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Application of electron beam for wastewater disinfection

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Abstract

The objective of the study is to consider the possibility of applying the nanosecond electron beam for disinfecting wastewater. The advantages of this method have been illustrated. The mechanism of influence of ionizing radiation on cells has been described. The microbial suspension has been irradiated with the electron accelerator, and then the effectiveness of the electron beam as a disinfecting agent has been assessed. In most cases there has been a bactericidal effect, while in some cases a bacteriostatic effect has been observed. On the example of *E. coli* culture, it has been shown that the nanosecond electron beam is an effective disinfecting agent for the of wastewater treatment.

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Keywords: Electron beam, bactericidal effect, disinfection, wastewater.

1. Introduction

Nowadays, the problem of clean water shortage is more and more urgent. This is due to the overpopulation of the planet and, as a result, to increased fresh water consumption. The untreated wastewater discharge into water sources leads to microbiological contamination. To solve this problem, chemical methods of disinfection (chlorination, ozonation) are widely applied, but when they are used in water, toxic compounds are produced. Thus, a great alternative to these methods may be nanosecond electron beam disinfection.

Currently, researchers have identified a wide range of nanosecond electron beam for radiochemical sterilization applications. This method can be used for sterilization of medical instruments, glassware for blood preparations, as well as in the food industry for disinfecting bottles[1]. Also, several studies indicate the possibility of using the

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electron beam for the treatment of domestic sewage from organic contaminants, petroleum and textile waste[2, 3]. Based on the above mentioned facts, we can conclude that the prospects of using an electron beam as a sterilizing agent for wastewater disinfection are rather promising.

A bactericidal effect of ionizing radiation (IR) is ensured by its direct (physical) and indirect (chemical) action. When radiation moves through a substance, it gives birth to ionization and excitation; molecular bonds are broken, resulting in damage to biological tissues. The indirect effect of IR is caused by the facts that under its influence free radicals are formed in water that intensely react with each other and with the molecules of the substance. During these reactions hydrogen peroxide may be generated in the cell, which is detrimental to some types of microorganisms[4].Taking into account that we are interested in water suspensions of microorganisms disinfection, this mechanism becomes more important. The biological effect of ionizing radiation is related to the amount of energy that is absorbed by the cell or tissue. In this regard it is important to determine the radiation dose.

For today we know an effective method of disinfecting water with influence of continuous ionizing radiation. However, in this case, irradiation of the whole volume of the treated water leads to an increased power source of ionizing radiation, and it complicates personnel protection[5]. By different groups of researchers it was found that when the nanosecond electron beam is used, sterilization dose is reduced[6], which can significantly reduce the power consumption, and is safer for personnel.

2. Experimental

Identification of the nature of a nanosecond electron beam irradiation on wastewater microorganisms impact was carried out on the example of a typical representative – *Escherichia coli*. The purpose was to determine the basic conditions for successful neutralization of a pure culture *Escherichia coli* in aqueous medium. Irradiation experiments with a culture *Escherichia coli* were repeated three times for averaging the results.

2.1. Materials

A microbial culture of *Escherichia coli* was used for the experiments. The culture was cultivated on the nutrient medium of the following composition: 1 liter of distilled water, agar nutrient for culturing microorganisms, dry 41 g, and 2% glucose (sterilized in a steam autoclave at 120°C, 15 minutes). Sterile distilled water (sterilized in a steam autoclave at 134°C, 20 minutes) was used for preparing samples. 90% ethanol or isopropyl alcohol was used for disinfection. Samples were placed in cuvettes, volume 0.07 ml (Fig. 1).

2.2. Sample preparation

Composite parts of cuvettes were sterilized in a steam autoclave at 134°C, for 20 minutes. The suspension test culture was prepared from a culture *Escherichia coli*, grown on agar medium containing 2% glucose at 37°C for 24 hours. To prepare the bacterial slurry, *E. coli* culture was washed away from the agar by sterile distilled water. The resulting slurry of microbes was used for further manipulation.

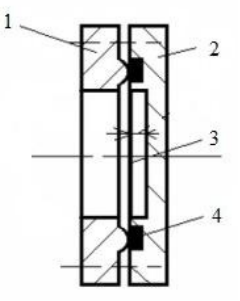

Fig. 1.Diagram of the cuvette: 1 – cover, 2 – frame, 3 – foil, 4 – gaskets.