Research on the Method of Improving Water Quality in Closed Water by Photocatalysis

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Abstract. At present, eutrophication of closed water bodies is a global problem of water environment pollution. About 80% of closed water bodies in China have eutrophication problems. Existing treatment methods have high cost and secondary pollution problems. Therefore, the use of photocatalytic technology to treat inorganic nitrogen, organic pollutants and algae in the surface of closed water bodies can better avoid the eutrophication of water bodies. Occurs to achieve the purpose of maintaining the water environment.

1. Introduction
At present, the research on eutrophication of closed water bodies is a global problem of water environment pollution. China's closed waters are widely distributed because of its small water area and easy pollution. The water body has low self-purification capacity and high eutrophication [1]. Eutrophication is a manifestation of organic pollution in water that accelerates the aging process of water. According to statistics, about 80% of closed water bodies in China have eutrophication problems.

The existing treatment methods mainly include biological treatment [2], chemical treatment and mechanical treatment. The biological treatment process has a long processing cycle and a large difficulty factor, which may also cause biological invasion. The chemical treatment method is costly and easily causes secondary pollution. The mechanical treatment method has high energy consumption, and it is easy to bring the sediment with more serious underwater pollution to the water during the process of extracting water, causing secondary pollution.

Based on the above problems, we have designed a method based on the principle of photocatalysis to improve the water quality of closed waters, and designed a device to operate with this method. The device uses the wind energy and the electric energy to cooperate with the driving device to extract the surface water layer, and purifies the water by the photocatalysis principle, thereby achieving the purpose of improving the water quality. Compared with the traditional method of dealing with eutrophication of water bodies, the device can efficiently treat organic and inorganic pollutants, achieve energy self-sufficiency, has the advantages of no pollution, reusable, etc., greatly reducing the cost of consumption, and has good energy saving and emission reduction. Benefits and social benefits.
2. Method design

2.1. Principle of the method
The method mainly relies on the principle of photocatalysis as a technology, and uses a photocatalyst as a medium. The photocatalyst processing principle [3] is as follows. When the semiconductor is irradiated with light, the excited electrons transition from the semiconductor valence band to the conduction band, at which time the conduction band obtains photogenerated electrons, and the valence band leaves photogenerated holes, thereby generating a current carrying current inside the semiconductor. Child. These carriers can migrate to the surface of the semiconductor to oxidize or reduce the species adsorbed on the surface. The water or oxygen in the air is catalyzed into an active group with strong oxidizing ability, which can decompose organic compounds and some inorganic substances and destroy the cell structure of the microorganisms. At the same time, doping different photocatalyst materials with different kinds of metal ions leads to different results. After comparison experiments, we selected γ-Fe2O3 as the carrier of photocatalyst coating [4], which can double the surface area of TiO2 photocatalyst and improve the photocatalytic utilization of light.

2.2. Device design

2.2.1. Water intake section
(1) Drive module
The drive module is mainly divided into two parts, the wind drive and the motor drive. The two drive modes cooperate with each other to achieve self-sufficiency in energy required for the device to operate.

Wind driven: The vertical axis fan is compared with the horizontal axis fan. The biggest difference is that the main axis direction is perpendicular to the incoming flow direction. This structural difference brings more advantages to the vertical axis wind turbine. Mainly reflected in the following aspects: good wind performance, no yaw system; blade support structure is more reasonable, easy installation and maintenance; low noise; small impact of alternating stress.

The wind driven module [5] has a spiral fan blade inside the upper end blade and a vertical fan blade on the outside, which can receive wind in all directions to ensure the maximum utilization of wind energy. The lower end is connected to the main shaft of the plunger pump through a bevel gear by a vertical connecting rod. The wind power drives the connecting rod to rotate, and the main shaft of the plunger pump is rotated by the bevel gear, and the sewage on the water surface is pumped to the processing module for processing.

Motor drive: In order to ensure that the whole device can work at any time, the drive module also contains motor drive, which is used to compensate for the defects that the wind drive cannot drive the device when there is no wind.

(2) Plunger pump module
The spindle rotates to drive the chassis with uneven thickness, and the chassis pushes the plunger to move back and forth. When the plunger moves backward [6], the plunger tube is internally vacuumed and the water is drawn in. After that, the plunger pump rotates with the main shaft, rotates to the other side and is pushed forward by the chassis to discharge the moisture inside the plunger tube to achieve the purpose of pumping and discharging the surface water. The extracted sewage is confined in the photocatalyst treatment module through a transparent baffle.

The plunger pump consists of a swash plate, a plunger and a cylinder. The swash plate and the return disk cause the rotating plunger to periodically extend and retract in the plunger chamber of the cylinder. The plunger and the plunger chamber and the volume of the closed working volume of the distribution plate is changed to complete the water absorption process.
3. Adjustment module

In order to control the working state of the plunger pump, it can be switched from the wind drive to the motor drive, or when it is necessary to deal with the waste residue, the adjustment module is set on the main shaft of the motor.

A small electric push rod is arranged as a telescopic shaft in the main shaft portion of the motor, and the telescopic shaft is connected with the bevel gear of the wind drive module. The control system controls the retracting state of the telescopic shaft so that the telescopic shaft can be in three different working positions.

