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Application Research of Pulse Light Fenton Integrated Echnology in the Treatment of Brewing Yellow Water

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Abstract: Yellow water is the blind ditch water produced in Baijiu fermentation pool, which has the characteristics of high chemical oxygen demand (COD) concentration, poor biodegradability and difficult degradation. The pulse light Fenton integrated sewage treatment scheme designed in this project has a comprehensive COD removal rate of over 98%. After treatment, it can meet the Class A standard of the "Pollutant Discharge Standards for Urban Sewage Treatment Plants" and be directly discharged. Firstly, by pre treating yellow water with pulsed light, the B/C ratio can be increased from 41.8% to 71.3%; After anaerobic and aerobic biochemical treatment, the COD concentration has significantly decreased; Finally, pulsed light Fenton treatment can degrade COD to below 50 mg/L, Amount of ferrous and H_2O_2 is also significantly reduced.

Keywords: Pulsed light Fenton; Brewing Yellow Water; High COD Concentration; Removal Rate

1. Introduction

Yellow water is a brownish yellow, slightly viscous and turbid liquid that leaks from the upper layer to the bottom of the cellar during the solid-state fermentation process of producing strong aroma Daqu liquor. In the solid-state fermentation process of Baijiu, nutrients undergo complex reactions under the action of microbial communities to form various metabolic products. It has the characteristics and difficulties of complex composition, high organic matter concentration (COD can reach 100000-30000 ppm), poor biodegradability, and difficult degradation [1-2]. The main treatment methods still use traditional coagulation, blow off, gas stripping, oxidation-reduction, activated sludge method, and biological contact oxidation method [3-6]. There has been a lack of systematic, effective, and low-cost methods for harmless treatment of yellow water both internationally and domestically.

In the early days, there was no appropriate treatment method and resource utilization means for yellow water and other brewing wastewater. With the continuous innovation of brewing technology, today's yellow water produced in the brewing process is basically used and disposed by resource utilization and disposal means such as cross steaming to extract alcohol from yellow water [7-8]. However, the COD concentration of the pan bottom water produced after cross steaming is still very high [9], and its treatment is still a problem, and the environmental problems caused by the failure to meet the discharge standards of brewing wastewater will still limit the production and development of Baijiu enterprises.

We have designed a pulse light Fenton integrated sewage treatment scheme by studying the characteristics of yellow water, which can fully degrade large molecular organic compounds in yellow water, greatly improve the biodegradability of yellow water, and stably meet the national pollutant discharge standards; At the same time, it is planned to organically combine the above links into integrated equipment, save equipment utilization space, and enhance the mobility and flexibility of sewage treatment equipment.

2. Materials and Methods

2.1 Experimental Materials

The blind ditch water (yellow water) produced at the bottom of the cellar of a Baijiu production enterprise is brown, with a chroma of 2000

times, COD of 9.9 × 10^4 mg/L, BOD5 of 4.12 × 10^4 mg/L, total nitrogen of 4390 mg/L, ammonia nitrogen of 1280 mg/L, and PH of 3.2. It has the characteristics of high organic matter concentration, poor biodegradability, and acidic pH.

2.2 Experimental Testing Methods

The detection methods for various indicators are shown in Table 1

Table 1. List of Testing Methods

Index	Unit	Test method
Chemical Oxygen Demand (COD)	mg/L	HJ828-2017 Dichromate Method
Five day biochemical oxygen demand (BOD)	mg/L	HJ 505-2009Dilution and Inoculation Method
PH	—	HT1147-2020 Electrode method
Ammonia nitrogen	mg/L	HJ 535-2009Nessler's reagent spectrophotometric method
total nitrogen	mg/L	HT 636-2012 Alkaline potassium persulfate digestion UV spectrophotometry
chroma	double	HT1182-2021 Dilution ratio method
Suspended solids	mg/L	GB11901-1989 Weight method

2.3 Experimental Plan and Process Route

The pulse light Fenton integrated solution is divided into three stages (see Figure 1): the first is the preprocessing unit. Pretreatment of yellow water by pulsed light, which excites hydrogen peroxide to generate hydroxyl radical active species to degrade some biologically toxic organic compounds in yellow water, greatly improving the biodegradability of yellow water; The second is the biochemical processing unit. Organic matter in yellow water is converted into gases such as methane and carbon dioxide through an upflow anaerobic sludge bed reactor (UASB), while removing the majority of COD. Then, COD is further removed through aeration in an aerobic tank; The third is the deep processing unit. The remaining COD is deeply oxidized and removed through pulsed light Fenton technology to meet national emission standards.

