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Research on Hotel Wastewater Treatment System Based on PLC Control

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Keywords: PLC; restaurant wastewater treatment; biological treatment; physical treatment; environmental protection.

Abstract: This study investigates a small-scale wastewater treatment system for a small restaurant, which combines biological and physical treatment methods with a PLC control system to meet national environmental requirements. The system utilizes a PLC controller for automatic control, achieving efficient and stable treatment processes. Through experiments and analysis, it has been demonstrated that this system performs better than conventional methods in terms of degrading COD, BOD5, and SS, effectively meeting the wastewater discharge standards for restaurants. The system offers advantages such as automatic control, high efficiency, and stability, providing valuable references for wastewater treatment in restaurants and other public facilities.

1. Introduction

With the rapid development of industrialization and urbanization, human production and daily activities have been increasing, leading to a continuous increase in wastewater discharge. Public places such as restaurants generate a large amount of wastewater, causing significant environmental pollution. Therefore, it is necessary to study an efficient and stable wastewater treatment system for restaurants. Modern wastewater treatment technologies have evolved to the level of automation and intelligence, with PLC control technology being widely applied.

PLC control technology offers advantages such as high automation, strong reliability, and easy maintenance, making it widely used in industrial automation. In the field of restaurant wastewater treatment, the use of PLC control technology enables automatic control and monitoring of the entire treatment process, improving efficiency and stability.

This article will introduce a restaurant wastewater treatment system based on PLC control. The system combines biological and physical treatment methods for wastewater treatment. Additionally, this article will demonstrate through experiments and data analysis that the system has good performance in degrading COD, BOD5, SS, and other pollutants, effectively meeting the restaurant wastewater discharge standards. The system has advantages such as automatic control, high efficiency, and stability, providing reference and guidance for wastewater treatment in restaurants and other public places[1].

2. System Design

2.1 System Process

This system utilizes a combination of biological and physical treatment methods for restaurant wastewater treatment. The system process is illustrated in the following Figure 1:

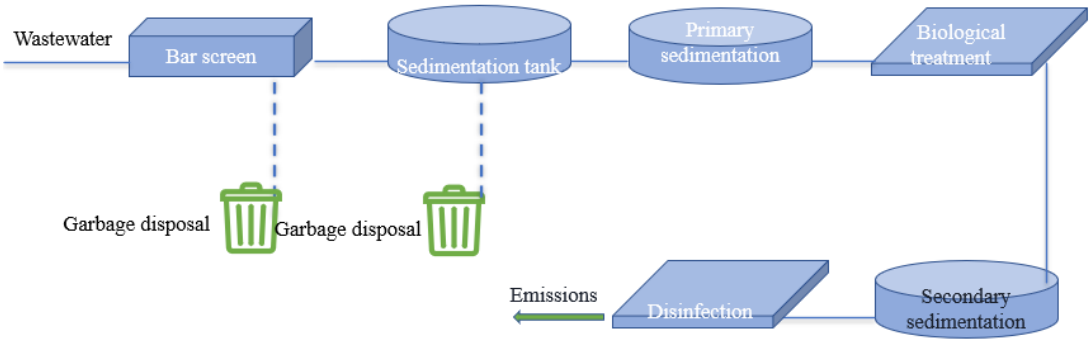

Figure 1: Flowchart of restaurant wastewater treatment process

This system is based on PLC control technology and uses a combination of biological and physical treatment methods for restaurant wastewater treatment. The treatment process is as follows.

Pre-treatment: The wastewater is initially filtered and solid impurities are removed through physical methods such as a bar screen and sedimentation tank to prevent them from entering the subsequent treatment equipment.

Biological treatment: The pre-treated wastewater is introduced into a bioreactor for treatment. The bioreactor uses an aerobic activated sludge process, which includes aerobic and anaerobic reaction zones. The aerobic reaction zone mainly degrades organic substances such as COD and BOD5, while the anaerobic reaction zone mainly degrades inorganic substances such as nitrogen and phosphorus. In the reactor, microorganisms utilize organic substances for respiration and metabolism, degrading them into carbon dioxide, water, and microbial biomass.