When the telescopic shaft is in the longest position, it meshes with the bevel gear of the wind driven device, and the whole system is in the wind driven working state; when the control system controls the telescopic shaft to contract to the second working state, the bevel gear and the motor on the telescopic shaft Part of the bevel gear contacts, at this time the plunger pump works by the motor; when the telescopic shaft is fully retracted, the contact between the bevel gear on the telescopic shaft and the other two bevel gears is cut off, and the plunger pump is interrupted. In this way, the purpose of adjusting the working state of the whole set of devices is achieved.

2.2.2. Processing section. A composite photocatalyst coating [5] with a γ-Fe₂O₃ carrier is coated on the bottom plate of the floating device as a photocatalyst treatment module. The residue collection module collects the waste residue remaining on the substrate after the treatment.

The residue collection module is shown in Fig. 1. After the inorganic nitrogen and most of the organic pollutants in the water body are treated by the photocatalyst in the processing stage of one cycle, the partially treated waste residue is retained on the bottom plate of the floating device. On the circular bottom plate, there is a concave fan-shaped movable plate. After the end of the 1 hour period, the movable plate and the squeegee rotate around the central axis, and the opening is opened. The residue on the surface of the movable plate is pushed directly into the collecting module by the opening higher than the part of the movable plate, and the waste residue of other parts is a squeegee that is rotatable about the central axis pushes the residue into the collection device.

The cyanobacteria and green algae in the algae treated by the device have a high protein content, and the polysaccharides, proteins and fats present in the treated algae can be used for processing fine feed or high-quality fertilizer. These residues can be recycled manually and sent to the factory for subsequent processing.

![Fig. 1 Residue collection module](image)

2.2.3. Control section

(1) Control of the water intake part

Energy supply control: Due to the instability of wind energy, work requirements cannot be achieved without wind. At this time, the operation of the water intake part depends on the motor, and the power supply mode is switched by the adjustment module to switch the power supply mode from the wind turbine energy supply to the motor power supply. The surface water is taken up to a certain amount. When the photocatalyst module fails to completely treat the part of the sewage, the power supply is
interrupted by the regulating module, that is, the water is interrupted, and the water needs to be reconnected when the water is taken.

![Energy mode control](image)

**Fig. 2 Energy mode control**

Control of water quantity: Two pressure sensors are arranged at the vertical height of the baffle, the pressure sensor 1 is at the bottom of the baffle, the pressure sensor 2 is at a height of 30 cm, and the bottom disc is 2 m in diameter. When the pressure sensor 1 is under water pressure, the adjustment module is controlled by signal conversion, and the adjustment module control starts to supply energy. When there is water pressure at the pressure sensor 2, the adjustment module is controlled by signal conversion, and the adjustment module controls the terminal to supply energy. After the extraction of 942L of water, the pumping is stopped, and the water is discharged to restart the pumping.

![Water volume mode control](image)

**Fig. 3 Water volume mode control**

(2) Control of the processing part

The processing module processes the sewage for 1 hour, and controls the drain switch through the timer to open once every 1 hour. When there is no pressure at the pressure sensor 1, the drain port is closed.

(3) Control of working mode

Since there is no light at night, the photocatalyst can't work, but the rest can work. Therefore, the working mode is different between day and night. The day and night mode of operation is automatically switched using a circuit control device containing a photoresistor.

In the evening, the energy supply mode of the water intake module is only for wind power supply, the drain switch is normally open, and the timer only controls the rotation of the scraper and the movable plate. The wind pushes the plunger pump to pump water into the baffle. Since the drain port is normally open, the water is directly discharged, the algae is left in the baffle, and the algae is collected into the collecting box through the rotation of the movable plate and the scraper to reach Low energy consumption in the evening to collect algae. Daytime is the normal working mode.

![Night work mode](image)

**Fig. 4 working mode control**
3. The process
The device can be placed directly on the closed water surface for work. This work relies on the vertical axis wind wheel and battery motor as the drive module of the device to drive the plunger pump. The adjustment module controls the operating state of the drive module. The plunger pump module extracts the sewage on the surface of the water body into the photocatalyst treatment module. The photocatalyst treatment module utilizes the catalysis of TiO2 to carry out a photocatalytic reaction to treat inorganic nitrogen and most organic pollutants in water quality. Eventually, the residue of algae and other substances will be collected and collected in the waste residue collection box for treatment.

4. Conclusion
There is always no suitable solution for the treatment of water pollution in small enclosed waters. The device uses photocatalyst to treat inorganic pollutants and organic pollutants, and is environmentally friendly. At the same time, the algae floating on the surface of the water is inactivated and collected, and can be applied to the production of fertilizer. The water quality improvement efficiency of the device was calculated to be 86.4% (0.9m3/h). Taking the water body of Heikeba in Hefei as an example, the treatment area is 500m2 and the depth is 1m. At the same time, 5 sets of the device are used, and the standard can be reached in 46 days.

Compared with the biological treatment method, the device has the advantages of simple operation, short treatment period and avoiding biological invasion; compared with the chemical treatment method, the device can be recycled and more environmentally friendly; compared with the mechanical treatment method, the energy required for the device is greatly reduced. Need to provide additional water, saving a lot of manpower and resources.

The device can be applied to the landscape water body of the community, maintains the beauty of the landscape water body, reduces the workload of the community property, and has certain social benefits. Since most of the landscape water bodies are connected to groundwater, it can avoid the pollution of urban groundwater by treating the pollution of landscape water bodies. It can also be applied to freshwater fish ponds to reduce the cost of handling eutrophication of fish ponds and ensure the quality of fish ponds and fish ponds. The device can be improved to prevent water pollution in large waters.

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