An Intelligent Embedded System for detecting and analyzing pollution in water samples.

Background of the invention:

In recent years, environmental pollution caused by microplastics has become a growing concern due to its negative effects on aquatic ecosystems, marine life, and ultimately on human health[1]. Microplastics are small plastic particles less than 5 millimeters in size[2] that accumulate in aquatic environments, such as oceans, rivers, and lakes, leading to water pollution and directly affecting organisms that depend on these waters.

Microplastics enter the marine food chain when ingested by marine organisms, endangering the entire ecosystem and increasing the likelihood of humans being exposed to pollution through the consumption of contaminated seafood. This challenge has prompted many scientists and inventors to search for innovative solutions to address this growing problem. Research indicates that water pollution is responsible for 50% of child deaths and 80% of common diseases in humans[3].

In addition, this pollution contributes to the elimination of organisms that depend on aquatic environments, which are an essential part of the human food chain, thus disrupting the ecological balance. It is known that half of the oxygen we need is produced by algae and aquatic plants [4].

Microplastics are created by the breakdown of larger plastics due to chemical decomposition, exposure to sunlight, and ocean waves [5]. Scientists estimate that there are at least 170 trillion plastic particles in the oceans, with a total weight of nearly two million tons [6].

In 2022, researchers from the Hull York Medical School in the UK discovered 39 microplastics in 11 out of 13 samples of live human lungs, proving that these particles can reach places previously considered inaccessible due to the narrowness of the airways [7]. This discovery comes after a similar discovery of plastic particles in human blood for the first time, indicating the widespread presence of these materials in the human body and the possibility that they contain carcinogens that affect human health [8].

As the health and environmental threats resulting from the spread and accumulation of microplastics in aquatic ecosystems increase, finding innovative solutions becomes essential. This invention contributes to the detection and treatment of microplastic particles, which improves water quality, protects the environment, and enhances public health by reducing pollution and its harmful effects.

General description of the invention:

1- The study focuses on the removal of microplastics on the aggregation and stabilization technique using organosilanes. This method is based on two stages:

Agglomeration stage: where organosilanes bind to the surface of microplastic particles, and aggregate them into large blocks.

Fixation stage: where these particles are fixed in a hybrid silica gel, which is formed as a result of a chemical reaction catalyzed by water, and includes the formation of siloxane bonds.

Despite the high efficiency of some types, the removal of highly polar polymers such as PVC is less efficient. During the stabilization process, remnants of organosilanes may remain in the water, which represents an environmental problem. These techniques may be expensive when applied on an industrial scale and require improvements to reduce the deposited residues. [9]

The MIDT system is based on metal-organic frameworks (MOFs), which are efficient and environmentally friendly compared to the chemicals used in the assembly and stabilization method, which may leave harmful residues. The system is also solar-powered, making it sustainable and easy to operate in multiple locations, while the assembly and stabilization method requires more complex infrastructure and higher energy consumption.

2- Natural coagulation process has been used to remove microplastics from wastewater treatment plants. This method involves adding natural coagulants to water to collect small particles such as microplastics into larger flocs that can be easily separated using solid-liquid separation techniques.

Coagulation is a simple and cost-effective technology used in water treatment plants. Although coagulation can be effective for larger particles, very fine particles may remain poorly confined. Improvements are needed to increase its effectiveness in dealing with all types of microplastics. [10]

The MIDT device not only treats microplastics, but also allows monitoring of water quality by measuring parameters such as temperature, turbidity, pH, and dissolved salts, making it an integrated water treatment system. While coagulation methods focus primarily on removing suspended particles, they face limitations when dealing with a variety of contaminants. The device provides higher accuracy in treating small and very fine particles using metal-organic frameworks (MOFs).

3- Gravity filtration technology is used. Water is passed through a filter medium such as sand or activated carbon using gravity. It is less energy-intensive, but its effectiveness in removing microplastics is limited.

Membrane ultrafiltration uses pressure to push water through a membrane, and is effective in removing plastic particles larger than 25 microns. However, it does not remove particles smaller than the pore size and may become clogged due to sediment buildup.[11]

Ultrafiltration is limited in its efficiency in removing very fine plastic particles, and this process requires continuous maintenance to overcome the problem of membrane clogging. Unlike the MIDT device, which uses artificial intelligence to treat pollution with higher accuracy and efficiency. The MIDT device relies on integrated systems and smart technologies to detect microplastics with high accuracy in real time, making it more sensitive and accurate compared to these two methods that rely on physical filtration.

4- The study focuses on the bioanalysis of plastic and microplastics using bacteria and fungi. The process begins with microorganisms adhering to the plastic, where enzymes break down the polymers into smaller molecules, which are then absorbed by bacteria and used in metabolism. However, toxic substances are released when the plastic decomposes into small molecules, causing health problems. Microplastic particles are linked to persistent organic pollutants, which increases their toxicity and the possibility of their transfer through the food chain and slows the biodegradation of some types of plastic, especially those with long and complex polymer chains. [12]

The MIDT device relies on artificial intelligence technology to analyze data and detect microplastics in real time, while biodegradation requires a longer time to show results, as microorganisms need a long period of time to decompose plastic materials. Also, biodegradation may lead to the production of harmful chemical by-products as a result of the interaction of microbes with additives in plastic, while the device aims to reduce these harmful chemical reactions using metal-organic frameworks (MOFs) that improve removal efficiency without generating additional pollution.

