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WATER TREATMENT IN A SMART HOME ECOSYSTEM

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Abstract

This article describes the design and economic characteristics of a modular water purification system built from standardized column segments. Each column can include up to three quickly interchangeable segments, each holding up to three disposable ion-exchange cartridges filled with OZOLA sorbent. The cartridges, based on mass-produced polymer fiber sleeves, ensure low consumable costs. The modular system is mounted on a dedicated platform equipped with pumps, mechanical self-cleaning filters, and measurement and control devices. A complete purification unit with a capacity of 1 m³/hour – comprising three three-segment columns, a pump, and a two-stage inlet and outlet filtration cascade – has a total cost of 35,000 USD. The modular design supports rapid maintenance, scalability, and cost-efficient operation.

Keywords: *Smart Home Ecosystem, Smart Home Infrastructure, Modular Purification Systems, Ion Exchange Purification Process, Application for Purification of Dried Biomass, Symmetrical Electrochemical Electrode Cell, Active Working Surface*

A comprehensive water supply system consists of 4 groups of interconnected modules, based on their principles and interactions:

Modules for input control and pre-treatment, including water storage tanks at the system's entry point and reserve water tanks for peak loads. Pre-treatment includes electrochemical disinfection, aeration, and oxygen concentration enhancement to full saturation levels. The input control modules operate on a contactless method based on the principles of electromagnetic resonance spectroscopy.

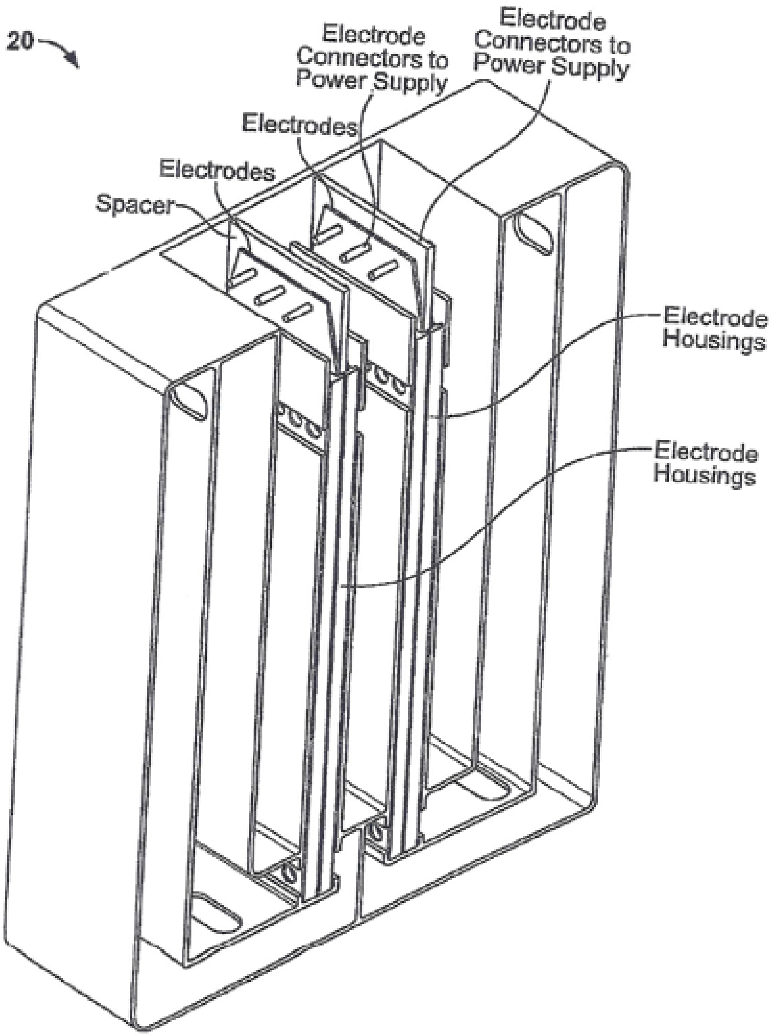
Local modules for electrochemical treatment, specific to each residential unit, including flow meter blocks at the entry point with a real-time monitoring section (contactless, operating on the principles of electromagnetic resonance spectroscopy).

Used water storage modules, which separate water into at least two categories: wastewater containing toilet residues and general wastewater.