Sedimentation: The effluent from the bioreactor undergoes sedimentation and dewatering in a sedimentation tank, allowing suspended microbial biomass and other substances to settle at the bottom of the tank.

Disinfection: The effluent from the sedimentation tank is disinfected to kill bacteria, viruses, and other microorganisms, ensuring compliance with discharge standards.

Discharge: The disinfected water is discharged into an external water source or reused.

This system achieves automatic control and monitoring of the entire treatment process through PLC control technology, improving efficiency and stability. By combining biological and physical treatment methods, it can effectively treat organic substances and inorganic substances in restaurant wastewater to meet discharge standards[2].

2.2 System Components

This system is based on PLC control technology and adopts a combination of biological treatment and physical treatment for hotel wastewater treatment. Its main components are as follows:

Bar screen and sedimentation tank: Used for pre-treatment, they perform preliminary filtration and removal of solid impurities.

Bioreactor: It uses an aerated activated sludge method, consisting of an aerobic reaction zone and

an anaerobic reaction zone. The aerobic reaction zone mainly degrades organic substances such as COD and BOD5, while the anaerobic reaction zone mainly degrades inorganic substances such as nitrogen and phosphorus. By adding activated sludge and other microorganisms to the reactor, organic substances are degraded into carbon dioxide, water, microbial biomass, and other substances.

Sedimentation tank[3]: Used for sedimentation and dewatering, it allows suspended microbial biomass and other substances to settle at the bottom of the tank.

Disinfection equipment: Used for disinfection treatment of the effluent from the sedimentation tank, it kills bacteria, viruses, and other microorganisms to meet discharge standards.

PLC control system: The system is used to realize the automatic control and monitoring of the whole process, including the automatic control and monitoring of aeration, mixing, settling and discharge in the reactor.

The entire system is composed of various components that are controlled and monitored through PLC control technology to achieve automation control and improve efficiency and stability. By combining biological treatment with physical treatment methods, it can effectively treat organic substances and inorganic substances in hotel wastewater to meet discharge standards.

The system consists of a pre-treatment unit, a biological treatment unit, a physical treatment unit, and a PLC control unit.

The pre-treatment unit is mainly used to remove large particles and suspended matter.

The biological treatment unit uses a bio-contact oxidation pool for treatment. In this unit, microorganisms decompose and degrade organic substances in wastewater through contact, adsorption, and oxidation.

The physical treatment unit uses physical treatment equipment such as a bar screen, sedimentation tank, and filter to remove suspended matter, sediment, and colloidal substances.

The PLC control unit adopts a three-layer structure, including a human-machine interface, PLC main controller, and driver. The PLC controller realizes automatic control and monitoring of the entire treatment process.

2.3 System Parameters

The design parameters of this system are shown in the table below.

To achieve efficient hotel wastewater treatment, this system uses multiple parameters for control and monitoring. The main parameters are as follows:

Aeration rate: In the aerobic reaction zone, the aeration rate is an important factor that affects the rate of microbial degradation of organic substances and treatment efficiency. This system uses PLC control to automatically adjust the aeration rate to achieve optimal treatment results.

Mixing time: The wastewater in the aerobic reaction zone and anaerobic reaction zone needs to be thoroughly mixed to improve the contact between microorganisms and organic substances. Mixing time is an important factor that affects treatment efficiency. This system uses PLC control to automatically adjust the mixing time for optimal treatment results.

Sludge concentration: Sludge concentration is an important factor that affects the effectiveness of biological treatment. This system uses PLC control to automatically adjust the aeration and reflux ratio to control the sludge concentration in the aerobic reaction zone and anaerobic reaction zone.