Brief explanation of the drawings:

[1] (Temperature sensor)

[2] (pH sensor)

[3] (TDS sensor)

[4] (Turbidity sensor)

[5] (Water tank)

[6] (Solenoid valve)

[7] (Check valve)

[8] (Syringe pump)

[9] (MicroFluidics chip)

[10] (Digital Microscope)

[11] (Submersible pump)

[12] (MOF and Mesh)

[13] (Solar panel)

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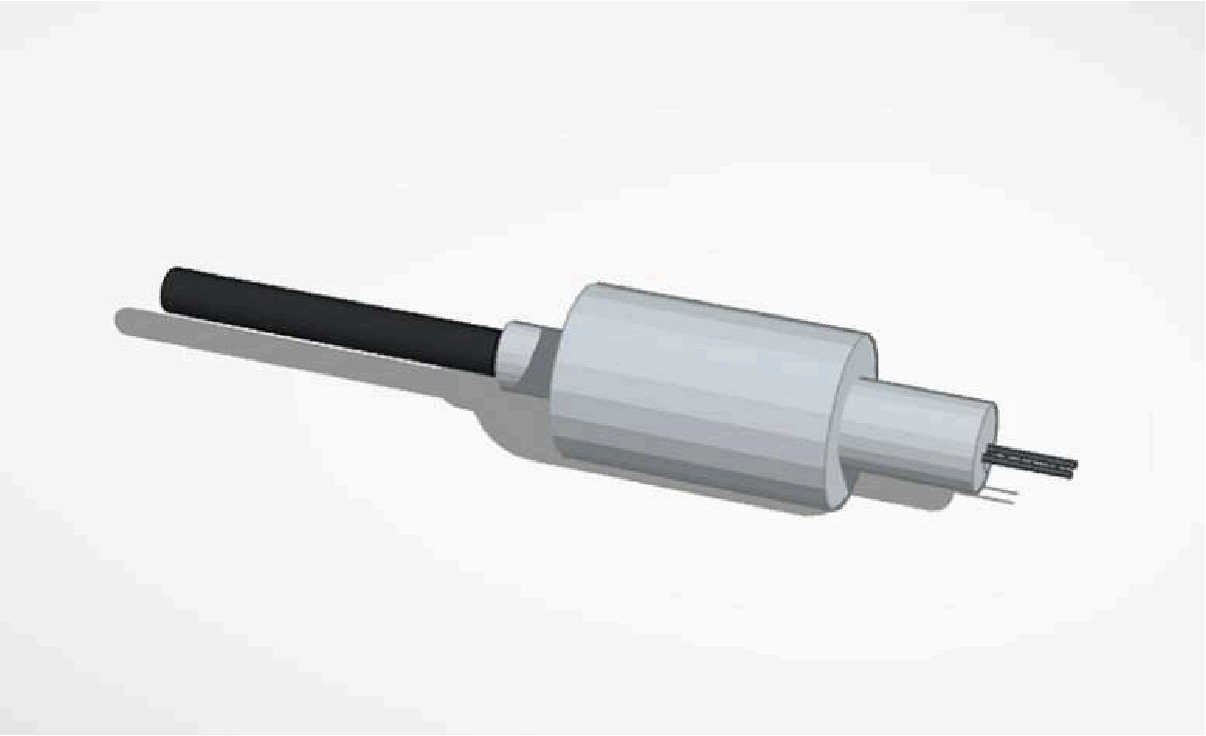

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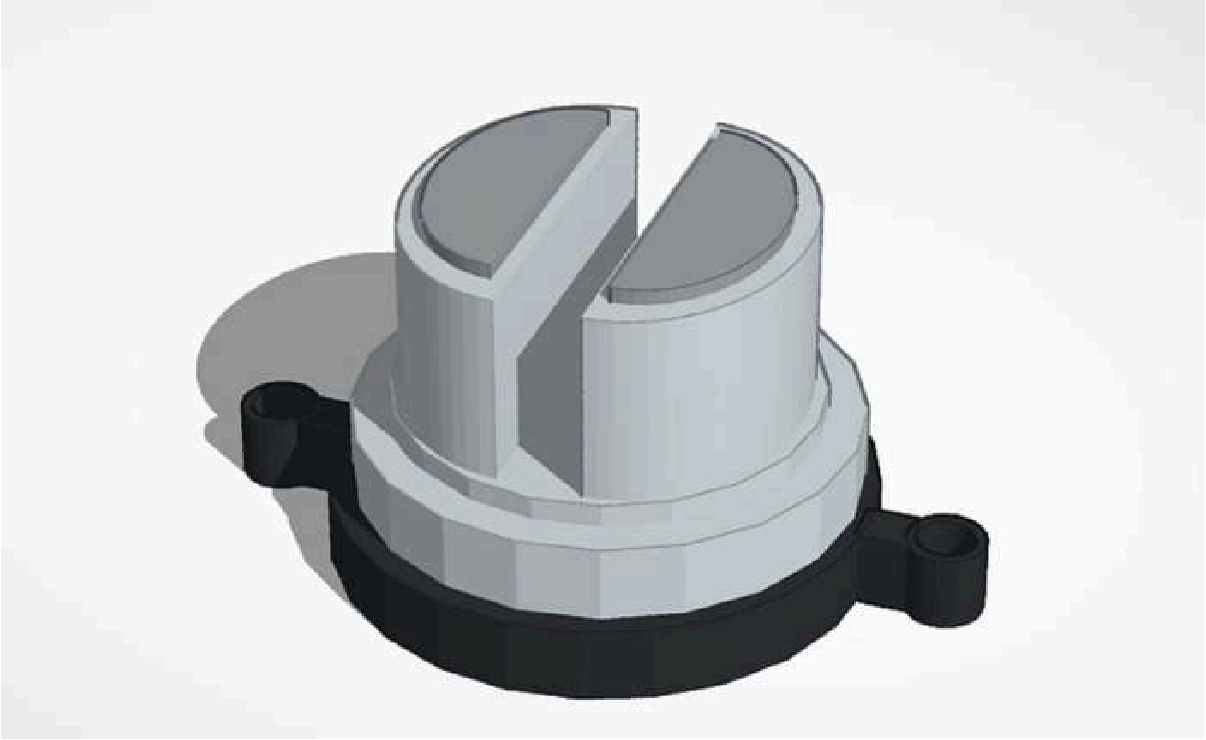

