L(T3)、50ind./ L (T4), forming five density gradients. The remaining raw water is used for the determination of 12 indicators, including total nitrogen, total phosphorus, soluble total nitrogen, soluble total phosphorus, active phosphorus, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, turbidity, total suspended solids, organic debris concentration, and inorganic ash concentration, and is taken as the initial value. The experimental period is 11 days, and the mixing is performed every 12h. The concentration of organic debris and inorganic ash is only measured before and after the experiment, and the other indicators are measured on the 2nd, 3rd, 5th, 7th, 9th, and 11th days of the experiment, respectively. The data measured on the 3rd day of the total suspended solids concentration is missing.

Turbidity is measured with WGZ-3; The specific determination methods of total nitrogen, total phosphorus, soluble total nitrogen, soluble total phosphorus, active phosphorus, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, and other indicators refer to the Monitoring and Analysis Methods for Water and Wastewater (Fourth Edition); The suspended solids are measured by the gravimetric method. First, the water sample is filtered by the calcined GF/C (Whatman) filter membrane, then the filter membrane is dried at 105 °C for 4h, then put into a muffle furnace, and the temperature is adjusted to 550°C for 6h to obtain the content of inorganic ash (ISS). The content of organic debris (OSS) is the difference between the content of total suspended solids and the content of inorganic ash (ISS) [21].

The net removal of a measure in group *i* large on day *t* is expressed as $\Delta C_{it}$, represents the experimental group. *t* is the number of days of the test, and this removal was calculated using equation (1):

$$\Delta C_{it} = C_{0t} - C_{it} \tag{1}$$

In the formula, the $C_{0t}$ indicates the concentration of a control indicator on day *t*. The net removal amount $\eta_{it}$ of a large index in group *i* on day *t* is calculated by using equation (2):

$$\eta_{it} = \frac{\Delta C_{it}}{C_{0t}} * 100\% \tag{2}$$

SPSS18.0 software was used to carry out a one-way ANOVA for each index of data. Through the single factor analysis of variance, the influence of different purification conditions (that is, different flocculants or purification process combinations) on each index can be compared, and which treatment method can achieve a better purification effect under specific conditions can help determine the best purification conditions and further optimize the suspended matter purification process of surface water. Based on this, the following purification tests were carried out.

## Results

### Flocculant Purification Effect

The flocculants prepared in this paper include three types: organic flocculants (polyacrylamide PAM, chitosan CTS, new cellulose), inorganic flocculants (polymeric ferric chloride PFC, polymeric aluminum ferric chloride PAFC), and organic-inorganic composite flocculants (polyacrylamide chitosan PAM-CTS, polymeric aluminum chloride polyacrylamide PAC-PAM). When these three different flocculants purify the raw water in the study area, the turbidity removal rate is shown in Fig. 2.

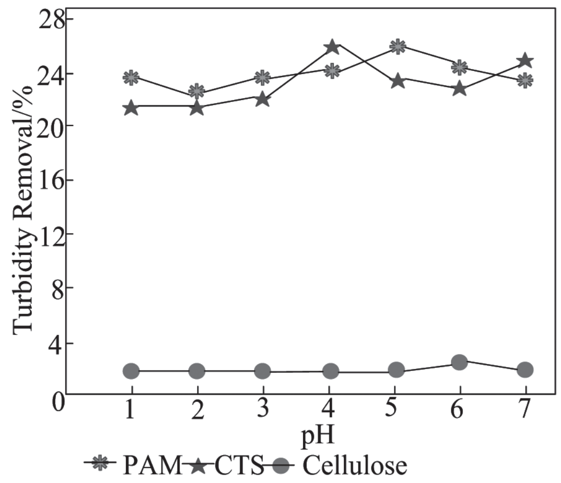
It can be seen from the analysis of Fig. 2 (a) that when the organic flocculant is used alone, it is less affected by pH, and the purification treatment effect is poor. Among the three organic flocculants, the highest turbidity removal rate is below 28%. The purification effect of PAM and CTS flocculants is better than that of cellulose flocculants, and the purification effect of these two organic flocculants is relatively close. Fig. 3 (b) shows that the inorganic flocculant is greatly affected by pH when it is added alone. When the pH value of PFC and PAFC is 6-14, the turbidity removal rate is high, and when the pH value is 8, the flocculation purification effect is the best. Judging from the test results in the figure, the purification effect of these two flocculants can meet the basic needs of raw water purification. It can be seen from Fig. 3 (c) that the flocculant compounded by PAM-CTS has a poor removal effect on suspended solids in raw water studied in this paper, but the flocculant compounded by PAM-PAM has an ideal removal effect on suspended solids in raw water, and the optimal removal effect of turbidity is between 90% and 92%. The effect of purifying suspended solids in raw water is good, so it can be determined that using PAM-PAM compound flocculant to purify suspended solids in turbid surface water in this study area can initially obtain an ideal purification effect.

