Study on the removal methods of plankton in micro-polluted reservoir water

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Abstract. In recent years, water pollution and eutrophication are becoming increasingly serious, plankton represented by Cyclops and algae frequently appear in many urban micropolluted water sources. The current methods to remove algae include catching, adding algicide, adding oxidant, enhanced coagulation and so on, and the current methods to remove the Cyclops include adding oxidant, coagulant precipitation treatment, biological activated carbon filtration, etc. This paper analyzes the effect of different methods on removing plankton in the water, and their advantages and disadvantages, to solve the problem of algae and Cyclops due to seasonal reasons for short outbreaks.

1. Introduction
Cyclops and algae are common plankton in reservoir water. From May to September in northern China each year, algae began to multiply, meanwhile, they can provide food and nutrients for the Cyclops. From September and October each year, the number of Cyclops is the largest because nutrients and temperature are the most suitable for Cyclops’ survival at this time. Due to the plankton blooms in the short time, the problem of eutrophication in water is more serious [1-2], and increase the difficulty of waterworks treatment.

2. Hazards of algae and Cyclops
Due to seasonal water quality changes in reservoir water, eutrophication occurs in the water. Cyclops is one of the indicators of eutrophication, it is suitable for living in eutrophic water bodies. Due to its large number has gradually become a dominant species, changing the plankton population structure and breaking the ecological balance of water in nature. As it is a visible organism, it can bring adverse sensory effects to people. In addition, some viruses and pathogenic organisms such as metacercaria can live in the body of the Cyclops, making the Cyclops a vector of disease transmission [3], and cyclops has a strong swimming ability, can penetrate the filter, and strong antioxidant. If waterworks add a lot of oxidants will cause disinfection byproducts to exceed the standard. When the concentration of algae in the water is high, the operation cost of algae removal by membrane filtration, air flotation and other methods in the water plant is high [4], while the use of chemical algal removal agent will cause secondary pollution.

3. The methods of removing algae and Cyclops

3.1. Methods of removing algae

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In the reservoir waters in the north, diatoms and green algae are mainly found in the water, they make up about 60 to 70 percent of all algae. The microscopic structure of green algae is shown in figure 1. When the concentration of algae is high in the reservoir water, it will increase the water’s color and odor, simultaneously, algae, especially cyanobacteria, will release algal toxins, which will harm people's health, so it's necessary to remove it.

![Figure 1. The microscopic structure of green algae](image)

The methods of removal are as follows:

1. Catching
   Mechanical catching can be used to remove algae in large quantities quickly, but requires more workforce, cannot be applied to the entire area of the reservoir water, and cannot effectively remove all algae from the water. It is usually used to collect certain commercially valuable algae.

2. Adding algicide
   Adding the algicide can effectively and quickly remove algae, obtain short-term results, Common types of algicide such as copper sulfate, cinnamic acid, etc., among them, copper sulfate is the most widely used algae killing agent at present. When the effective dose of copper sulfate is 0.5-1.0mg/L, the removal rate of algae can reach 70%-90% [5]. However, copper sulfate cannot be added in large quantities, which will increase the copper salt content in the water. Therefore, only when the concentration of algae in the reservoir water is high, copper sulfate is used.

3. Preoxidize to remove algae
   Preoxidation is to inactivate algae through oxidants acting on proteins or chloroplasts in algal cells. Currently, oxidants commonly used to inactivate algae are Sodium hypochlorite, permanganate, ferrate and so on. With permanganate and ferrate on algae inactivated effect is best. Chlorine dioxide and ozone on algae inactivated effect are also good, the chlorine dioxide add 1 mg/L, removal rate can reach 75%, at the same time also can effectively remove the odor in the water, but it is not widely used in China because it is not easy to store and is prone to explosions and it needs to be produced and used at the same time.

   Ozone can also play a good role in the inactivation of algae, and can effectively remove algal toxins released by algae. Studies have found that 96% microcystin can be removed from water. However, if bromine ions are present in the water, trihalomethanes, haloacetic acids are produced. Moreover, it requires a large investment in technology and equipment, strict operation and management skills, and high operating costs. It is rarely used at present.

4. Algal removal through enhanced coagulation
Coagulation precipitation is also a common water treatment method. Some studies have shown that the diameter of algal cell colloid is about 6 μm. Colloid in natural water is usually charged colloid, so the coagulant can be used to compress the algae negatively charged surface, forming a powerful polymers. At present, there are many waterworks in northern China using polyaluminium chloride coagulant, and add the polyaluminium chloride or aluminum sulfate coagulant can at the same time of strengthening coagulation precipitation, effectively improve the efficiency of algae removal, up to more than 90%.

3.2. Methods of removing Cyclops
The Cyclops of northern China are begin to appear in June, because the temperature at that time is beginning to be suitable for the Cyclops, but the density is low at about 15 per litre. After September, due to nutrients and temperature, the optimum conditions for the survival of this species have been reached, they begin to appear in large numbers, usually up to 60 per litre. The microscopic structure of Cyclops is shown in figure 2.

![Microscopic structure of Cyclops](image)

Figure 2. The microscopic structure of Cyclops

The common methods of removal are as follows:
1. Preoxidize to remove Cyclops

Oxidants can directly destroy the body wall structure of Cyclops by infiltration or adsorption, or enter the body of Cyclops and destroy the organelles, thus destroying the normal genetic and metabolic level of Cyclops and finally causing its death. Therefore, the two factors of oxidizing ability and time become the key factors for effective inactivation. At present, the commonly used oxidants to inactivate the Cyclops are chlorine dioxide, sodium hypochlorite and so on.