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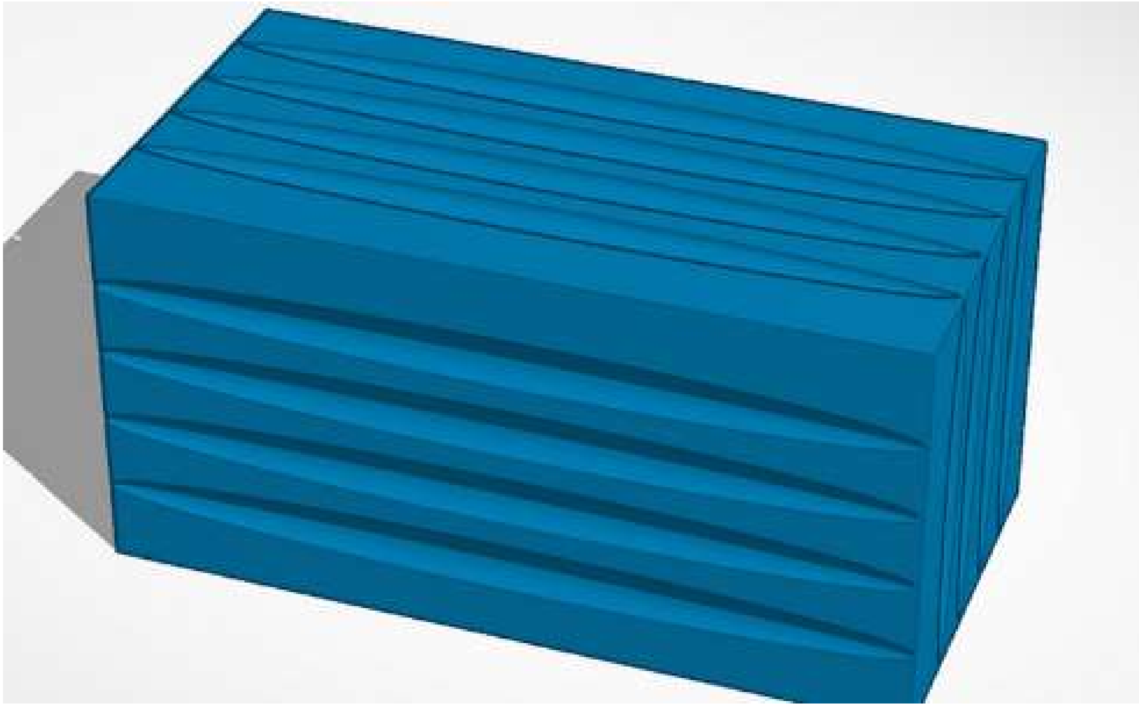

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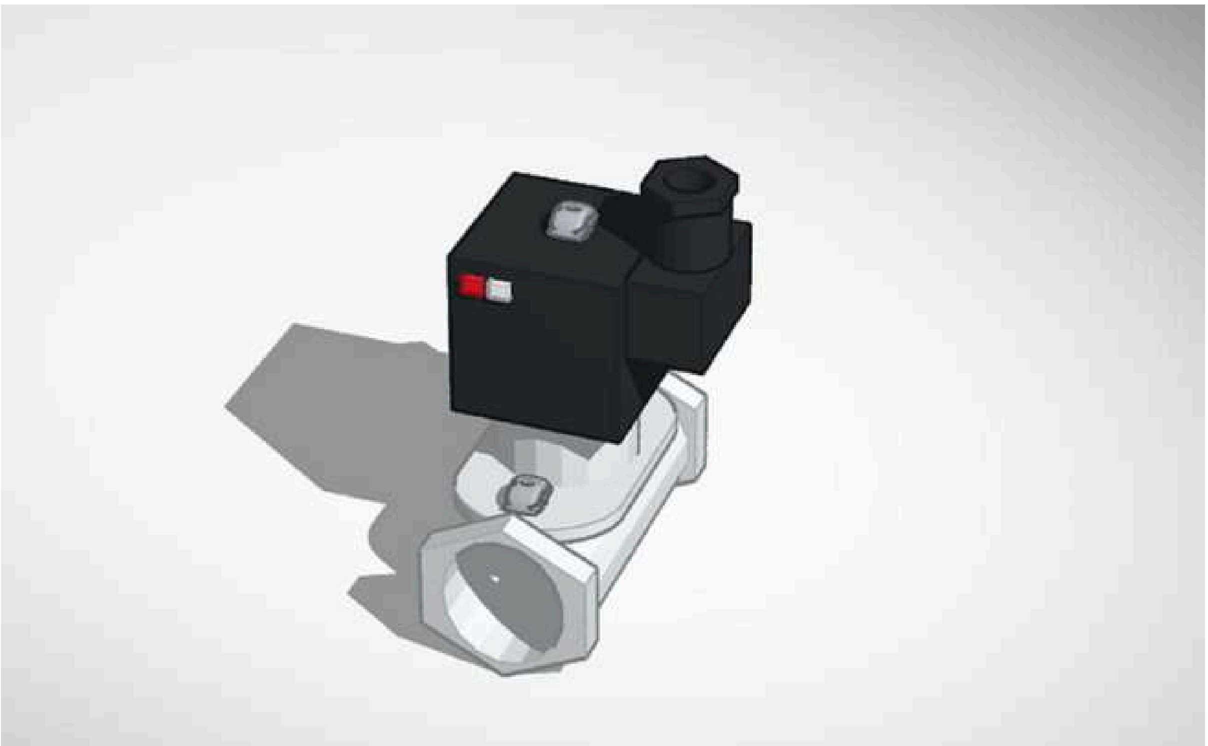