### Purification Effect of Ultrafiltration

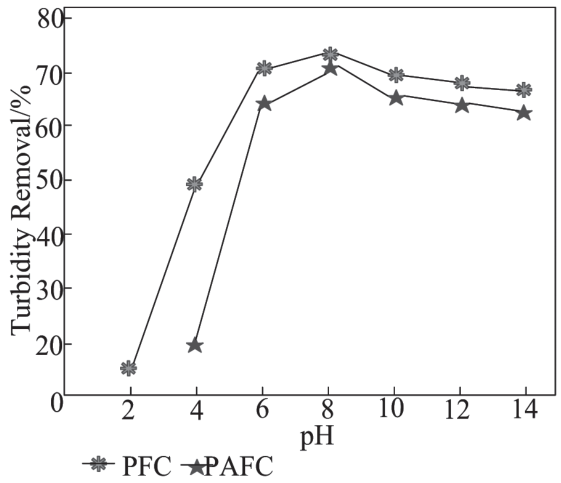
After the flocculant purification of the raw water, only the suspended solids in the raw water will be coagulated together and precipitated at the bottom, no longer suspended in the raw water, but these suspended solids are still present in the raw water, and by the impact of the rainy season, the turbidity of the surface water is even higher, so the use of ultrafiltration technology in the flocculant purification based on the purification of the turbidity of the surface water will further purify the raw water.

The turbidity and suspended solids removal rate of the ultrafiltration effluent of raw water were determined using a benchtop turbidimeter, and the test results are shown in Fig. 3.

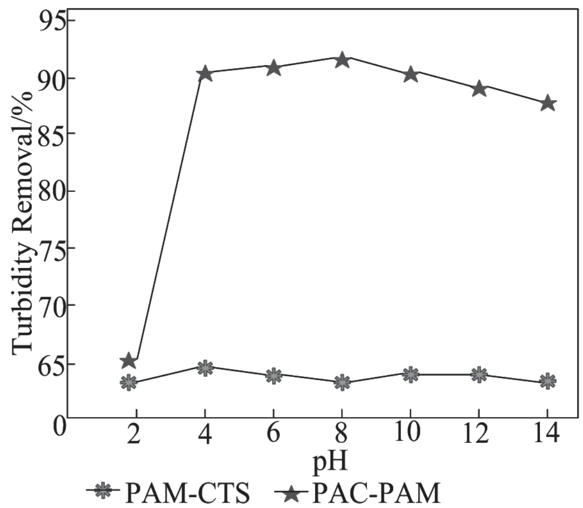
It can be seen from Fig. 3 (a) that when ultrafiltration combined with flocculant purification technology is compared with the use of ultrafiltration technology alone, the purification effect is better and the average turbidity of the effluent is lower than when using flocculant alone ultrafiltration technology 10%.It can be seen from the



