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Experimental Study on the Removal of Algae and Odor with the Combined Process of Potassium Permanganate and Powdered Activated Carbon

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***Abstract*—The pre-oxidation agent is potassium permanganate ($KMnO_4$) and the adsorbent is powdered activated carbon in this experiment. The raw water is treated by $KMnO_4$ comparing with $KMnO_4$ and powdered activated carbon in order to study the removal of turbidity, algae and odor. When the $KMnO_4$ dosage is 1.2mg/L, the removal rate of turbidity, chlorohyll(a) and odor are 75.3%, 76.2%, 68.2% respectively. When the dosage of $KMnO_4$ and powdered activated carbon are 1.2mg/L and 15mg/L respectively. The removal rate of turbidity, chlorohyll(a), and odor are 90.3%, 92.7%, 91.9% respectively. The experimental results show that the process that $KMnO_4$ combined with powdered activated carbon achieved more effective turbidity removal.**

Keywords-potassium permanganate; powdered activated carbon; algae; odor; coagulation

I. INTRODUCTION

The meaning of water remediation technology[1-2] is to use physical, chemical and Biological method to decrease the concentration of toxic and harmful substance in the water, which leads to repair part, even whole water ecological environment so as to reach the requirement of water function.

Algae can secrete some odor causing substances such as olefine, fatty alcohol, aldehydes and thioether. And the algae sinking into bottle of tank rot easily, which results in fishy smell. Morever, some kinds of algae can create algal toxin[3-4].

Organic pollutant can stick to colloidal solids surface, increasing solids stability, decreasing their collision probability, so algae organic pollutant is going to hinder colloids sedimentation and destabilization. And most water treatment plants usually use general coagulation to dispose raw water containing algae. With simply increasing dosage, the sludge quantity is also increasing, which is disadvantage to remove algae, aggravating filter load, shorten backwash cycle and increasing cost[5].

Aiming these kinds of problems, this experiment compares KMnO4 and KMnO4 combined with powdered activcated carbon in algae water treatment.

II. MATERIAL AND METHODS

A. Quanlity of Raw Water

The raw water takes from Kongmu Lake in East China Jiaotong University. The turbidity is 7.750NTU. The chlorohyll(a) is 167.8mg/m3. Olfact is 285.7 and pH is 7.4.

B. The Methon of Measure Water Index

1) Turbidity: TDT-2 scattered light turbidimeter is used to measure water turbidity.

2) Olfact: After experiment, supernate is acquired and diluted by a certain volume of odorless water, then artificial smelling after heating 30 min under(60±1)°*C*. The olfact is a proportion that odor is stinking when odorless water is diluted to supernate. And the olfact is confirmed by five people, calculating by mean value method.

3) Chlorohyll(a): After experiment, 200mL water sample is obtained and filtered by acetate cellulose membrane whose diameter is 0.45μm, ground by 90% acetone to extract chlorohyll(a). Then it is centrifuged in 15min on 4000r/min. Supernate is aquired to measure the absorbancy in spectrophotometer when the wave lengths are 750nm, 663nm, 645nm and 630nm respectively.

III. RESULTS AND DISCSSIONS

A. Coagulant Selection and Best Dosage

After blending, these 1L water samples are injected severally into six same beaker in six-units stirring apparatus, stirring quickly 0.5min under 320r/min, stirring intermediately 8min under 170r/min with 6 kinds of coagulation condition(15, 20, 25, 30, 35, 40mg/L), and stirring slowly 10 min under 80r/min, standing 30min before taking 2cm supernate to measure.

Coagulation mixing experiments are cunducted to three kinds of coagulants such as aluminium polychlorid, aluminum sulfate and ferric trichloride. Fig. 1, 2 and 3 respectively show the index and removal effect.

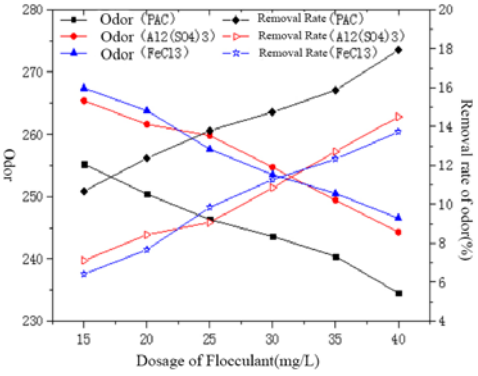


Figure 1. Effect of different coagulants dosage on removal rate of turbidity.