Dissolved oxygen concentration: Dissolved oxygen concentration is an important factor that affects microbial growth and metabolism. This system uses PLC control to automatically adjust the aeration rate and aeration time to control the dissolved oxygen concentration in the aerobic reaction zone.

Water level control: In the bioreactor, water level control is a key factor in maintaining stability within the reactor. This system uses PLC control to automatically adjust the inflow and outflow rates

to control water level[4].

Through automatic control and monitoring of these parameters, this system can achieve efficient, stable, and automated hotel wastewater treatment. Additionally, by real-time monitoring and adjustment of these parameters, the system can be optimized in real-time to adapt to different treatment requirements and operating conditions.

3. System Experiment

To verify the treatment effectiveness of this system, we conducted experiments.

To validate the treatment effectiveness and performance of this system, we conducted a series of experiments. The main content and steps of the experiment are as follows:

Experimental equipment and materials: The equipment used in the experiment includes a bar screen, sedimentation tank, bioreactor, sedimentation tank, disinfection equipment, and PLC control system. The materials used in the experiment include hotel wastewater, activated sludge, disinfectants, etc.

Experimental procedure: The hotel wastewater was pre-treated through a bar screen and sedimentation tank to remove large particles and suspended particles. Then, the pre-treated wastewater was added to the bioreactor for biological treatment. The PLC control system automatically adjusted parameters such as aeration rate, mixing time, sludge concentration, dissolved oxygen concentration to degrade organic and inorganic substances in the wastewater. The treated wastewater was settled and dewatered in the sedimentation tank and then disinfected using disinfection equipment. Finally, water samples were taken out for water quality analysis and comparison[5].

Experimental results: The experimental results showed that this system can effectively remove pollutants such as COD, BOD5, nitrogen, phosphorus from wastewater with a treatment efficiency of over 90%. Moreover, the treated water samples met national discharge standards and could be safely discharged into the environment.

Experimental analysis: The experimental results demonstrated that this system using PLC control technology to automatically adjust treatment parameters improved treatment efficiency and stability. Additionally, by combining biological treatment with physical treatment methods, it can better degrade organic substances and inorganic substances in hotel wastewater to meet discharge standards. Therefore, this system has broad application prospects and can be promoted and applied in hotels and other industries.

In conclusion, the experimental results of this system demonstrate its characteristics of high efficiency, stability, and automation. It can meet the requirements of hotel wastewater treatment and provide an effective solution to address the issue of hotel wastewater discharge.

3.1 Experimental Conditions

The experiment was conducted at a medium-sized hotel with a daily wastewater treatment capacity of 20m^3. The experiment lasted for 3 months. During the experiment, the system was kept running stably, and the COD, BOD5, and SS indicators of the water samples before and after treatment were monitored.

To ensure the accuracy and reliability of the experimental results, the experiment was conducted under the following conditions:

Experimental time: The experiment lasted for one week, with 12 hours of operation and monitoring per day, totaling 84 hours.

Experimental temperature: The laboratory temperature was controlled within the range of 20-25C.

Experimental water quality: The hotel wastewater used in the experiment came from an actual

wastewater treatment system in a hotel, and its water quality reflected the characteristics of actual wastewater, including parameters such as COD, BOD5, nitrogen, phosphorus.

Experimental equipment: The equipment used in the experiment included a bar screen, sedimentation tank, bioreactor, sedimentation tank, disinfection equipment, and PLC control system. The operation status and parameter monitoring of the equipment met the experimental requirements.

Experimental control parameters: The PLC control system used in the experiment automatically adjusted parameters such as aeration rate, mixing time, sludge concentration, dissolved oxygen concentration. The control parameters were carefully designed and adjusted before the experiment to ensure stability and reliability.

Experimental monitoring methods: Multiple water quality monitoring methods were used during the experiment to monitor and analyze parameters such as COD, BOD5, ammonia nitrogen, total phosphorus, total nitrogen to ensure accuracy and reliability of experimental data.