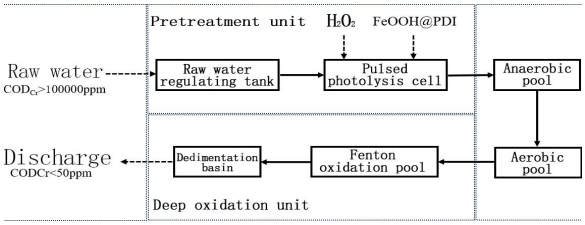

Figure 1. Roadmap for the Treatment Process of Brewing Wastewater

2.4 Experimental Setup

It is mainly composed of multiple reaction tanks, mechanical systems, and control systems. The structural diagram is shown in Figure 2.

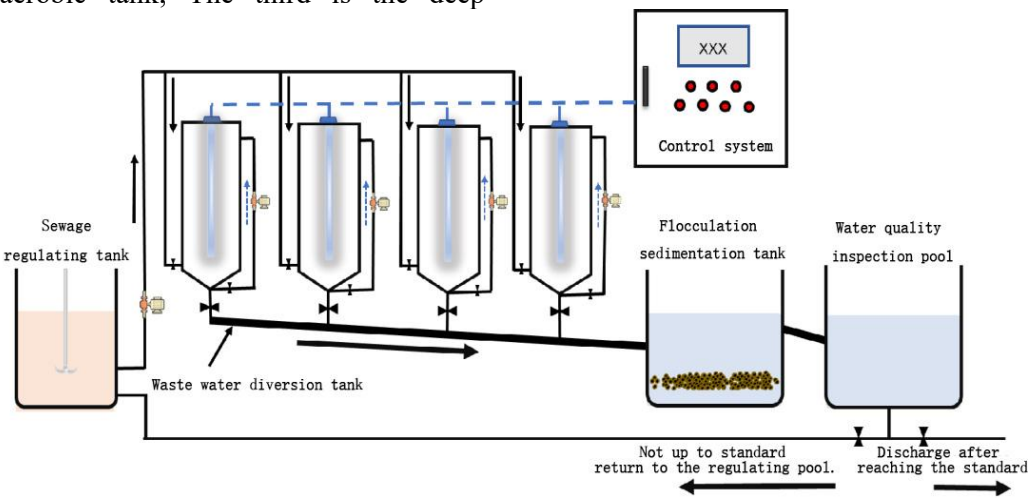

Figure 2. Structure Diagram of Pulse Light Fenton Integrated Device

3. Results and Discussion

Take 1L of yellow water sample and process it through pulse light pretreatment unit, anaerobic+aerobic biochemical treatment unit, and pulse light Fenton deep treatment unit. Measure the pollutant indicators before and after treatment in each unit, calculate the COD removal rate and B/C ratio, and finally evaluate the treatment effect.

3.1 Experimental Measurement and Effect Evaluation of Pulse Light Preprocessing Unit

Pulse strong light technology is a world leading

light source technology that uses instantaneous discharge pulse engineering technology and special inert gas lamps to excite strong white light in the form of pulses, with a spectral distribution similar to sunlight, and a light intensity equivalent to thousands or even tens of thousands of times the intensity of sunlight reaching the Earth's surface [10-11].

Take 1L of yellow water sample and treat it with a pulse lamp for 30 minutes, 60 minutes, and 90 minutes respectively. At the same time, add 50ml of H_2O_2. Measure the changes in COD, BOD5, pH, and chromaticity in the yellow water before and after treatment, and calculate the B/C. Take three parallel samples for synchronous testing and take the average value.