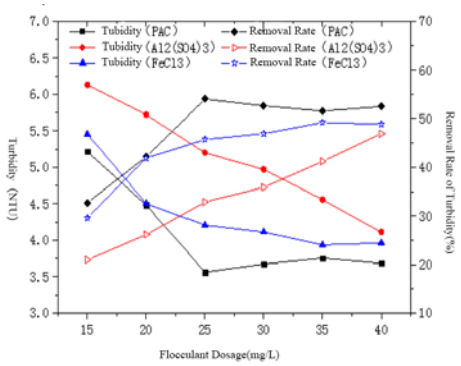


Figure 2. Effect of different flocculant dosage on removal rate of chlorohyll(a)

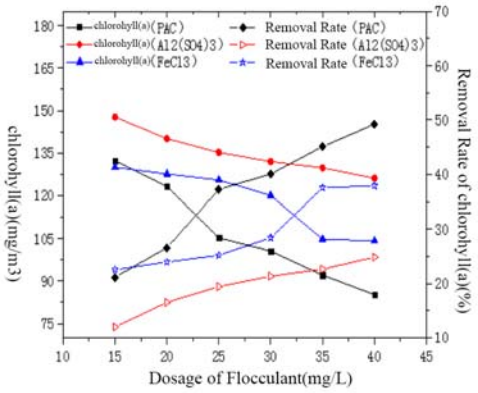


Figure 3. Effect of different flocculant dosage on removal rate of odor

Comparing and analyzing the effect of three kinds of coagulant, it can be known that aluminium polychlorid is better than aluminum sulfate and iron trichloride in turbidity, chlorohyll(a) and odor removal. And the best dosage of these three kinds of coagulants, aluminium polychlorid, aluminum sulfate and iron trichloride, are 25mg/L, 40mg/L and 35mg/L respectively. By this time, the removal of turbidity are 54.0%, 46.9% and 49.2% while removal of chlorohyll(a) are 37.3%, 24.9% and 37.5%, and the removal of odor are 13.8%, 14.5% and 13.7%. Considering the experimental effect and cost, the best coagulant is aluminium polychlorid, and its dosage is 25mg/L.

B. $KMnO_4$ Pre-oxidation Experiment

The 1L water samples are injected severally into six same beaker in six-units stirring apparatus, stirring slowly 15min under 60r/min with 0.8, 1.2, 1.6, 2.0 and 2.4mg/L KMnO4, stirring quickly 0.5min under 320r/min. And then aluminium polychlorid is put into it with intermediate stirring 8min which is 170r/min before slow stirring 10min with 80r/min, standing 30min before taking 2cm supernate to measure. Fig.4 presents the removal effect.

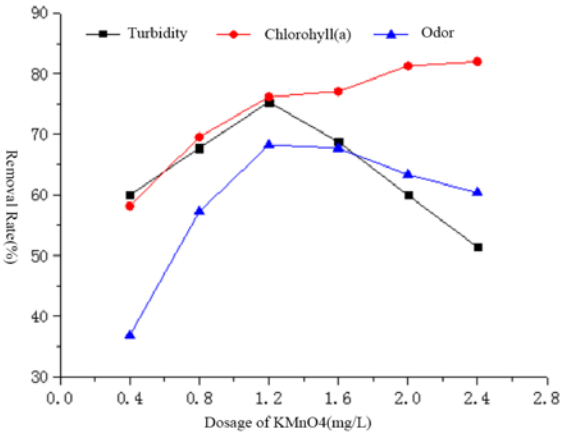


Figure 4. Effect of dosage of potassium permanganate on removal rate of water quality indexes

When the dosage of KMnO4 is increasing from 0.4 to 1.2mg/L, the removal of turbidity is rising. And when its

1.2mg/L, the removal is best by 75.3%, and the turbidity is 1.914NTU. The main reason is that the strong oxidizability of KMnO4 can inactivate algae to promote flocs destabilization, enhancing the diameter and velocity so as to improve algae removal effect. When the dosage is over 1.2mg/L, the turbidity removal is decreasing because the rest of KMnO4 leaves in the water to create chroma and disturb indirectly turbidity measure.

With increasing the dosage of KMnO4, its pre-oxidation can inactivate algae to easily form flocs to settle, so that the algae can be removed[7]. When the dosage of KMnO4 is 1.2mg/L, the removal rate of chlorohyll(a) is 76.2%. Meanwhile, the chlorohyll(a) is 40m/m3. While KMnO4 dosage is over 1.2mg/L, the rate is slightly increasing.

When the dosage of KMnO4 is 1.2mg/L, the removal rate of odor is 68.2%. Its removal mainly rely on strong oxidizability of KMnO4 and the adsorption of the intermediate products in reaction[8]. The range of KMnO4 dosage is from 1.2 to 2.4mg/L, and the exceeding KMnO4 can oxidize the odourless matter to odour matter, oxidizing the macromolecule odour matter to the micromolecule so as to increase olfact[9-10]. Considering various factors, the best KMnO4 dosage is 1.2mg/L.

C. The Experiment of KMnO4 Combined with Powdered Activated Carbon

The 1L water samples are injected severally into six same beaker in six-units stirring apparatus, stirring slowly 15min under 60r/min with 1.3mg/L KMnO4, then stirring quickly 0.5min under 320r/min. The 25mg/L floculant and powdered activated carbon(5, 10, 15, 20, 25 and 30mg/L) are injected, stirring intermediately 8min under 170r/min, and then stirring slowly 10min under 80r/min, standing 30min before taking 2cm supernate to measure.Fig.5 presents the removal effect.

