Municipal Landfill Leachate Real-time Processing Measurement and Control Method

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Abstract. Landfill leachate is one of the main sources of stench in refuse transfer stations, and it is also one of the main pollution sources in municipal waste water pipe network. This paper designs an automatic treatment and process control system for landfill leachate based on plasma to realize real-time monitoring and automatic control of multiple parameters in the process of landfill leachate treatment. The whole system is divided into two parts: on-site control and remote control. remote control: single-chip microcomputer collects signals of each sensor, communicates with wifi module through serial port, and PC logs into internet of things cloud platform to realize real-time monitoring. The single-chip microcomputer remotely controls the external execution module through the wifi module. Field control: taking the data detected by turbidity and dissolved oxygen sensors as input of fuzzy control, establishing a correct fuzzy rule base and obtaining a fuzzy output set; IO port communication is carried out between PLC and single-chip microcomputer to read the result of fuzzy control operation of single-chip microcomputer and intelligently control the external executing mechanism. Finally realize the function of man-machine interaction.

Introduction
Landfill leachate is one of the main sources of stench in refuse transfer stations, and is also a major pollution source of municipal waste water pipe network. How to solve the problem of landfill leachate, especially the design of the measurement and control system is an important part. Yu [1,2] focused on the study of sequencing batch activated sludge process. The sequencing batch activated sludge measurement and control system designed by Yu is equipped with multiple Oxidation-Reduction Potential, a ph meter, and a dissolved oxygen detector. The system can monitor and query the Oxidation-Reduction Potential, ph value of aeration tank, and dissolved oxygen concentration in organic waste water in real time. Referring to the existing plasma landfill leachate treatment technology, this paper studies and designs a treatment device based on plasma ozone technology to treat landfill leachate together with ultrasonic wave and aeration tank. Through the decomposition of landfill leachate by plasma plus ultrasonic waste liquid spraying reaction tank, the treated landfill leachate can reach the standard for discharge.

Processing Device Structure
The design application is generally transferred in the waste transfer station. The existence of the waste transfer station is a centralized place to dispose of the scattered waste, and its application largely solves the problem of waste disposal. The Waste transfer station not only needs to deal with solid waste, but also treats the leachate generated by the accumulation of waste transfer station. As shown in Figure 1, it is the waste transfer station.

The system for treating landfill leachate is shown in Figure 2. The landfill leachate treatment device is a waste liquid sealing chamber, a waste liquid circulation filter tank, a plasma plus ultrasonic waste liquid spray reaction tank, a circulating pump and a air pump, and active particle aeration. The active particle explosion gas reaction pool and the waste liquid circulation filter tank are installed inside the waste liquid sealing chamber, and the air pump and the circulating pump are installed outside the waste liquid sealing chamber. The plasma generator in the plasma plus
ultrasonic waste liquid spray reaction tank is installed above the waste liquid spray chamber, and the air pump suction chamber and the waste liquid spray head are respectively installed at the inlet of the air pump and the outlet of the circulating pump, and the piezoelectric ultrasonic transducer is located below the waste spray chamber.

Figure 1. Waste transfer station.  Figure 2. Landfill leachate treatment device.

The plasma plus ultrasonic waste liquid spray reaction tank and the active particle explosion gas reaction tank are connected to both ends of the air pump, and the two are connected to each other by a air pump, and the air pump draws the gas in the spray reaction tank into the aeration tank. The air outlet and the air outlet check valve are disposed on the other side of the sealed casing with an activated carbon filter mesh. The plasma plus ultrasonic waste liquid spray reaction tank is composed of a piezoelectric ultrasonic transducer, a plasma generator, a waste liquid shower head, a waste liquid spray chamber, and an air pump suction chamber.

Waste Leachate Measurement and Control System

As shown in Figure 3, it is the framework diagram of the landfill leachate system. The system consists of PLC, PIC microcontroller module, WIFI module, sensor module, plasma module, ultrasonic module, circulating pump, air pump, IoT server and PC for remote monitoring.

Figure 3. Landfill leachate system framework.

The overall structure of the system is divided into two parts: on-site control and remote measurement and control. Remote measurement and control part: the landfill leachate terminal uses PIC16F1939 single-chip microcomputer as the core processor, the main function of the single-chip microcomputer: real-time acquisition of the sensor to detect the dissolved oxygen content and turbidity content of the sewage, through the serial communication with the ESP8266 WIFI module via the router The data is uploaded to the IoT server in real time; the MCU periodically polls the status value on the server through the ESP8266 WIFI module, and remotely controls the external execution module according to the obtained value. Field control part: GS dissolved oxygen sensor and GE turbidity sensor data of the real-time acquisition device of the single-chip microcomputer, the fuzzy data control algorithm is carried out, and the simple I/O port communication is performed with the S7-200CN PLC. Level signal, reasonable control of plasma, air pump, ultrasonic high and low gear work; field workers select water quality samples at the sampling port of the device, according to the experimental results.
Fuzzy Control

The more detailed and dynamic information of the system, the higher the precision of the control. However, in the multivariable complex control system, the characteristics of the controlled object are difficult to describe by the general materialization rules, and there is no suitable testing method, which makes it impossible to establish a suitable mathematical model [3]. For complex and variable control systems, it is difficult to obtain satisfactory control effects using traditional control theory.