Table 2. Experimental Study of Pulsed Strong Light Technology on Yellow Water Treatment

Testing items	Raw water concentration	30min	60min	90min
CODcr(mg/L)	98500	56900	54100	50600
CODcr removal rate(%)	—	42.2%	45.1%	48.6%
BOD_5(mg/L)	41200	38608	38553	37884
B/C	41.8%	67.8%	71.3%	74.9%
PH	3.2	3.77	3.77	3.77
Chromaticity (degree)	24215	23235	21593	20566
Temperature (℃)	27.8	28.3	29	29.7

As shown in Table 2, for high concentration organic wastewater with COD of about 100000 mg/L and BOD5 of 41200 mg/L, the initial B/C is 41.8%, which is relatively low, indicating poor biodegradability. After 30 minutes of treatment with pulse light, the B/C ratio reached 67.8%. After 60 minutes of treatment, the B/C ratio reached 71.3%. After 90 minutes of treatment, the B/C ratio reached 74.9%. According to relevant information, a B/C ratio of over 70% indicates excellent biodegradability [12]. Organic matter is easily degraded by microorganisms and can be directly subjected to anaerobic and aerobic biological treatment.

3.2 Experimental Determination and Effectiveness Evaluation of Anaerobic+Aerobic Biochemical Treatment Unit

Take 1L of yellow water sample with a biochemical ratio of over 70% after pulse light pretreatment, adjust the pH between 7-8, and enter the anaerobic and aerobic treatment devices. Measure the changes in COD and BOD5 in the yellow water before and after treatment, and calculate the COD removal rate. See Tables 3 and 4 for details.

As shown in Tables 3 and 4, after 12 hours of anaerobic treatment, the COD removal rate of sewage can reach 76%. After 8 hours of aerobic treatment, the COD removal rate can reach 92%, and the comprehensive COD removal rate of the two can reach over 98%.

3.3 Deep Processing Unit-Experimental Measurement and Processing Effect Evaluation of Pulse Light Fenton Collaborative Processing Technology

Pulsed Light Fenton Technology is an advanced oxidation technology that combines pulsed light technology with Fenton reaction. The synergistic reaction of the two can significantly improve the yield of hydroxyl radicals in traditional Fenton reaction, reduce the amount of Fe^{2+} and reaction time, and efficiently degrade recalcitrant organic compounds. The remaining COD is deeply oxidized and removed through pulsed light Fenton technology to meet national emission standards. The experimental results are shown in Table 5.

Table 3. COD Removal Efficiency of Anaerobic Treatment Unit (mg/L)

Testing items	inlet	4h	8h	12h
CODcr(mg/L)	54100	41650	24900	13050
COD removal rate(%)	-	23	54	76

Table 4. COD Removal Efficiency of Aerobic Treatment Unit (mg/L)

Testing items	inlet	4h	8h	**12h**
CODcr(mg/L)	13050	3784.5	1044	—
COD removal rate(%)	-	71	92	—

Table 5. Small Scale Experiment of Deep Treatment of Yellow Water Using Pulsed Light Fenton Technology (mg/L)

Testing items	inlet	10min	20min	30min
CODcr(mg/L)	1044	229.5	100.5	49.5
COD removal rate(%)	—	80.2%	90.4%	95.3%

As shown in Table 5, the average COD of the yellow water after pretreatment and biochemical treatment is 1044 mg/L, with some difficult to degrade large skeleton substances remaining. Experiments show that after 10-30 minutes of treatment with the pulse pulse light Fenton synergistic treatment device, the COD removal rate can reach up to 95.3%, and the final COD

can reach 49.5 mg/L. It shall meet the standard limits for direct discharge of water pollutants for newly-built enterprises (COD<100 mg/L) in Table 2 of the Discharge Standard for Water Pollutants for Fermented Alcohol and Baijiu Industry [13] and the direct discharge standard for Class I A (COD<50 mg/L) in the Discharge Standard for Pollutants from Urban Sewage Treatment Plants [14].

4. Conclusion

The pulse light Fenton integrated technology has shown significant effectiveness in treating high concentration organic wastewater from brewing, with a comprehensive COD removal rate of up to 99%; After processing, it can meet the national pollutant emission standards and be directly discharged; Can quickly improve the biodegradability of yellow water, with an increase rate of 71%; The processing cost is also significantly reduced compared to the ordinary Fenton method.

Acknowledgments

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