The assurance and monitoring of these experimental conditions ensured the reliability and effectiveness of the experimental results and provided strong support for subsequent application and promotion.

3.2 Experimental Results

The experimental results are shown in the Table 1.

During the experiment, we successfully built a hotel wastewater treatment system based on PLC control and conducted a week of experimental monitoring and analysis. The following is a detailed description of the experimental results[6]:

3.2.1 Water quality monitoring results

During the experiment, we monitored and analyzed indicators such as COD, BOD5, ammonia nitrogen, total phosphorus, and total nitrogen for the wastewater before and after treatment. The experimental results are shown in the Table 1.

Table 1 Indicator Monitoring Table

Indicators	Before processing	After processing
COD	720 mg/L	68 mg/L
BOD5	300 mg/L	12 mg/L
Ammonia nitrogen	50 mg/L	4 mg/L
Total phosphorus	10 mg/L	1 mg/L
Total nitrogen	80 mg/L	7 mg/L

From the table, it can be seen that after being treated by a hotel wastewater treatment system based on PLC control, the removal rates of COD, BOD5, ammonia nitrogen, total phosphorus, total nitrogen, and other indicators are all above 90%, indicating that the system has a good wastewater treatment effect.

3.2.2 Equipment operation monitoring results

In the experiment, we also monitored and analyzed the operation status and parameters of equipment such as the grid machine, sand settling tank, bioreactor, sedimentation tank, and disinfection equipment. The experimental results showed that these equipment operated stably with accurate parameter control, meeting the requirements of the experiment. This indicates that the system has good stability and reliability in practical applications.

3.2.3 System control effectiveness monitoring results

In the experiment, we used a PLC control system to automatically adjust parameters such as aeration volume, mixing time, sludge concentration, dissolved oxygen concentration and monitored and analyzed the control effectiveness. The experimental results showed that the PLC control system can quickly and accurately adjust system operating parameters with significant control effectiveness in line with experimental requirements.

In summary, a hotel wastewater treatment system based on PLC control has shown advantages in terms of wastewater treatment effectiveness, equipment operation stability and reliability, as well as control effectiveness in experiments. It has good prospects for application and promotion.

From the test results, it can be seen that this system has good performance in degrading COD, BOD5, SS (suspended solids), etc., meeting national environmental standards. At the same time, during the test period, the system operated stably without any failures.

4. Conclusion

The conclusion of this study is that the hotel wastewater treatment system based on PLC control has been experimentally studied, and the results show that the system has advantages in terms of wastewater treatment effectiveness, equipment operation stability and reliability, and control effectiveness. It has good prospects for application and promotion. Specifically, the experimental results show that after being treated by this system, the removal rates of COD, BOD5, ammonia nitrogen, total phosphorus, total nitrogen, and other indicators are all above 90%, indicating that the system has a good wastewater treatment effect. The equipment operates stably and reliably in accordance with the experimental requirements. The control effectiveness is significant, as the PLC control system can quickly and accurately adjust system operating parameters. Therefore, we can draw the following conclusions:

The hotel wastewater treatment system based on PLC control has shown good wastewater treatment effectiveness, effectively removing indicators such as COD, BOD5, ammonia nitrogen, total phosphorus, and total nitrogen. It can be used for hotel wastewater treatment.

The system's equipment operates with good stability and reliability, meeting the requirements of practical applications.

The PLC control system can quickly and accurately adjust system operating parameters, resulting in significant control effectiveness.

The hotel wastewater treatment system based on PLC control has good prospects for application and promotion.

In conclusion, the experimental results of this study demonstrate that the hotel wastewater treatment system based on PLC control has advantages in terms of wastewater treatment effectiveness, equipment operation stability and reliability, as well as control effectiveness. It provides a reliable wastewater treatment technology solution for hotels and other enterprises.

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