Fuzzy Control Principle

Fuzzy control [4] is a kind of control method based on fuzzy set theory, fuzzy language and fuzzy logic. It uses human knowledge and experience to control a controlled object. It is usually represented by "if". The condition, the "then represents the result" is expressed in the form, so it is also known as language control. The fuzzy controller is similar to the human brain, fuzzing the input, formulating fuzzy rules, making fuzzy decisions, and finally accurately controlling the actuator [5]. Its principle block diagram is shown in Figure 4:

![Figure 4. The block diagram of fuzzy controller.](image)

Landfill Leachate Fuzzy Control System

The landfill leachate designed in this project uses the dissolved oxygen and turbidity as variables to construct the landfill leachate fuzzy control system. The schematic diagram of the fuzzy control system is shown in figure 5. Where D1 and Z1 are the data detected by the DO sensor and the turbidity sensor, respectively, Ed and Ez represent the deviations of D1 and Z1 from the given standard value, respectively, and ECd and ECz represent the rate of change of the deviation of D1 and Z1, respectively. This topic selects the two-dimensional fuzzy controller to deal with the landfill leachate system. The two-dimensional fuzzy controller has two input variables: deviation E and deviation change rate Ec, where Ec=dE/dt. The deviation E and the deviation change rate Ec can effectively reflect the dynamic characteristics of the output variable, which is superior to the control effect of the one-dimensional fuzzy controller.

![Figure 5. Schematic diagram of fuzzy controller for landfill leachate system.](image)

Fuzzy Controller Implementation

After the system is running stably, the deviation E and the deviation change rate EC are obtained according to the data of the turbidity and dissolved oxygen sensor read by the single-chip microcomputer, and the deviation degree EC is quantified. The membership degree function table is obtained by querying the corresponding membership degree value, and then according to the fuzzy. The control rule finds the output [6]. According to the maximum membership degree method, the external actuator is adjusted with the maximum output value as the output control amount. Finally, according to the high, medium and low output control quantity, the combination of the high and low speeds of the three actuators is calibrated. The corresponding program flow is shown in Figure 6.
Software System

Compared with wireless technologies such as Bluetooth and ZigBee, the advantages of WIFI are more obvious, and the transmission distance is longer and the transmission rate is larger. Usually WIFI coverage distance can reach 100 meters, and some scientific laboratories can even increase the coverage distance to several kilometers.

Programming Implementation

The design is mainly divided into two aspects: field control and remote measurement and control. Remote measurement and control: The landfill leachate terminal uses the PIC16F1939 microcontroller as the processor. The main function of the single-chip microcomputer: collecting the dissolved oxygen content and turbidity content of the sewage detected by the sensor, and transmitting the data to the music network server through the router through the serial port communication with the WIFI module [7]; the single-chip microcomputer periodically polls the server through the WIFI module. The state value of the Boolean sensor controls the execution module according to the obtained value, as shown in Figure 7, which is the main program flow chart.

On-site control: The single-chip computer detects the sensor data for fuzzy control algorithm, and performs simple I/O port communication with PLC. PLC recognizes the high and low level signals sent by the single-chip microcomputer, and controls the plasma, air pump and ultrasonic high and low gears. PLC control panel shown in Figure 8. The water sample is taken at the sampling port of the device, and the plasma, air pump and ultrasonic high and low gears are controlled according to the experimental results and expert experience.

WIFI Implementation

This design selects ESP8266 wireless RF module as WIFI module. When programming, the RXD, TXD and GND of USB to TTL module are respectively connected with TXD, RXD and GND of ESP8266. The pin of GPIO0 of ESP8266 must be connected to the negative pole. After the program wants to power down and re-run, this pin must be pulled high or left floating. The CH-PD pin on the WIFI module needs to be connected to a 20K pull-up resistor at any time. It is important to note
that when programming, the ESP8266 is particularly harsh on the power supply voltage of the power module. It cannot be powered by USB to TTL 3.3V or 5V. This mode is unstable. This design uses two dry batteries to supply power. In this paper, the Arduino programming software is used to program the ESP8266. As shown in Figure 9, the Arduino software is used to program the WIFI module.

![Figure 9. ESP8266 Hardware connection diagram.](image)

**Conclusion**

A system device based on plasma synergistic ultrasonic wave and aeration tank for treating landfill leachate is designed, which has the following advantages:

- Remote monitoring and control monitoring. The user can remotely monitor and control the internal sewage treatment of the landfill leachate unit through the computer.

  The performance is stable and simple. The combination of single chip microcomputer and PLC is applied to the measurement and control system. The fuzzy controller realizes the intelligent adjustment of sewage treatment by landfill leachate.

**References**


