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Research on efficient and economical treatment methods for algal pollution in landscape water

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Abstract. A water body in Guilin was selected for this study. In order to find out the best dosing ratio, we conducted research experiments on combined algae removal methods and obtained a more economical and efficient mixed dosing ratio for treating water bodies. If this solution is replicated, it will contribute to the development of marine and freshwater fisheries; to the construction of a green ecosystem and human public healt.

1 Introduction

Algal pollution is a major problem with regard to water treatment. PAERL, H. W. et al. studies on marine algal blooms showed that enhanced foreign organic loads (DOC and POC) and enhanced foreign inorganic nutrient loads (nitrogen and/or phosphorus), etc. in the right combination can lead to the development and persistence of algal blooms [1]. To explore the source of algal blooms, HW Paerl , RS Fulton et al. determined that human activities are related to the extent and scale of cyanobacterial blooms [2]. For example, organic matter brought by human activities causes excessive algal blooms in the water bodies of tourist cities, and MA Burford, AT Revill et al. found through their study that in the presence of sewage, algal concentrations increase [3] and can have a significant effect on the ecological balance in water bodies. L Legendre found in their study that microalgal blooms have a significant impact on benthic and pelagic food webs [4]. R Alonso-Rodriguez et al. pointed out that algal blooms can cause economic losses due to the death or reduced growth of fish and shrimp [5]. PR Epstein et al. isolated cholera virus from algal blooms and consumed by fish, molluscs and crustaceans and transported to several coastal communities, which can cause poisoning if inadvertently consumed by humans [13]; J Wang et al. discussed that harmful algal blooms can have multiple effects on marine ecosystems and public health, and that in areas of algal blooms. The detection of shellfish toxins in areas of algal blooms is a serious risk to human health [14]. It has been reported that red tides have occurred more frequently in China in recent years, averaging 70-80 times per year and causing direct economic losses of nearly 200 million RMB per year.Research into algae suppression is urgently needed to address the ecological and human health risks caused by algal pollution. There are many ways to remove algae, and the latest research is currently directed towards HM Stoll, JR Encinar et al. proposed an equal volume of sodium hypochlorite (2.8%) and hydrogen peroxide (30%) in a mixture for oxidation treatment for the most complete and rapid oxidation of algal organic matter [6]. Zhiqian et al. proposed that polyaluminium chloride (PAC) is an important flocculant in drinking water and wastewater treatment [7]. However, the current method of algae removal still suffers from a lack of in-depth research on dosage and dosing methods.Therefore, exploring the effective scheme of NaClO combined with PAC for the treatment of algal pollution in landscape water provides new ideas for the scheme applicable to algae removal in water. To this end, a water body in Guilin was selected for this study. In order to find out the best dosing ratio, we conducted research experiments on combined algae removal methods and obtained a more economical and efficient mixed dosing ratio for treating water bodies. If this solution is replicated, it will contribute to the development of marine and freshwater fisheries; to the construction of a green ecosystem and human public health.

2 Materials And Methods

2.1 Determination of raw water quality indicators

The water sample is a landscape water in Guilin City, placed in a beaker to observe, more turbid, there is a little suspended matter, static sedimentation suspended matter can sink to the bottom, no odor and obvious color.

2.2 pH, temperature measurement method

Take 100ml of water sample in a beaker and measure the pH value of the water sample with a pH meter; measure the temperature value of the water sample with a

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thermometer.

2.3 Turbidity measurement method

Using turbidity meter to determine turbidity, first turn on the machine to warm up, with ultrapure water to do the blank sample correction and zeroing.Each measurement first to ultrapure water to wash, and then the water sample rinse twice, wipe dry, and then measured, such as data stability, transcription.

2.4 Algal density measurement method

Use a microscope to count algae, wash and dry the hemocytometer plate and coverslip, cover the coverslip first, use a dropper to draw water samples from the groove next to the plate, let it cover the counting area under surface tension, adjust the microscope, find the counting area under four times to adjust the aperture and focal length to be clearly visible and then turn to 10 times to observe, adjust the clear and then turn to 40 times to observe, by constantly adjusting the focal length to count The algae in the counting area will be counted out, each sample count up and down two counting areas, and take the average value to record. Each time to count algae, the number of experiments set up in the blank sample and a group of raw water samples to exclude sampling errors. The algae count should be performed strictly according to the Analytical Methods for Water and Wastewater Monitoring (4th edition).

