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Pilot Study on Electrochemical Oxidation Treatment for Lightly Polluted Water

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According to the problem of Wenyu River in which C/N was mismatch and biodegradability was poor, a new kind of electro-catalytic oxidation technology was adapted to replace the traditional lightly polluted water quality improvement process and the pilot test was conducted based on the laboratory test. The results showed that the average removal rates of NH_3-N, COD, BOD_5, total nitrogen were 63.53, 55.91, 44.42, 20.67 and 67.47 %, respectively on the condition of electrolytic voltage of 6 V, plate distance of 1 cm, electrolysis time of 10 min, the handling capacity of 2 m^3/h, molar ratio of sodium chloride dosing (NH_4 + -N/Cl^-) was 1:3 and effluent fully meet the process requirements. In addition, after the electrochemical oxidation process, the biodegradability of effluent was increased from 0.35 to 0.51 or so.

Keywords: Electrochemical oxidation, Lightly polluted, Water quality improvement.

INTRODUCTION

Currently, contaminated river water treatment technology has been mainly tested, and was divided into physical, chemical and biological/ecological methods[1-4]. Physical techniques typically require specific equipment, high implementation costs, only for small rivers and urban river landscape of higher value[5]. Advantages of chemical technology are quick and have a significant effect in the short term water purification[6-8]. But it needs adding to the river algaecide, lime and other artificial chemicals, water purification, while easy to aquatic plants, animals and micro-organisms produce toxic effects, bio-security and ecological security is poor. Biological/ecological restoration measures mainly cultivated using plant or culture inoculated microbial life activities for the transfer of contaminants in the river water, transformation and degradation, so that the water to be purified, sustainability is good, keeping strong, low construction cost, low energy consumption, *etc*., are in polluted rivers and more and more emphasis on practical application, but an investigation by the Wenyu River water quality analysis, found that the C/N ratio uncoordinated, poor biodegradability, limiting the biological/ecological technology[9-11]. Electrochemical techniques possessed low operating costs, high efficiency, no secondary pollution, simple equipment, both oxidation, flotation, flocculation, sterilization. The pilot study for the water quality characteristics of Wenyu river using a new type of electro-catalytic oxidation technology was applied to micro-polluted river water purification conducted in-depth research to provide important reference data for engineering applications.

EXPERIMENTAL

Electrolytic system: Oxidation of micro-polluted water and electricity in the pilot plant was shown in Fig. 1. Firstly, by pretreatment of raw water grille, rear electromagnetic scale is pumped through the flowmeter inflow electrolysis device by the second reaction tank after the water into the subsequent processing system, the bottom of the electrolysis device has a mud valve. Reactor was made of stainless steel plate with 60 cm × 60 cm × 150 cm. Meanwhile, anode electrode plate was coated with Ti/RuO_2-IrO_2 and cathode electrode was made of stainless steel.

Influent quality: Wenyu river water was applied to the raw water, vary with the seasons, water quality fluctuations, but the difference was small, the water quality profiles was shown in Table-1.

RESULTS AND DISCUSSION

NH_3-N and total nitrogen removal under different voltage: Tests were used to constant voltage 6, 7 and 8 V, plate spacing is fixed at 1 cm, electrolysis time determined 10 min, processing capacity of 2 m^3/h, the molar ratio of adding sodium chloride (NH_4 + -N/Cl^-) 1:3, specific indicators parameter after electrochemical oxidation effluent is shown in Figs. 2 and 3.

TABLE-1
CHARACTERISTICS OF WASTEWATER SAMPLE USED IN THE EXPERIMENTS

Parameter	Unit	Concentration
pH	–	6.5-8.5
Chemical oxygen demand (COD)	mg L^{-1}	75-81
Biochemical oxygen demand (BOD_5)	mg L^{-1}	12-15
Ammonia nitrogen (NH_3-N)	mg L^{-1}	19-35
Total nitrogen (TN)	mg L^{-1}	21-38

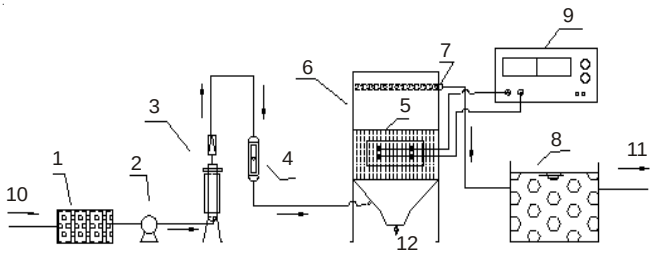

Fig. 1. Experimental procedure; 1 Grille, 2 Pump, 3 Electromagnetic scale, 4 Flowmeter, 5 Plate electrode, 6 Electrolyzer, 7 Outlet, 8 Secondary reactor, 9 Power supply, 10 Influent, 11 Effluent, 12 Mud mouth

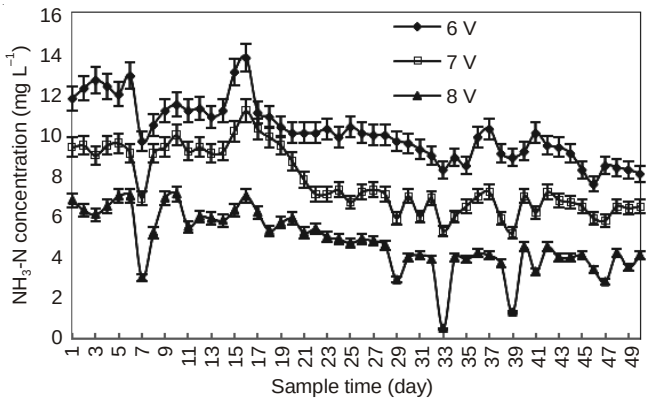

Fig. 2. Ammonia nitrogen concentration change by different voltage in successive testing