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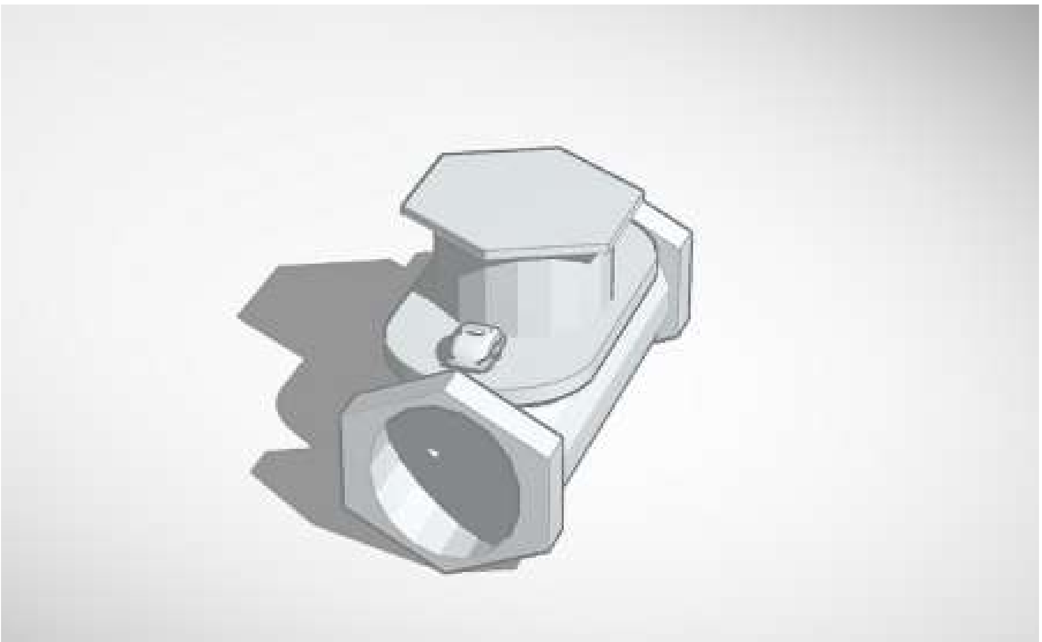

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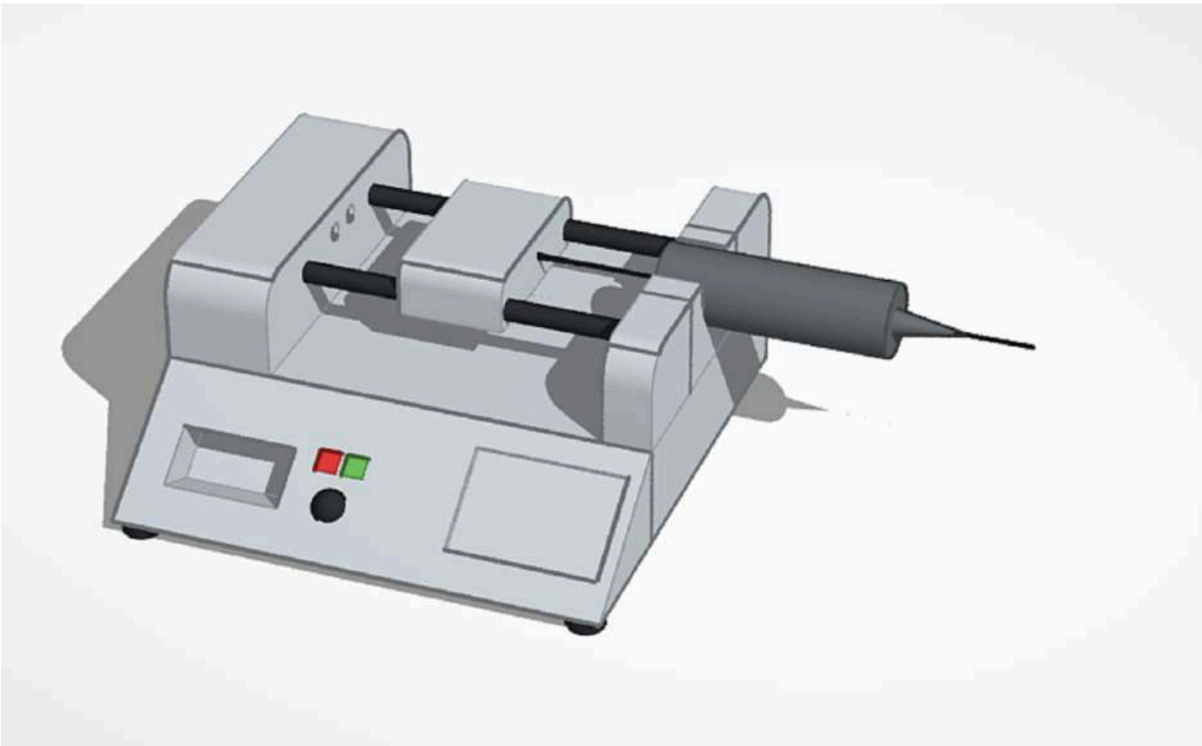