2.5 PAC coagulation, sedimentation and algae removal method

Shake the water sample well, reach into the middle of the water level of the bucket with a siphon tube, suck out the water sample into a measuring cylinder, take six groups of 200 ml of water samples in 250 ml beakers, individually add a certain concentration gradient of PAC (10, 20, 30, 40, 50, 60 mg/L), the existing active ingredient of polymeric aluminum chloride is 30%, set 10 min and 20 min under certain coagulation and stirring conditions. At the end of the time, 30 ml of supernatant was carefully pipetted into the colorimetric tube with a 10 ml pipette, labeled with the corresponding concentration, capped and ready to measure turbidity and algal density, and used to determine the optimal amount of PAC to be added separately.

2.6 NaClO oxidation method for algae removal

The sampling method was the same as above, and a certain concentration gradient of NaClO (effective concentration of 1, 2, 3, 4, 5, 6 mg/L) was added separately to the existing sodium hypochlorite solution with a mass fraction of 8% of the active ingredient, and the contact oxidation time was set to 10 min and 20 min under certain coagulation and mixing conditions. The turbidity and algal density were measured by the same method at the end of timing, and the optimal amount of NaClO was determined by this method.

2.7 NaClO-enhanced PAC coagulation, precipitation, and pre-oxidation for combined algae removal

Based on the above optimal oxidation conditions, the addition of PAC was reduced, and the compound ratio of NaClO and PAC was set for coagulation and precipitation experiments under the same conditions. Under certain stirring conditions, the precipitation was left for 10 min and 20 min, and the supernatant was taken and its turbidity and algal density were measured according to the same operation. Another group of NaClO optimum oxidation concentration of 50 mg/L was set as a reference for comparison.

Table1 Combined experimental dosing concentration compounding ratio

X-axis serial number	Compounding ratio1（NaClO：PAC）	Corresponding effective concentration ratio	Compounding ratio2（NaClO：PAC）	Corresponding effective concentration ratio
1	4:3	40mg/L:30mg/L	5:3	50mg/L:30mg/L
2	4：3.2	40mg/L:32mg/L	5：3.2	50mg/L:32mg/L
3	4：3.4	40mg/L:34mg/L	5：3.4	50mg/L:34mg/L
4	4：3.6	40mg/L:36mg/L	5：3.6	50mg/L:36mg/L
5	4：3.8	40mg/L:38mg/L	5：3.8	50mg/L:38mg/L
6	4：4	40mg/L:40mg/L	5：4	50mg/L:40mg/L

Table2 The mixing conditions designed in the experiment

Speed	PAC experiment	NaClO experiment	Joint Experiment	Corresponding G-value（14℃）	Corresponding GT value（14℃）
Before start	100 r/min operation Dosing after 1min	100 r/min operation Dosing after 1min	100r/min operation Dosing after 1min		
Fast	500 r/min operation Dosing after 2min	80 r/min operation Dosing after 5min, 10min, 20min	Run NaClO stirring first, then run PAC stirring	326.7	19602.0
Medium speed	150 r/min operation Dosing after 3min			64.7	39012.0

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Slow	80 r/min operation Dosing after 5min			27.8	45684.0

3 Results & Discussion

Table3 Raw water quality index

Projects	Turbidity（NTU）	Temperature（℃）	pH	Algae density（ea/L）
Numerical value	13.2～14.4	14~18	6.8~7.2	1.7×106～1.9×106

According to the Reclaimed Water Quality Standard for Landscape Environment Water (GB/T18921-2002), the turbidity of recreational landscape environment water should be ≤ 5 NTU and the pH is between 6.0 and 9.0. The turbidity in the raw water quality index is greater than the prescribed limit The main reason is that the water tested is introduced to the sampling site through artificial means. This means that the water has limited mobility, small capacity and limited opportunities to be purified. Furthermore, trash and other debris such as fish feed is frequently added to the sample site resulting in serious eutrophication and algae multiplication.

