DOI: http://doi.org/10.21698/simi.2019.fp42

THE COMPARISON OF DESTRUCTION DEGREE BETWEEN DIFFERENT TYPES OF MICROORGANISMS UNDER GAS/CAVITATION CONDITIONS

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Abstract

Comparison of values of destruction degree of microorganisms of different types (*Micrococcus luteus*, *Pseudomonas fluorescens*, *Bacillus cereus*, *Sarcina lutea* bacterias and *Saccharomyces* yeasts) under the simultaneous treatment of water by cavitation and gas is carried out. Has been determined the nature of the gas in which the cells were most actively destroyed by comparing the values of destruction degree. The greatest effectiveness of microorganisms destruction was achieved with the Ar/US-action, regardless of the type of microorganisms, their morphological characteristics and their initial amount per unit volume of water. Morphological features have an influence only on the duration of cavitation treatment of water.

Keywords*: bubbling*, *cavitation*, *destruction degree*, *gas*, *microorganisms*

Introduction

Microbiological contamination of water is one of the contamination factors of natural water and sewage, with which scientists are fighting till today (Ashbolt 2015, Pachepsky et al 2018). Various scientists have proposed many methods of microbiological water purification, but they mainly determine the total number of destroyed microbes, without specifying their genus. Much attention should be given to the identification of the aquatic microbiota and to establish varieties of microorganisms in the process of water decontamination. This task and its disclosure are set out in this paper. Here is the proposed cavitation method of water disinfection from microorganisms of a particular type. But the effect of cavitation on different types of microorganisms is uneven, which indicates the specificity of the cavitation field effect on microscopic organisms (Koval 2018, Badve et al 2015, Jain 2019). However, experimentally argued data that would confirm this fact in the literature are absent. Therefore, the study of this work is aimed at assessing the destruction degree of microorganisms of various types with simultaneous action of gas bubbling and cavitation.

Materials and Methods

Model waters were used for investigations to which microorganisms were added, namely *Micrococcus luteus*, *Pseudomonas fluorescens*, *Bacillus cereus*, *Sarcina lutea* bacterias and *Saccharomyces* yeasts. The purification process lasted 2 hours. Previous studies have shown that microorganisms number is not changed during two hours in the control experiments without cavitation and gas action in all investigated waters medium, that is enough for the experiment.

Cavitation processes in the aquatic medium were generated by ultrasonic (US) action (UZDN-2T) with the frequency of 22 kHz, power of 35 W was used. Gas bubbling into the water is an additional factor for intensification of the cavitation process, namely oxygen, carbon dioxide, argon and helium. All experiments were carried out under T = 298±1 K, P = 0.1 MPa.
The number of living cells was determined after the treatment by colony counting on a nutrient medium – meat and peptone agar. Calculated colonies were expressed as colony forming units per cubic centimeter.

Results and Discussion

Destruction degrees of microorganisms (D_d) after gas/US treatment equals to number of microorganisms (NM) concerning to initial number of microorganisms (NM_0) landed at 100% and expressed in percentage are presented in Table 1.
One may compare *Bacillus* destruction within a cavitation field for different gases being bubbled into its dispersion and so determine the gaseous atmosphere in which this process is most effective (Figure. 1).

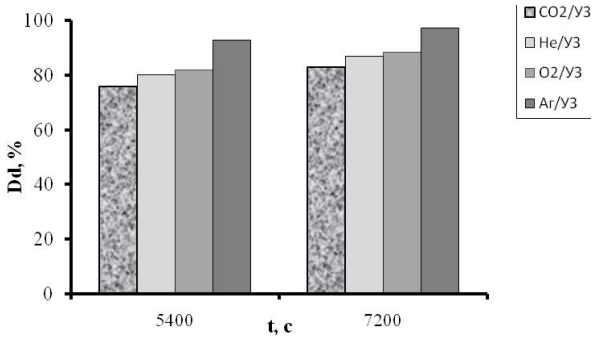

Figure 1. Dynamics of D_d changes of *Bacillus cereus* in time. Conditions: $NM_0 = 7 \cdot 10^4$ CFU/cm^3, T=298±1K.

Bacillary *Ps. fluorescent* type bacteria, unlike *B. cereus* microbial cells, are unable to form spores, they were investigated for their response to gas/cavitation treatment (Figure. 2).