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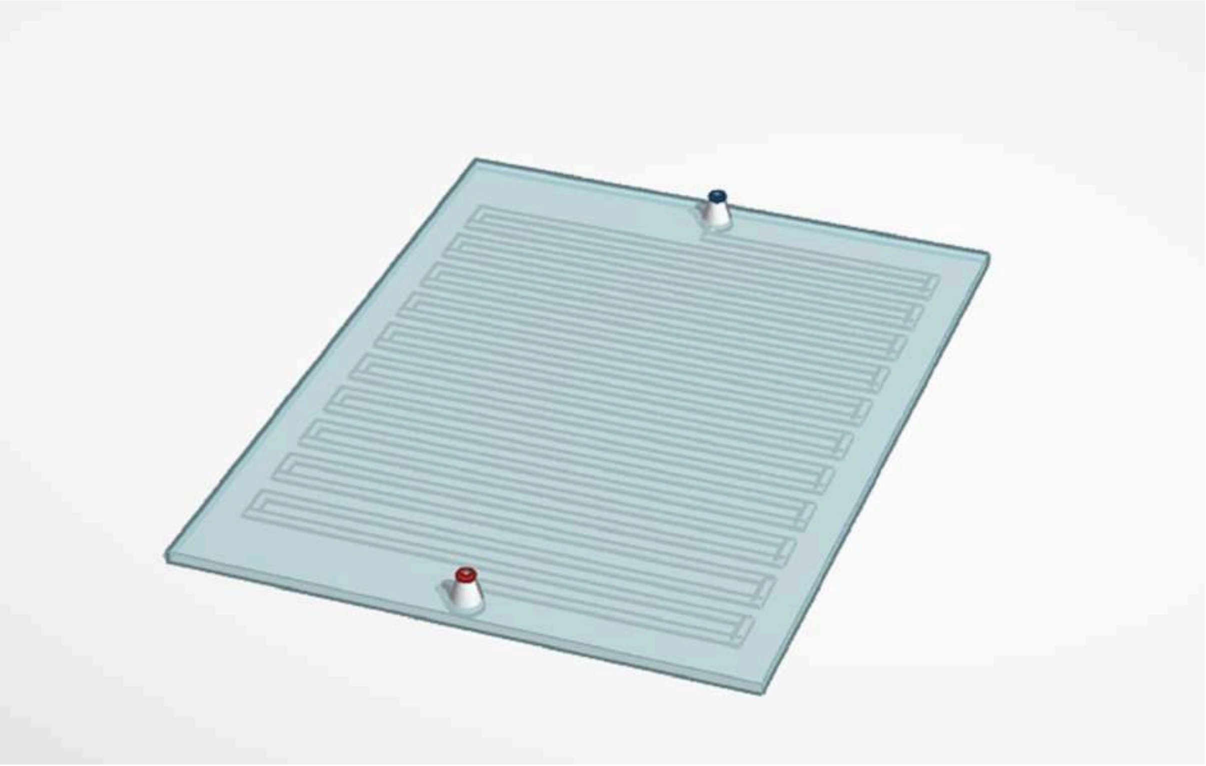

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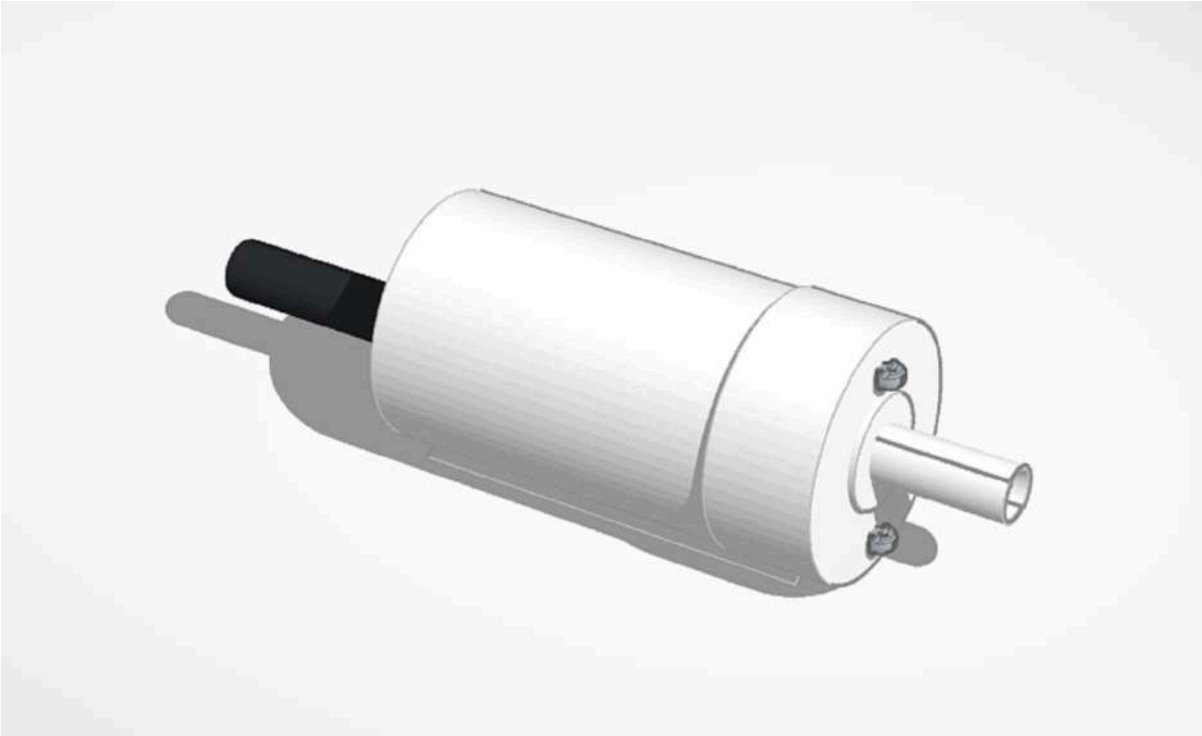