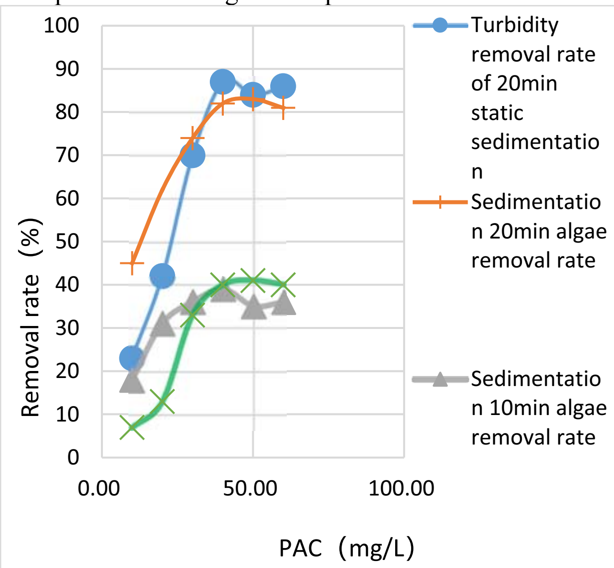

Fig1 Effectiveness of PAC coagulation and sedimentation methods for algae removal

①According to the removal rate of turbidity after 20 min of static sedimentation, it can be suggested that the optimal dosage is around 40 mg/L.

② Adding PAC alone, after 20 min of static sedimentation, the turbidity removal rate reached 87% under the optimal dosage. Referring to the data of 10 min of static sedimentation, it can be concluded that the algae removal rate and turbidity removal rate showed a certain positive correlation, when the turbidity removal rate was 87%, the algae removal rate was 82%, and when the algae removal rate was the highest 83%, the turbidity removal rate was 84%.

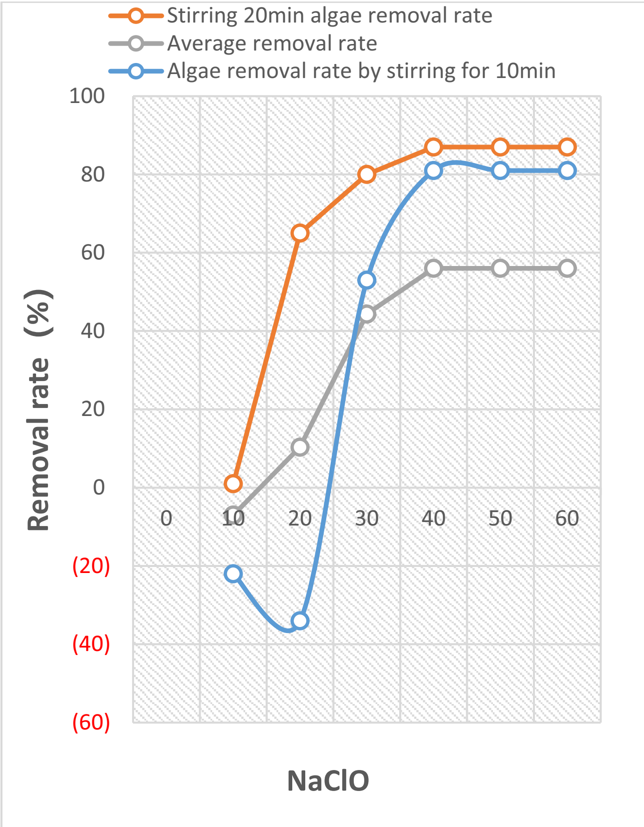

Fig2 Effect of sodium hypochlorite (NaClO) oxidation on algae removal

①With the increase of NaClO concentration, the algae removal rate showed a significant increase. When the contact oxidation time was 20 min and the NaClO dosage was 40 mg/L or more, the algae removal rate did not change much, so the optimal dosage was estimated to be between 40 mg/L and 50 mg/L.

②Under the condition of the same algae removal rate, the longer the time of contact oxidation, the less NaClO dosage is required. When the contact oxidation time was 10min and the NaClO dosage was 40mg/L, the algae removal rate was 81%. When the contact oxidation time was 20 min and the NaClO dosage was 30 mg/L, the algae removal rate was 80%. In the case of contact oxidation time of 10 min, the algae removal rate decreased with the increase of the dosage when the dosage of sodium hypochlorite was below 20 mg/LThe algae removal rate increased with the increase of the dosage when the dosage was above 20 mg/L. After the dosage reached 40mg/L, the removal rate of algae was basically unchanged.