(a) Turbidity removal rate of organic flocculant

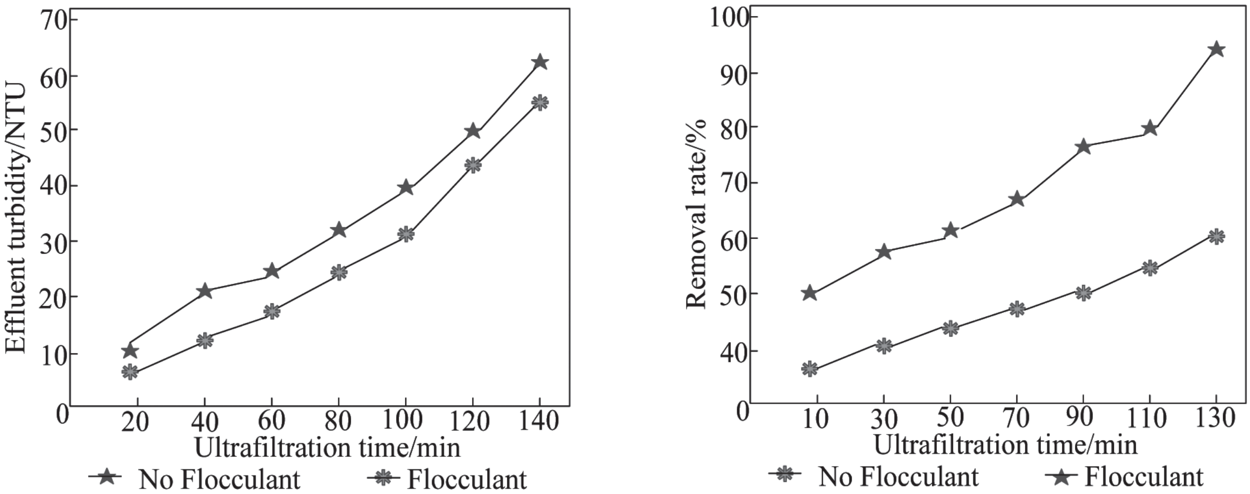


(b) Turbidity removal rate of inorganic flocculant



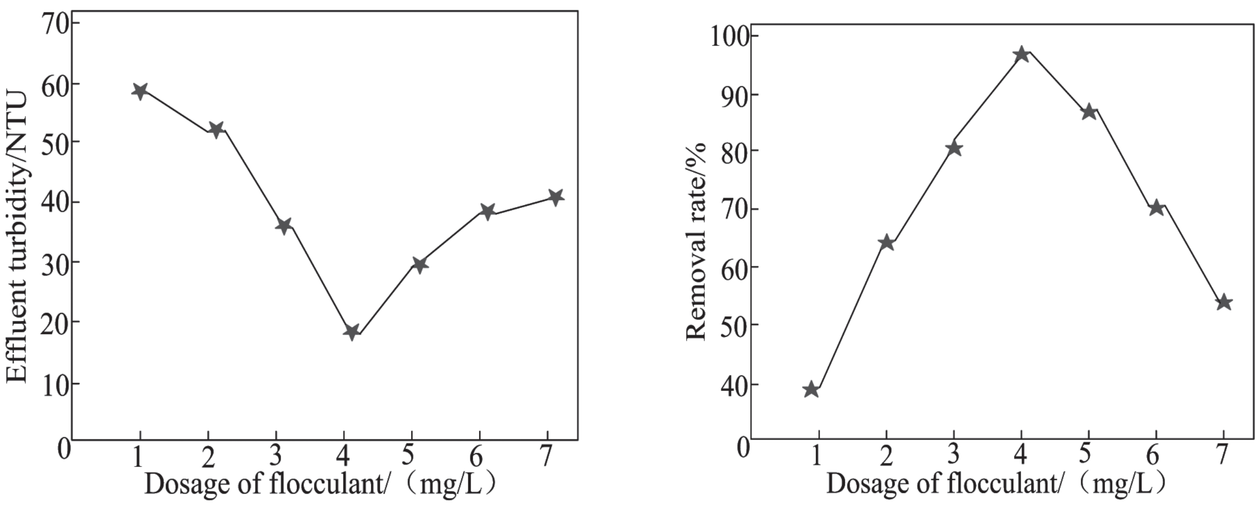
(c) Turbidity removal rate of organic-inorganic complex flocculant

Fig. 2. Turbidity removal rate of suspended solids.