Although ozone is a strong oxidizer, its duration is very short, generally no more than 3 minutes in the air, and no more than 15 minutes in the water. In water, it reacts with organic matter in raw water and decomposes itself. Meanwhile, ozone is not easy to preserve, so it needs to be prepared on the spot. The reason why ozone is not ideal for the inactivation of The Cyclops is that the shell of the Cyclops is thicker and has a strong antioxidant. If the oxidant has a short contact time with the Cyclops, it cannot act on the body of the Cyclops, so it cannot be inactivated. Potassium permanganate is also a more commonly used oxidant, but the inactivation effect of potassium permanganate on Cyclops is not ideal, and if a large amount of potassium permanganate is added, it will lead to the increase of color in the water.

Liquid chlorine also has a strong oxidation ability, which mainly inactivates Cyclops through hypochlorous acid permeation and diffusion into the cell membrane to block glucose metabolism. Although liquid chlorine can kill the Cyclops better, but the liquid chlorine and the natural organic
matter in the original water has a high reaction activity, so it can really act on the Cyclops is not much, generally only residual chlorine can oxidize the Cyclops, so the oxidation rate in the original water is lower than in distilled water. If the amount of liquid chlorine is increased, better inactivation effect can be achieved, but at the same time, the content of residual chlorine in water should also be considered.

2. Removal of Cyclops by coagulation sedimentation

Similar to remove algae, enhanced coagulation can also be good to remove the Cyclops. However, in general, the pretreatment process will be added before coagulation and precipitation in waterworks to remove the Cyclops, the Cyclops after oxidation activity decline, Therefore, the removal effect of Cyclops mainly depends on the ability of flocculant to cover and wrap, so flocculation body by flocculation settlement is closely related to cyclops removal effect. If the Cyclops is completely inactivated by the oxidant, all dead bodies sink to the bottom of the pond. Similar to the traditional particulate pollutants, flocculants can be naturally encapsulated and deposited in the sediments.

3. Removal of Cyclops by filter

The filtration effect of the filter material on the Cyclops mainly depends on the filter material. The type and size of the filter material directly affects the removal of the Cyclops. When the filter material aperture decreases, the penetration resistance of The Cyclops greatly increases. The individual size of the general Cyclops is about 1mm, when the filter material aperture is adjusted to less than 1mm, the retention effect of the Cyclops can be greatly improved. However, not all Cyclops can be removed from the filter. Some Cyclops and juvenilia with size less than 0.1mm can penetrate the filter layer and enter the subsequent water treatment unit, therefore, before passing through the filter, they need to be treated in coordination with coagulation, precipitation, oxidation and other processes to achieve the best effect.

4. The Method of simultaneously removing algae and Cyclops

In some northern cities, many reservoir water are in a state of micro-pollution, sometimes, algae and Cyclops are coexisting in the water, but it's not a lot. Therefore, when the algae and the Cyclops coexistence, the preoxidation synergy with conventional water treatment process to remove algae and Cyclops is the most effective way to handle it. Chlorine dioxide, sodium hypochlorite on the Cyclops has a good effect of inactivated, and potassium permanganate and potassium permanganate compound medicament has good inactivated effect on algae. Therefore, the plankton in water can be removed by adding compound agents.

For example: chlorine dioxide is compounded with potassium permanganate, its inactivated effect can reach more than 90%, at the same time, potassium permanganate can also prevent algal cell rupture, will greatly reduce the release of algal toxin due to cell rupture, but also strengthen coagulation precipitation, so as to achieve better removal rate. A compound of sodium hypochlorite and potassium permanganate may also be used, sodium hypochlorite as currently used oxidant in many northern cities, It had better inactivation effect on algae and Cyclops, so the sodium hypochlorite and potassium permanganate compound agents is also a good choice. simultaneously, different influencing factors, such as pH value and temperature, can be adjusted to achieve a better plankton removal rate. The influences of different factors on Cyclops and algae are shown in Table 1. This preoxidation method can also provide a basis for the design and operation of adding oxidizer in long-distance water delivery projects.

| Different influencing factors | The optimum range for plankton life |
|------------------------------|-----------------------------------|
| PH value                     | Around 6.58                       |
| Temperature                  | 10℃-20℃                           |
|                              | 20℃-30℃                           |
5. Conclusions
According to the seasonal water quality characteristics of the north reservoir, at present, the most commonly used method to remove algae is to add oxidants or algicides. When the concentration of algae in the water is high, algae can be inactivated by adding copper sulfate and other algicides. In addition, permanganate and ferrate have better inactivation effect on algae. When the concentration of algae is medium, they can be added to inactivate algae. In the micro-polluted reservoir water, because the algal concentration is not very high, they can be removed by preoxidation. For Cyclops, the most commonly used method is preoxidation combined with conventional water treatment. The commonly used oxidants are liquid chlorine, chlorine dioxide, sodium hypochlorite and so on. In some time periods, the water contains relatively more algae and Cyclops. In order to reduce the pressure and cost of waterworks, the method of adding oxidant can be used to remove algae and Cyclops at the same time.

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