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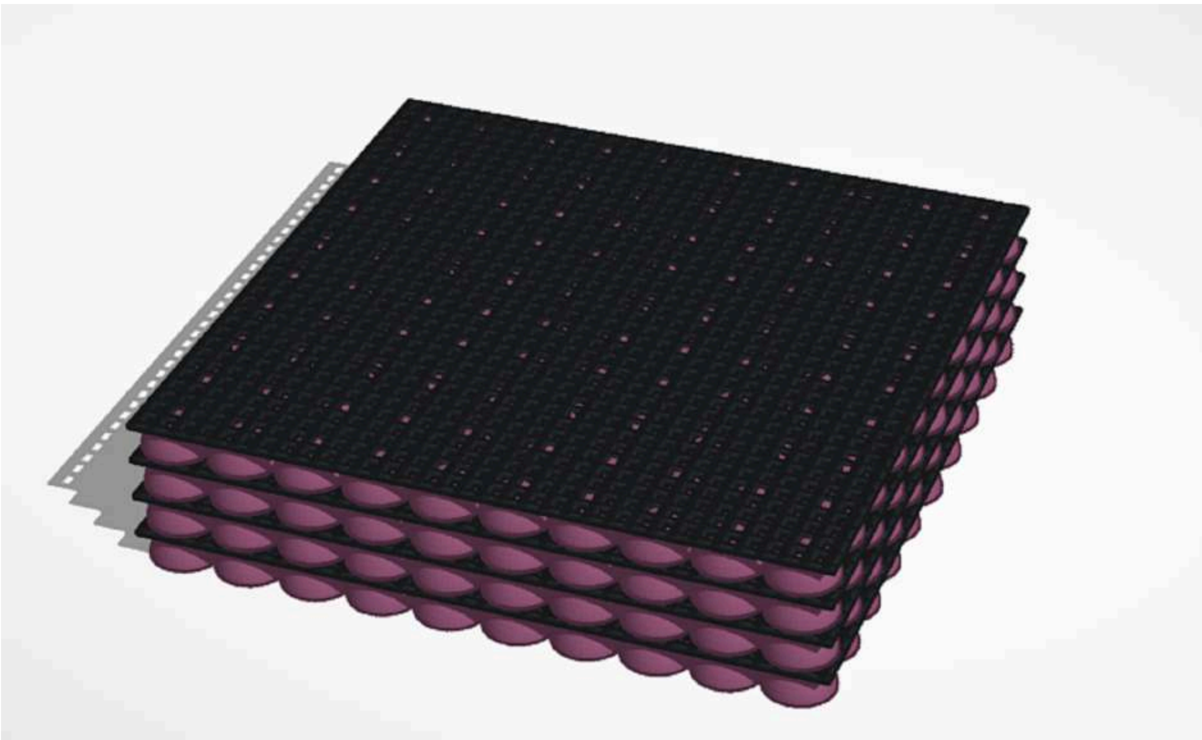

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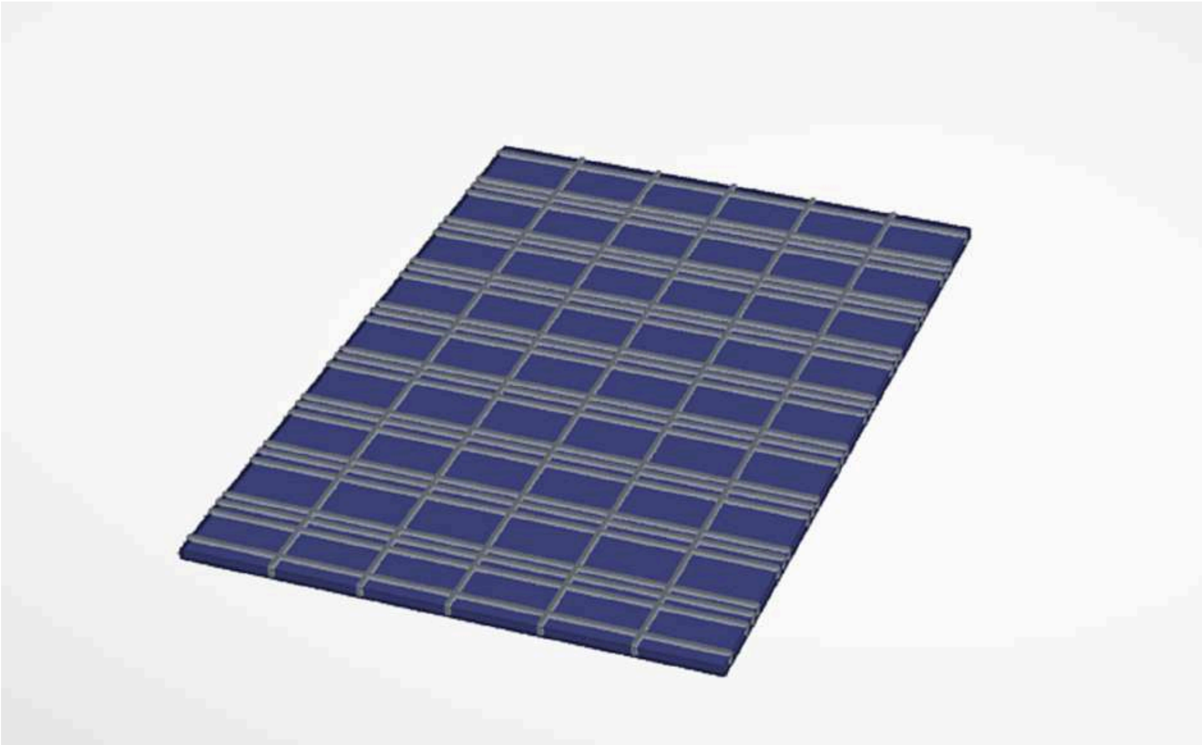