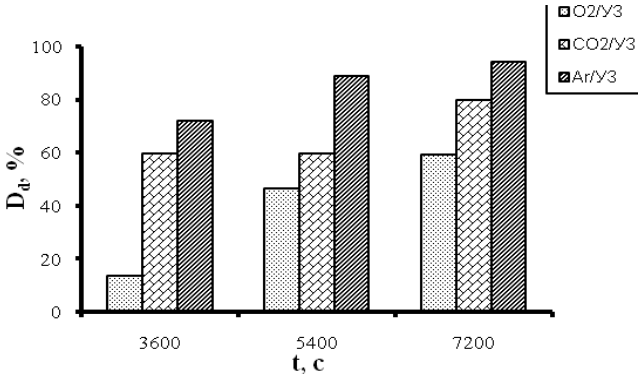

Figure 2. Dynamics of D_d changes of *Pseudomonas fluorescens* in time. Conditions: $NM_0 = 9.5 \cdot 10^4$ - for O_2/US; $NM_0 = 9.7 \cdot 10^3$ - for CO_2/US; $NM_0 = 1.8 \cdot 10^3$ – for Ar/US; T=298±1K.

It should be noted that during the first stage of being subjected to He/US effect (t=1800 s) an increase in *NM* was observed as a result of intensive disaggregation of microbial cells found in the effluent water, whilst active microorganism destruction proper ($t_{He/US}$=1800÷7200s) was only observed at the second stage. Therefore, in determining D_d values NM_{max} was considered instead of the NM_0. For that reason, in this particular instance the comparison between the effect of helium and other gases in a cavitational field is inappropriate (this is not shown in the Figure. 2).
The destruction effectiveness order for *Sacch. Cerevisiae* when subjected to various gas/cavitation combinations is presented on Figure 3.

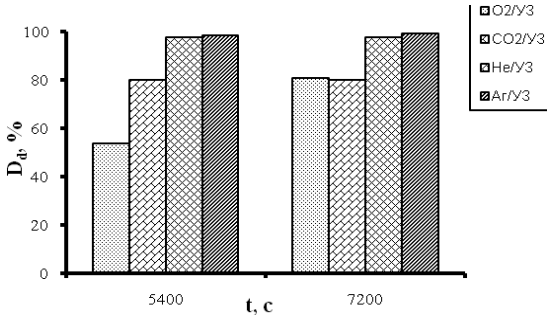

Figure 3. Dynamics of D_d changes of *Saccharomyces cerevisiae* in time. Conditions: $NM_0 = (4.2 \div 5.2) \cdot 10^3$ CFU/cm^3 – for He/US and CO_2/US and $NM_0 = (1.9 \div 2.07) \cdot 10^4$ CFU/cm^3 – for O_2/US and Ar/US; T=298±1K.

Table 1. Destruction degrees of investigated microorgamisms

Investigated microorgamisms	Destruction degrees (D_d) after t = 7200 s, %			
	Ar/US	He/US	O_2/US	CO_2/US
Bacteria				
Bacillus cereus	97.4	86.9	88.6	82.9
Micrococcus luteus	90.3	69.8	-	-
Sarcina lutea	97.0	95.3	-	-
Pseudomonas fluorescens	94.4	42.4	59.3	80.0
Yeast				
Saccharomyces cerevisiae	99.52	97.62	80.77	80.0

The process of water decontamination, depending on the cells size, is considered in the previous work (Koval 2018). The above data (Table 1) describes the ambiguity of the effect of gas nature on the efficiency of organisms destruction under cavitation influence. Hence, Ar/US-action demonstrated the best results, regardless of the microorganism's type. The value of destruction degree depends on morphological features of the cells.

Conclusions

The ratios of the number of microorganisms concerning to initial number of microorganisms are calculated. The highest values of destruction degrees of microorganisms have been established under Ar/US action, unlike He/US, O_2/US, CO_2/US regardless morphological features of the cells, type of microorganisms and initial concentration of the cells in the investigated water. While the value of destruction degree depends on morphological features of the cells as yeast cells were more likely to be destroyed under gas/cavitation conditions, compared with the destruction of bacterial cells that is explained by the morphological characteristics of the cells.

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