(a) Turbidity of ultrafiltration effluent (b) Removal rate of suspended solids

Fig. 3. Turbidity of ultrafiltration effluent and removal rate of suspended matter with or without flocculant.




(a) Turbidity of ultrafiltration effluent (b) Removal rate of suspended solids

Fig. 4. Influence of flocculant dosage on purification effect.

analysis of Fig. 4 (b) that the turbidity removal rate of raw water containing suspended solids after purification by flocculant combined with ultrafiltration is significantly higher than that of the purification technology using ultrafiltration alone, the maximum turbidity removal rate is 94%. It can be judged that the combination of flocculant and ultrafiltration can greatly improve the purification effect of suspended matter in turbidity surface water under the influence of the rainy season, avoid membrane fouling caused by the blockage of particulate matter in the treatment process, reduce the frequency of equipment maintenance and cleaning, and reduce the treatment cost.

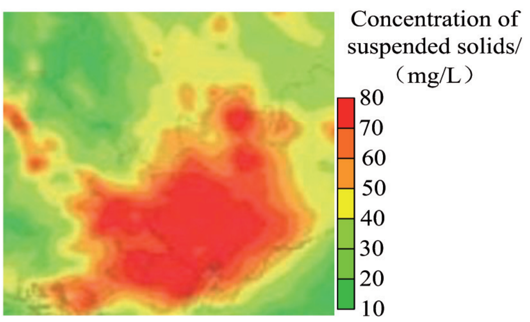
Effect of Flocculant Addition on Purification Effect

Clarifying the purification technology combining flocculant and ultrafiltration can achieve a better purification effect, but the dosage of flocculant needs to be determined in this process, so as to obtain a better purification effect under the influence of the rainy season. Set the dosage of flocculant at 1mg/L, 2mg/L, 3mg/L, 4mg/L, 5mg/L, 6mg/L and 7mg/L respectively. The test analysis results are shown in Fig. 4.

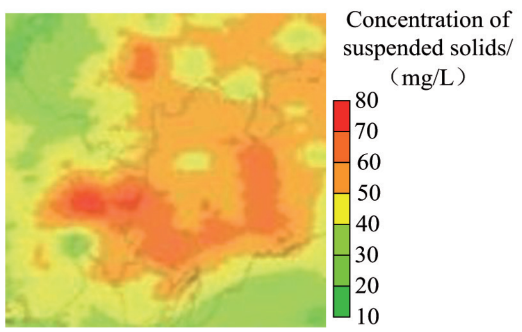
It can be clearly seen from Fig. 4 that when the dosage of flocculant is 4mg/L, the turbidity of wastewater during purification is lower and the removal rate of suspended solids is the highest. When the dosage of flocculant is 4mg/L, the purification effect is the best, and the time is more suitable for the purification of suspended solids in turbid surface water under the influence of the rainy season. By studying the effect of different dosages of flocculant on the purification effect, the best dosage of flocculant can be determined, which provides a specific reference for practical engineering applications.

Table 4. Concentration of suspended solids after purification of Daphnia magna.