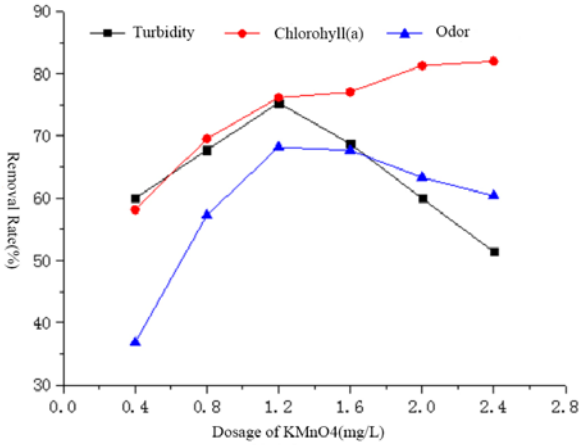


Figure 5. Effect of dosage of powedered activated carbon on removal rate of water quality indexes

With increasing the dosage of powedered activated carbonm, the removal rate is increasing followed by decreasing. The removal rate of chlorohyll(a) and odor rises steeply beteween 5 and 15mg/L. And when the dosage is over 15mg/L, the extent decreases relatively. When the dosage is 15mg/L, the removal rate of turbidity, chlorohyll(a), and odor are 90.3%, 92.7%, 91.9% respectively.

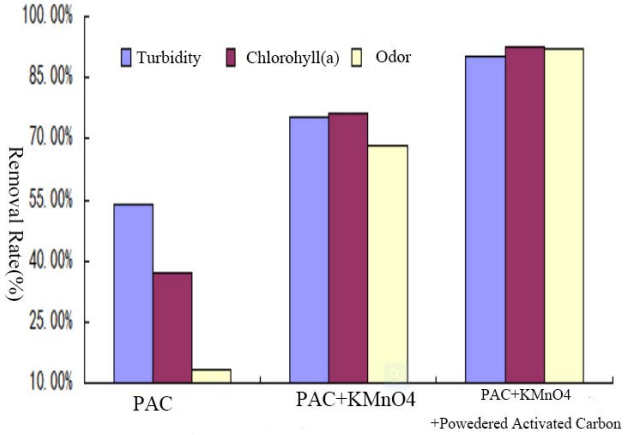
The KMnO4 oxidation technology possesses boundedness, for example, the manganese concentration in outlet is not controlled easily and the turbidity is high. It can adequately bring into play the former oxidability and latter adsorption that combines KMnO4 with powdered activated carbon. KMnO4 can decrease the electronegativity in particle surface and repulsive interaction of double electrode layer so as to destabilize and settle easily.

Meantime, the organic matter is going to oxidize and polymerize in the powedered activated carbon to improve its adsorption. The specific surface area of powedered activated carbon is big, and the pre-oxidation algae lose activity, which is advantage to be absorbed by activated carbon. The powedered activated carbon is a special reducive substance, accelerating to produce KMnO4 oxidative product which is new ecological hydrated manganese dioxide, preventing the overproof of manganese concentration in outlet. And the role of manganese dioxide is oxidation and adsorption[11-12].

Considering all elements, the best dosage of powdered activated carbon is 15mg/L.

D. Experimental Result Comparison

The Fig.6 shows the experimental result comparison of different technology.



PAC, 25mg/L; KMnO4, 1.2mg/L; Powedered Activated Carbon, 15mg/l

Figure 6. Contrast of the Processes Test Results

Comparing the experimental results of different technology, it can be known that KMnO4 combined with powedered activated carbon can better to dispose algae raw water, which can decrease algae content and remove odor to reach water ex-situ remediation.

IV. CONCLUSION

1) Comparing aluminum sulfate and ferric chloride, aluminium polychlorid is more effective in coagulation. But it is poor effect on odor and algae water treatment that coagulant is only injected, which can slightly remove algae, but not effective to odor.

2) Using KMnO4 to pre-oxidate raw water, it can decrease effectively turbidity and algae content, and remove part of odor. When the dosage of KMnO4 is 1.2mg/L, the removal rate of turbidity, chlorohyll(a) and odor are 75.3%, 76.2% and 68.2% respectively.

3) It owns Complementarity and cooperativity that KMnO4 combines with powdered activated carbon to dispose raw water. And when the dosage of KMnO4 and powdered activated carbon are 1.2mg/L and 15mg/L, the removal rate of turbidity, chlorohyll(a) and odor are 90.3%, 92.7% and 91.9% respectively.

4) When the KMnO4 combined with powdered activated carbon, the removal rate of turbidity, chlorohyll(a) and odor are 36.3%, 55.4% and 78.1% more than those with conventional water treatment technology. Meanwhile, it also offers technical support for pollutional lake water ex-situ remediation, repairing water ecological setting, satisfied the requirement of sustainable development.

ACKNOWLEDGMENTS

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