Used water regeneration modules, with at least two sections: one for water containing fecal particles and one for other water. These modules include separation systems with vortex foam generators and final control systems that work without direct contact, operating on the principles of electromagnetic resonance spectroscopy.

In addition to the operational modules, the comprehensive water supply system includes a control and processor section with elements of artificial intelligence and artificial neural networks, enabling remote control and real-time monitoring.

Figure 1. *The diagram presents the model of an electrochemical reactor with two electrode cells*



Water Purification from Radioactive Isotopes and Heavy Metals Using Biomass Obtained From Algae of the Type – Ozola

Ion Exchange Purification Process

As practice has shown, dried biomass of algae of the type – OZOLA has the ability to undergo ion exchange reactions for the absorption of heavy metal ions and radioactive isotope ions. To achieve purification, water must pass through the biomass volume, where, during the contact time, ion exchange occurs, and the biomass absorbs radioactive metal isotopes and associated heavy metal ions.

As tests and industrial operation of water purification systems at nuclear reactors have shown, the level of purification using algae of the type OZOLA can be reduced to residual concentrations of 0.000001 milligrams per liter, which exceeds the requirements of current environmental standards.

Design of the modular purification system

The modular purification system consists of one or more columns, each of which is made up of standardized segments. Typically, a column may have one, two, or three segments connected by a special element made of nylon and polyvinyl chloride, with a silicone rubber seal.

It takes no more than 1 minute to connect or disconnect a segment. Each segment accommodates up to three ion-exchange cartridges. Each ion-exchange cartridge consists of a knitted sleeve made of fibers, into which OZOLA is poured.

The ion-exchange cartridges are single-use. The knitted sleeves made of polymer fibers are mass-produced, and their cost does not exceed 5 USD each.

The columns and necessary piping are assembled and mounted on a special stand, which includes pumps, mechanical self-cleaning filters, and measurement and control instruments.

The cost of one modular purification system, designed for a capacity of 1 cubic meter per hour, which includes three columns (each with three segments), a pump, a cascade of two mechanical filters at the inlet, and a cascade of two automatic mechanical filters at the outlet, is 35,000 USD.

The cost of OZOLA for one ion-exchange cartridge is 50 USD.

Principle of Operation of a Symmetrical Electrochemical Electrode Cell in Water Treatment in Hospitals

The liquid, and in the case of hospitals, water, under the influence of gravitational forces, enters the inlet of the device housing for water treatment according to the principle of communicating vessels. The flow of liquid or water, in a laminar regime, penetrates inside the electrode volume through a permeable contact.

The electrode and its entire internal volume are under the influence of a positive electrical potential due to the connection of the contact and the electrode to a positive electrical potential source. Depending on the water flow rate or the device's performance, the power of the power supply can vary.

For a device with a flow rate of 5 gallons per hour, the power supply can be 3 kilowatts, with three possible combinations of current and voltage:

- Current: 50 amperes, Voltage: 60 volts;
- Current: 30 amperes, Voltage: 100 volts;
- Current: 100 amperes, Voltage: 30 volts.

For a device with a flow rate of 150 gallons per hour, the power supply may be 10 kilowatts, achieved by forming an integrated power supply from at least 3 modules, each with 3 kilowatts, with combinations of current and voltage similar to those for the 5-gallon-per-hour device.

Under the influence of gravitational forces, the liquid or water rises through the electrode volume and, spreading across it, seeps through the membrane and contact into the internal volume of the second electrode, which is connected to the negative electrical potential source. The distance between the electrodes is determined only by the thickness of the membrane, and since this distance is a maximum of 0.8 mm, the efficiency of the electrode pair, the entire volume of which has an active electrochemical function, is very high.

From the moment the liquid or water enters the volume of the electrode connected to the negative electrical potential source, an active, rapid electrochemical processing of the materials contained in the liquid begins inside the electrode cell.

After passing through the cathode volume, the liquid exits the device housing through the outlet window.

Since significant areas of active working surface are involved in the electrochemical process, thanks to the three-dimensional structure of the electrodes, it is possible, in combination with an increase in current density, to achieve a significant enhancement in the effect of changing the properties of the materials contained in the water on the surface of carbon fibers that make up the volume of the electrodes

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