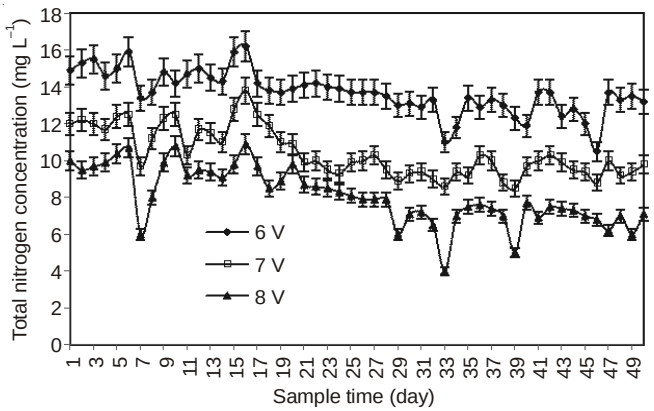

Fig. 3. Total nitrogen concentration change by different voltage in successive testing

As shown in Figs. 2 and 3, with electrolysis voltage increases, the Wenyu river raw water ammonia and total nitrogen removal rate is rising, while the electrolysis voltage of 6 V, the average removal rate reached 63.53 % ammonia, total nitrogen removal rate reached 55.91 %. When running voltage control was of 7 V, ammonia removal efficiency of 72.24 % on average and total nitrogen removal rate reached 66.23 %; when the voltage up to 8 V, the average removal rate reached 83.53 %; total nitrogen removal rate reached 76.82 %. This is because the larger the voltage between the plates, the higher the anode electrode potential, the stronger the oxidation of the anode surface, a strong oxidizing solution of H_2O_2 and $HO^{\bullet}$ Freedom reaction rate in the HRT has generated oxidizing the more active role of the intermediate product. The concentration of pollutants in the effluent from the point of view, the next three voltage effluent total nitrogen concentrations were 9.7, 7.5 and 5.3 mg/L. It can meet the processing requirements, but with the voltage increases, tons treatment also significantly increased energy consumption, therefore, considering two factors to choose the best electrolysis voltage of 6 V.

Organics removal under optimal voltage: According to demonstration project on Wenyu river water ammonia nitrogen, total nitrogen removal, electrolysis voltage control can be learned when the voltage was of 6 V, ammonia nitrogen and total nitrogen removal had been very stable, water quality fully meet the research objectives total nitrogen less than 15 mg/L requirements and lower consumption of tons of water and electricity, so subsequent tests to monitor the removal of chemical oxygen demand and BOD_5 during the electrolysis voltage of 6 V (Fig. 4).

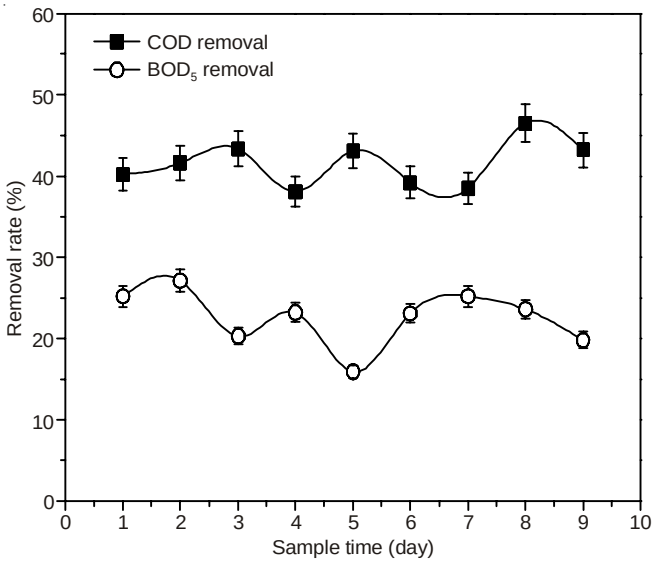

Fig. 4. Organics removal effect under the optimal voltage

As shown in Fig. 4, the electrochemical oxidation effects for chemical oxygen demand and BOD_5 exhibited a good tendency. The results showed the average concentration in the effluent chemical oxygen demand was 34.08 mg/L, chemical oxygen demand average removal rate was 44.42 % and the mean of BOD_5 in raw water was 21.83 mg/L, after the electrochemical oxidation, small changes in the magnitude of BOD_5, the removal rate of only 20.67 %, average effluent concentration of 17.33 mg/L. Meanwhile, BOD_5 removal rate is low, because some chemical oxygen demand oxidation strong oxidizing substances produced by electrolysis of BOD_5 the refractory material. In addition, the biodegradability of raw wastewater changed from 0.35 to 0.51 after treatment by electrochemical oxidation, which was conducive to the subsequent processing system further removal of organic matter.

Conclusion

Electrochemical oxidation technology can be used to improve the micro-polluted river water quality in water ammonia nitrogen total nitrogen, chemical oxygen demand and BOD_5. Under various electrolysis voltage, ammonia nitrogen and total nitrogen removal efficiency comparison, combined treatment effects and tons of water consumption were analyzed to determine the best electrolysis pilot test voltage was 6 V. When the electrolysis voltage was 6 V, plate spacing of 1 cm, electrolysis time of 10 min, processing capacity of 2 m^3/h, adding sodium chloride molar ratio (NH_4 + -N/Cl^-) 1:3, the average removal rate of ammonia 63.53 %. Under optimum operating parameters, chemical oxygen demand removal rate was 44.42 %, BOD_5 removal rate was 20.67 %. In addition, after the electrochemical oxidation treatment, the effluent biodegradability increased from the original 0.35 to about 0.51.

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