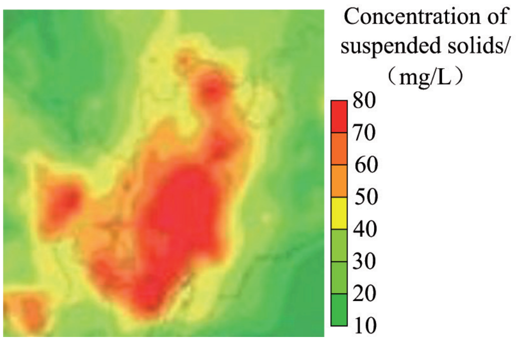
| Purification days/d | T0Concentration of suspended solids/ (mg/L) | T1Concentration of suspended solids/ (mg/L) | T2Concentration of suspended solids/ (mg/L) | T3Concentration of suspended solids/ (mg/L) | T4Concentration of suspended solids/ (mg/L) |
|---|---|---|---|---|---|
| 1 | 18.45 | 18.15 | 18.66 | 18.52 | 18.39 |
| 2 | 14.44 | 15.57 | 15.69 | 15.72 | 15.89 |
| 3 | 14.51 | 16.45 | 17.74 | 15.47 | 13.57 |
| 4 | 14.69 | 16.98 | 18.54 | 15.92 | 12.68 |
| 5 | 15.66 | 17.78 | 22.65 | 16.79 | 9.67 |
| 6 | 14.15 | 16.31 | 19.43 | 15.97 | 10.94 |
| 7 | 13.67 | 15.24 | 18.11 | 14.75 | 11.68 |
| 8 | 12.66 | 14.76 | 17.38 | 13.02 | 10.15 |
| 9 | 11.07 | 13.69 | 16.24 | 12.08 | 9.15 |
| 10 | 10.38 | 12.74 | 15.41 | 11.08 | 8.25 |



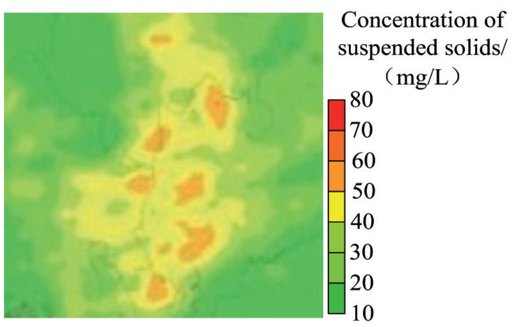

(a) After precipitation, flocculant is used for purification alone



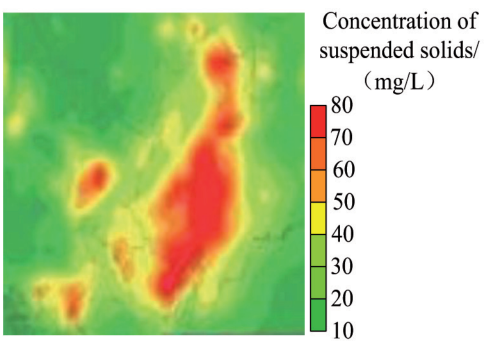

(b) Use flocculant alone for purification before precipitation



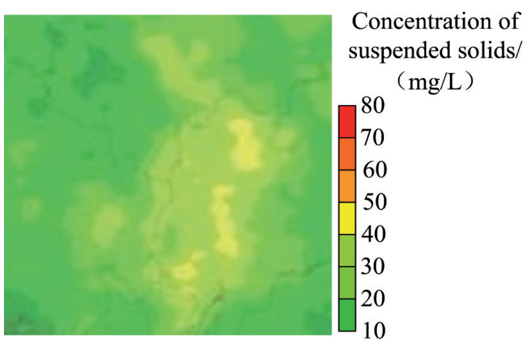

(c) Flocculant-ultrafiltration purification after precipitation




(d) Pre-precipitation flocculant-ultrafiltration technology purification




(e) Flocculant-ultrafiltration-Daphnia magna purification after precipitation




(f) Flocculant before precipitation-ultrafiltration-Daphnia magna purification

Fig. 5. Comparison of purification before and after rainfall.