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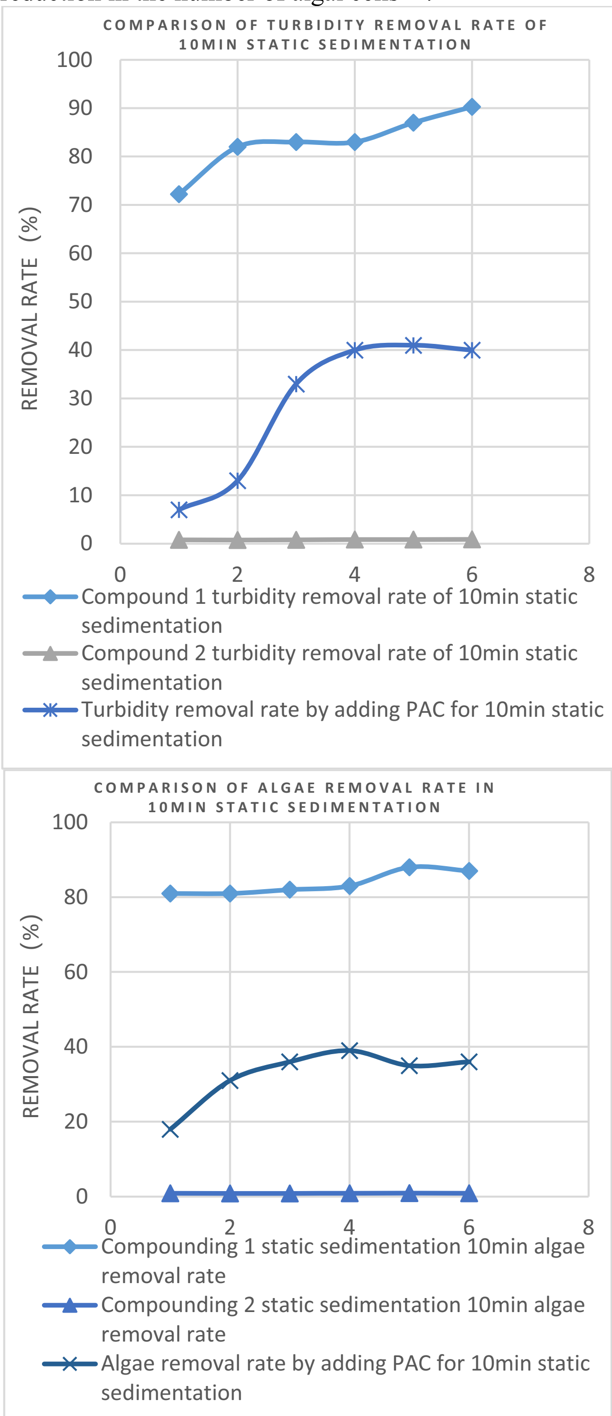
③In measuring the algal density, it was found that the species of algae that could be observed after NaClO injection were significantly reduced The algal cells of larger categories were not obviously green, the activity of the cells was greatly reduced, the cytoplasm of most inactivated algae leaked out, and the cells were dissolved [8].

④ NaClO removes chlorophyll from microalgae, but the reduction in chlorophyll a does not characterize the reduction in the number of algal cells [9].