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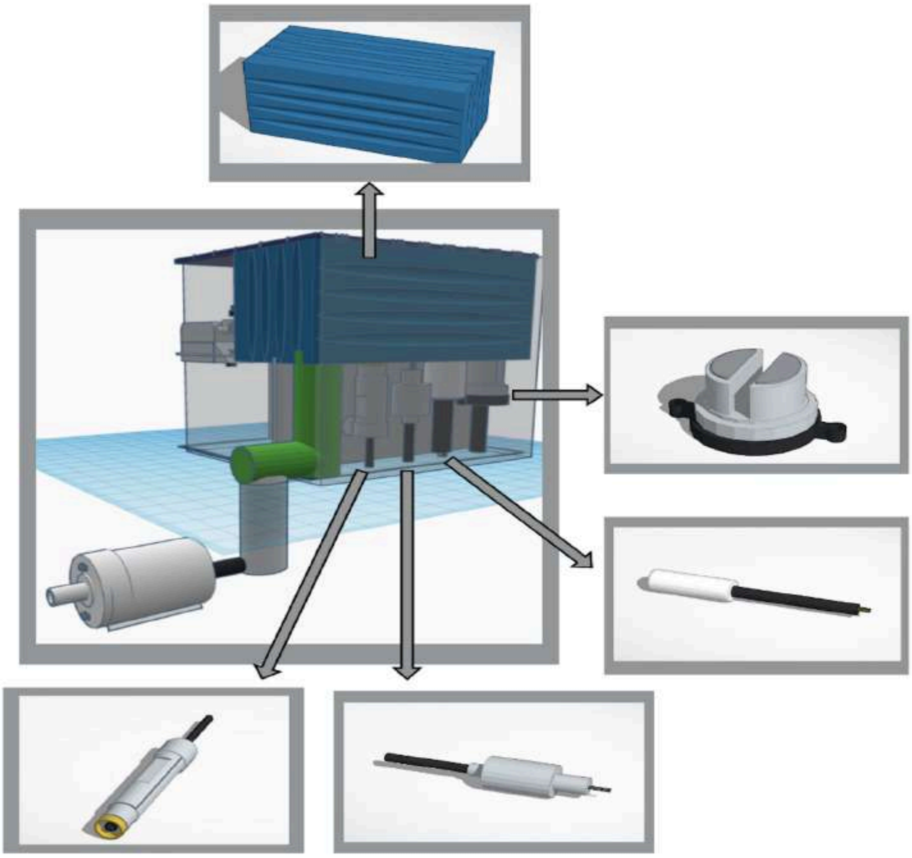