### Effectiveness of Large-Scale Decontamination

After the treatment with flocculant ultrafiltration purification technology, a large amount of suspended solids can be removed from the raw water, but some suspended solids and microorganisms still remain in the raw water. Therefore, Daphnia magna is used to further purify the raw water. Under different Daphnia magna densities (0ind./L (T0), 5ind./L (T1), 15ind./L (T2), 25ind./L (T3), and 50ind./L (T4)), with the passage of purification days, the changes in total suspended solids content in raw water after flocculation ultrafiltration purification are shown in Table 4.

It can be seen from Table 4 that the increase in density of Daphnia magna can reduce the content of suspended solids in raw water; that is, it can achieve the goal of purifying suspended solids in raw water. When using Daphnia magna for purification, there will be a significant increase in the concentration of suspended solids on the 5th day. This may be due to the influence of the surrounding environment. Daphnia magna has abnormal changes, so the purification effect changes. But as time goes on, the impact gradually stabilizes, so the concentration of suspended solids shows a stable downward trend. At the same time, it can be seen from the results in Table 4 that the greater the density of Daphnia magna, the smaller the concentration of suspended solids. It can be judged that the high-density Daphnia magna can reduce the concentration of total suspended solids.

### Verification of the Practical Application Effects of Purification Technology

The key purification technologies studied in this paper were applied in the actual area under study to observe the purification effect of suspended solids in the surface water of the study area under different purification technologies: ① flocculant alone, ② flocculant-ultrafiltration, and ③ flocculant-ultrafiltration-large-scale water, and the purification effect of the three technologies before and after the effect of precipitation was considered. Remote sensing images were used to collect the changes in suspended solids in the surface water of the study area before and after precipitation purification using these three techniques. The experimental results are shown in Fig. 5.

It can be seen from the analysis of Fig. 5 that the concentration of suspended solids in the study area after precipitation is significantly higher than that before precipitation, indicating that the impact of the rainy season will lead to an increase in suspended solids concentration in the surface water body in the study area. However, in general, the purification effect of the flocculant ultrafiltration Daphnia magna comprehensive purification technology is significantly better than the other two purification methods, and the purification effect is better both before and after precipitation. It can be concluded that the purification technology is suitable. The flocculant could rapidly aggregate suspended particles, ultrafiltration could further remove small particles and colloidal substances, and M. macrogestina accelerated the sedimentation of suspended particles through agitation and precipitation. These methods can be used to remove suspended matter in turbid surface water more efficiently.

## Conclusions

This paper takes an actual pond as the research object, studies the key technology of purification of suspended solids in turbid surface water under the influence of the rainy season, analyzes the effect of different flocculants on the purification, selects the flocculant that is more in line with the purification effect, combines the ultrafiltration technology, improves the purification effect of suspended solids in the surface water body, and uses high-density large-size storks for the small-sized suspended solids and microorganisms that are difficult to purify. A combination of flocculant, ultrafiltration, and daphnia purification technology was used to improve the purification effect of suspended solids in turbid surface water under the influence of the rainy season. After testing, the following conclusions can be drawn:

(1) Organic flocculant, inorganic flocculant, inorganic-organic flocculant, and organic-organic flocculant were used to treat the water samples collected in the study area. The results showed that the inorganic-organic compound flocculant had the best flocculation effect, while the inorganic flocculant had the second best flocculation effect.

(2) The purification technology of flocculant combined with ultrafiltration can significantly improve the purification effect, and when the dosage of flocculant is 4mg/L, the purification effect is the best.

(3) Compared with the control group, both the low-density treatment group and the high-density treatment group had inhibitory effects on the algae density; the latter was the most obvious. Daphnia magna can directly affect phytoplankton through feeding and mechanical interference, preferentially selecting green algae with particle sizes between 20~30 μm algae. Daphnia magna has an inhibitory effect on microsuspended solids in raw water, and the greater the added density, the stronger the inhibitory effect (except for protozoa), thus indirectly affecting the phytoplankton community.

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## Conflict of Interest

The authors declare no conflict of interest.

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