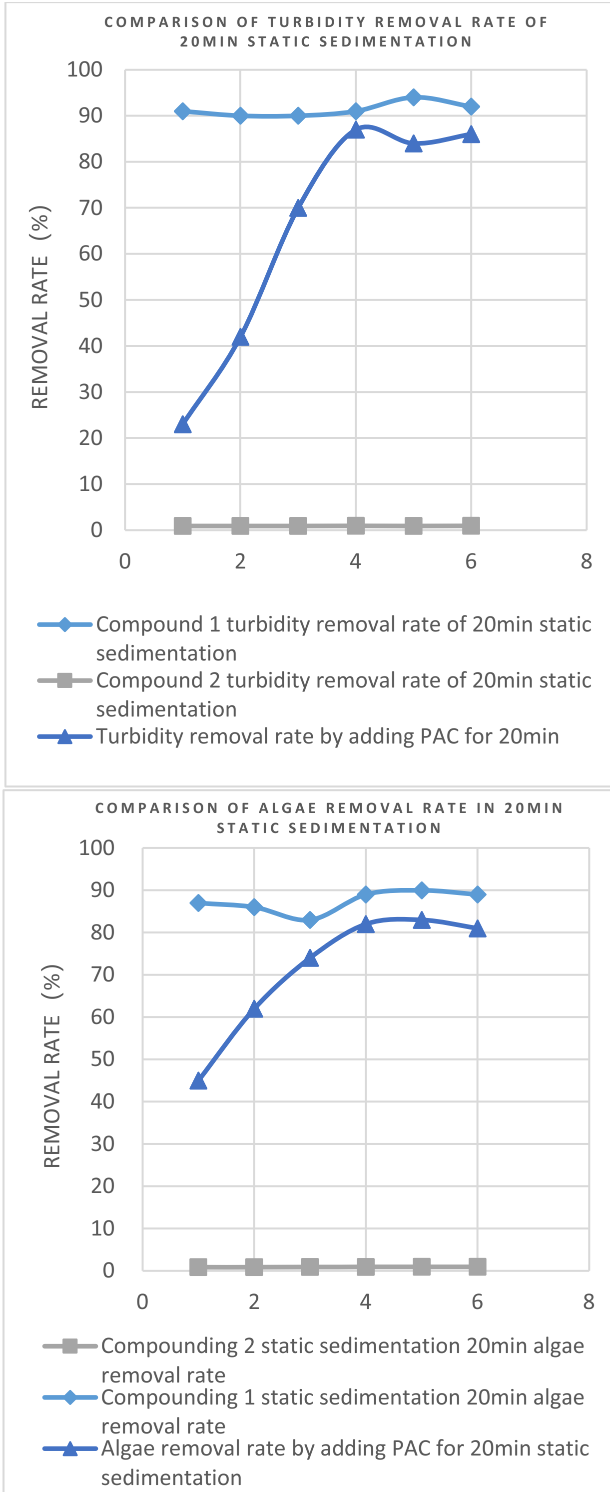


Fig3 NaClO as an enhancement of the combined coagulation, precipitation and pre-oxidation of PAC for algae removal

①The algae removal rate was very similar after 10 min and 20 min of static sedimentation, both reaching about 80%-90%, and with the increase of PAC concentration, the turbidity removal rate increased and the algae removal rate also increased accordingly.

② In the compound 1 group, the peak turbidity removal rate of 94% appeared at the PAC concentration of 38 mg/L after 20 min of static sedimentation, and the removal rate of turbidity in the compound ratio 2 group was 93% at this PAC concentration.

③Based on the removal rate of turbidity, it can be concluded that the optimal dosing point of PAC was shifted. The PAC concentration at 40 mg/L when used alone and 94% turbidity removal rate when used in combination was 38 mg/L in the compound ratio 1 group, and the algae removal rate differed by 3% when the PAC dosage was 36 mg/L in both compound ratio 1 and 2 groups.Therefore under the condition that the treatment effect was not significantly improved when the NaClO concentration was increased by 10 mg/L, it can be suggestedthat 30 mg/L is the best NaClO dosage, and the best PAC dosage is 38 mg/L under this NaClO dosage according to the compound ratio.

④Algae are colloidal substances, which are usually charged, and neutral hypochlorite molecules will adsorb on other charged colloidal particles of algae to destabilize them, so the pre-oxidation effect of NaClO can play a certain role in coagulation while killing algae [10].

4 Conclusions

Previously, N Betzer, Y Argaman et al. proposed a method to treat algae in oxidation pond effluent using ozone-rich oxygen [11]. P Gang, C Jing, et al. proposed a new method to mitigate harmful marine algal blooms using beach sand or silica sand modified with chitosan and polyaluminium chloride (PAC) [12]. these These methods are efficient and convenient to solve the problem of large-scale algae pollution and point to a new research area for water treatment technology. This paper compares the effects of PAC coagulation, precipitation and algae removal, NaClO oxidation and combined algae removal (pre-oxidation and coagulation), and derives the optimal ratio of NaClO to PAC. In the landscape water with turbidity of 13.2~14.4 NTU and algae density of 1.7×106~1.9×106ea/L, the optimal dosage of PAC was 40 mg/L, and the removal rate of turbidity reached 87%, and the removal rate of algae reached 81% when the dosage of NaClO was 40 mg/L and the contact oxidation time was 10 min, the NaClO:PAC was 4.3.8, and the sedimentation was 10 min: 3.8. The removal rate of turbidity reached 87% and 94% after 10 and 20 min of static sedimentation. Therefore, NaClO can greatly improve the removal rate of turbidity and algae during PAC coagulation and sedimentation, and can reduce the amount of PAC added under the premise of equivalence, but the degree of moderate oxidation of NaClO to water bodies with algae should also be considered. To a certain extent, this study provides a new idea for exploring the treatment of landscape water The results are of great significance in their application to water treatment in tourist areas. Water quality maintenance of water bodies in high density tourist areas promotes the tourism industry which thus has a positive impact on the social and economic circumstances in these areas. Moreover, the results of this study can inform strategies for conserving of landscape water quality since water bodies play an important role in overall ecological balance.

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