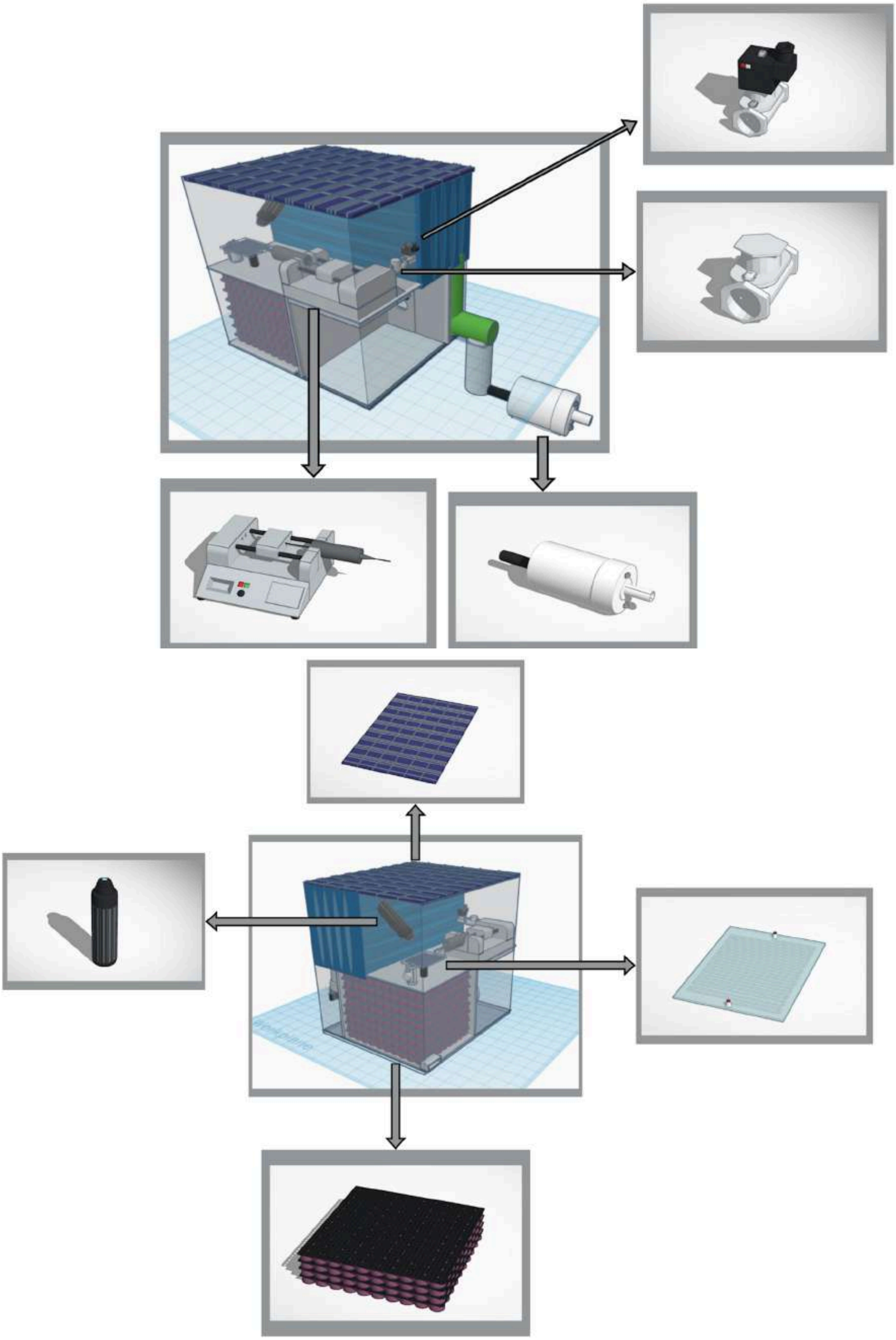

Detailed Description:

The system installed on the device contains:

-Temperature sensor

-pH sensor

-TDS sensor

-Turbidity sensor

-Water tank

-Solenoid valve

-Check valve

-Syringe pump

-Microfluidics chip

-Digital Microscope

-Submersible pump

-Metal Organic Framework and Mesh

-Solar panel

The "Integrated Smart Pollution Control System" device consists of a medium-sized box that can be placed in multiple locations. The device is designed to work in an integrated manner to achieve its goals of detecting and treating microplastics effectively. The device contains several main components:

Submersible Pump:

This pump draws contaminated water from the sea into a 500 ml tank. This tank is the first point for collecting contaminated water that will be measured and treated.

Measurement Tank:

It contains accurate sensors to measure pH, Temperature, Total Dissolved Salts (TDS), and Turbidity, allowing the device to accurately assess water quality.

Valve, Control and Pipe System:

This system includes a tube connecting the injection pump to the measurement tank. The tube contains a solenoid valve and a check valve to fully control the water flow and ensure that it does not return in the opposite direction to the tank, which improves the efficiency of the process and prevents any leakage.

Syringe Pump:

This pump draws water from the measurement tank and pumps it through a microfluidic chip placed on a light microscope platform. During this process, a video of the passing water is captured and analyzed in real time using artificial intelligence techniques to detect the presence of microplastics.

Water Treatment:

After the analysis process is complete, the water is directed to the treatment unit that uses metal-organic framework materials (MIL-101-Cr-SO3) in a circular manner within a mesh consisting of four layers on top of each other. Each mesh effectively removes microplastics, ensuring that the water is thoroughly cleaned.

Solar Energy:

The device is entirely powered by solar energy, making it sustainable and environmentally friendly, and can be used in various environments without the need for traditional energy sources.

Mechanism of Operation:

- First stage: Turning on the device and drawing water

When the device is turned on, the submersible pump draws water from the surrounding environment into the measuring tank.

- Initial examination: Measuring water quality

The physical and chemical parameters of the water in the measuring tank are measured using specialized sensors. These parameters include: pH, temperature, total dissolved salts (TDS), and turbidity.

After the measurements are completed, the water is drawn through a tube connected to the injection pump.

- Analysis using artificial intelligence

Water is pumped by a syringe pump through a microfluidics chip placed on the optical microscope platform.

- Detection of microplastics

After pumping water from the measuring tank, it passes through the microfluidic chip mounted on the optical microscope platform.

The microfluidic chip contains small channels that direct the water flow in an organized manner, allowing each part of the water to be accurately examined.

As the water passes through the channels, the optical microscope records high-resolution video of the movement and flow.

The artificial intelligence system is used to analyze the video in real time, to detect the presence of microplastic particles in the water.

The artificial intelligence technology is based on image recognition algorithms, which distinguish microplastic particles based on the size of the microplastic present in the water.

- Final treatment

Removal of microplastics After analysis, the water is directed to the treatment tank.

The microplastics are removed using MIL-101-Cr-SO3 materials, which are organized into a four-layer network, which helps in the effectiveness of removing microplastics.

- Output: Returning water to the environment

After treatment, the purified water exits the device and is returned to the surrounding environment, effectively reducing environmental pollution.

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