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HIGH-PERFORMANCE EQUIPMENT FOR ELECTRIC DISINFECTION OF WATER

Daniela Simina Stefan[1,*], Camelia Ungurean[1], Attila Tókos[2], József Lingvay[2], Ana Iulia Stefan[1,3*]

[1]Faculty of Chemical Engineering and Biotechnologies, The National University of Science and Technology Politehnica Bucharest, Gheorghe Polizu 1-7 Street, 011061 Bucharest, daniela.stefan@upb.ro, camelia.ungureanu@upb.ro, Romania
[2]I.C.P.E. Bistrita S.A., Parcului 7 Street, 420035, Bistrita, Bistrita Nasaud, iosiflingvay@yahoo.com, attila.tokos@icpebn.ro, Romania
[3]Regina Maria-Dental Hospital, Cozia 71 Street, Timisoara, iulia.stefan@reginamaria.ro, Romania,

**corresponding authors: daniela.stefan@upb.ro, iulia.stefan@reginamaria.ro*

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Introduction

Disinfection is the process of reducing the number of pathogenic microorganisms in a liquid medium or on a surface. Depending on the target microorganisms and the exposure time to the disinfecting agent, disinfection may be performed at different levels (low, intermediate, or high) [1].

The disinfection of liquid products, including pharmaceutical products (serums, natural extracts, liquid formulations, etc.) and food products (fruit juices, drinking water, dairy products, etc.), is a complex issue of considerable practical importance. Conventional fluid sterilization methods, such as thermal treatments (direct heating, exposure to high-frequency electric fields, including microwaves, ultrasound, etc.) or the addition of chemical disinfectants (such as chlorination of drinking water), have the significant disadvantage of altering the chemical composition of the treated product. Examples include the thermal degradation of vitamins in fruit juices and the presence of residual disinfectant compounds in the final product [2, 3].

Disinfection by ultraviolet (UV) radiation has limited applicability due to the significant attenuation of UV light in turbulent media and the relatively low energy efficiency of UV sources [4, 5].

This paper presents an original method and the corresponding equipment for the continuous-flow disinfection of liquid products based on the permeabilization of microbial cell membranes by means of high-voltage electrical pulses. Because the applied electrical pulses are of very short duration, the temperature of the treated product is not significantly affected.

The proposed disinfection system is fully automated and provides continuous-flow treatment without inducing chemical changes in the processed fluid. Through its dedicated SCADA system, it enables remote monitoring and control of the process while ensuring effective disinfection at low specific energy consumption [6].

Materials and methods

Design of the wastewater's disinfection equipment

The following criteria were considered in the design of the installation:

High treatment capacity with minimum investment costs, achieved through a continuous-flow process;

Environmentally friendly operation, excluding the use of chemical disinfectants, thermal treatments, and exposure to intense radiation;
Efficient disinfection of wastewater at minimal specific energy consumption;
Autonomous operation, with the treatment process controlled through a closed-loop automation system based on signals provided by dedicated sensors and transducers;
Remote monitoring, control, and adjustment of the technological process through a SCADA system.

Results and conclusions

The microorganisms present in the wastewater are inactivated through irreversible electroporation, which perforates the cell membrane by electrical breakdown. The principle of this method is illustrated in Figure 1.

Electroporation represents a modern alternative to conventional wastewater disinfection methods, as microbial inactivation is achieved by modifying cell membrane permeability rather than through heating or the use of chemical agents.

The current system has a specific energy consumption of 160 Wh/m³ of treated water. Based on an electricity cost of approximately 0.001 lei/Wh, the operating energy cost is approximately 0.16 lei/m³

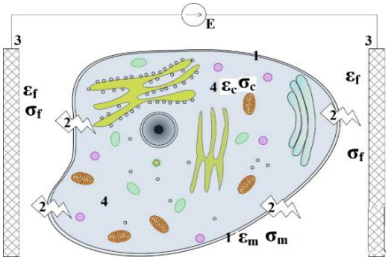


Figure 1 - Principle of cell membrane permeabilization by electrical breakdown: E – voltage source; 1 - cell membrane; 2 - pores generated by electrical breakdown; 3 - electrodes; 4 - cytoplasm.

For conventional chemical disinfection, the sodium hypochlorite dosage typically ranges between 16 and 40 mL/m³ of treated water. Considering an average hypochlorite price of approximately 5 lei/L, the corresponding treatment cost ranges from 0.08 to 0.20 lei/m³.

The pulsed electric field disinfection system offers a significant advantage over conventional chemical disinfection methods, as it does not require hazardous chemical reagents and does not generate toxic compounds such as trihalomethanes, which are known to be potentially carcinogenic.

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