# *E.coli* inactivation by high frequency ultrasound


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## Abstract

A very important stage in water and wastewater treatment processes is disinfection, which protects the public from pathogenic biocolloids (microorganisms). Microbial inactivation by ultrasound (US) provides a unique combination of simultaneously acting mechanisms including mechanical effects capable of disrupting cell membranes, chemical effects (including generation of active free radicals), and heat effects (i.e. generation of local hot spots). The aim of this work is to examine the efficiency of ultrasound irradiation on the inactivation of model bacteria. The strain of *E.coli* CN13 was selected for this purpose.


## Materials and Methods

An ultrasonic system (Meinhardt Ultraschalltechnik, Germany) composed of a 75-mm diameter titanium transducer operating at 582 kHz, a function generator, and an amplifier was employed. The transducer was mounted at the bottom of a cylindrical 2-L glass laboratory reactor with double walls to allow water circulation for cooling. The electric power of the system was adjusted at 133 W.

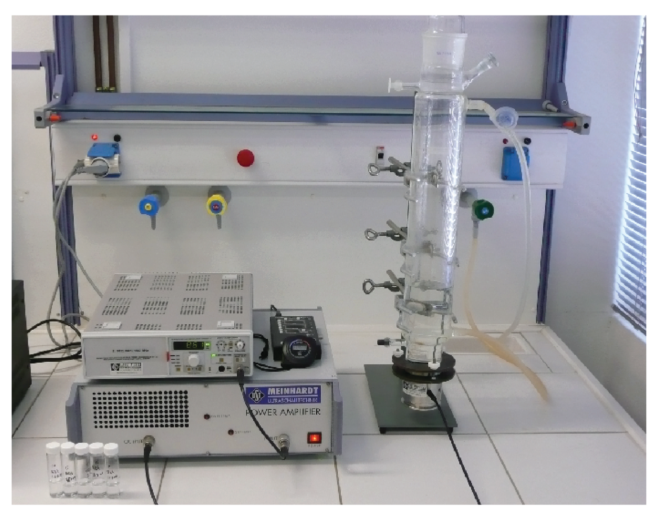

Fig. 1. Experimental setup arrangement.

The strain of *E.coli* CN13 was selected for the present experimental investigation because this bacterium is frequently found in raw and secondary treated municipal wastewaters. The *E.coli* CN13 inactivation experiments were conducted for several different initial concentrations ($10^2$-$10^6$ cfu/mL) using an ultrasound frequency of 582 kHz. Viable *E.coli* concentrations were determined by using the dispersion method. The inactivation rates were determined by fitting the experimental data with two kinetic models with constant and time-dependent inactivation rate coefficient, respectively.

## Inactivation kinetics model

The experimental data from the inactivation studies have been successfully described by a pseudo-first-order expression with a time-dependent rate coefficient as follows:

$$\frac{dC(t)}{dt} = -\lambda(t)C(t) \qquad (1)$$

where C is the concentration of the viable bacteria, t is time, and λ is the time-dependent inactivation rate coefficient of bacteria described by the following expression:

$$\lambda(t) = \lambda_o e^{-at} \qquad (2)$$

where λo is the initial inactivation rate coefficient, and a is the resistivity coefficient. Assuming that C(0) = Co, where Co is the initial concentration of bacteria, the solution to Eq. (1) is:

$$\ln\left(\frac{C(t)}{C_o}\right) = -\left(\frac{\lambda_o}{\alpha}\right)\left(e^{-at} - 1\right) \qquad (3)$$

## Effect of US on *E.coli* inactivation

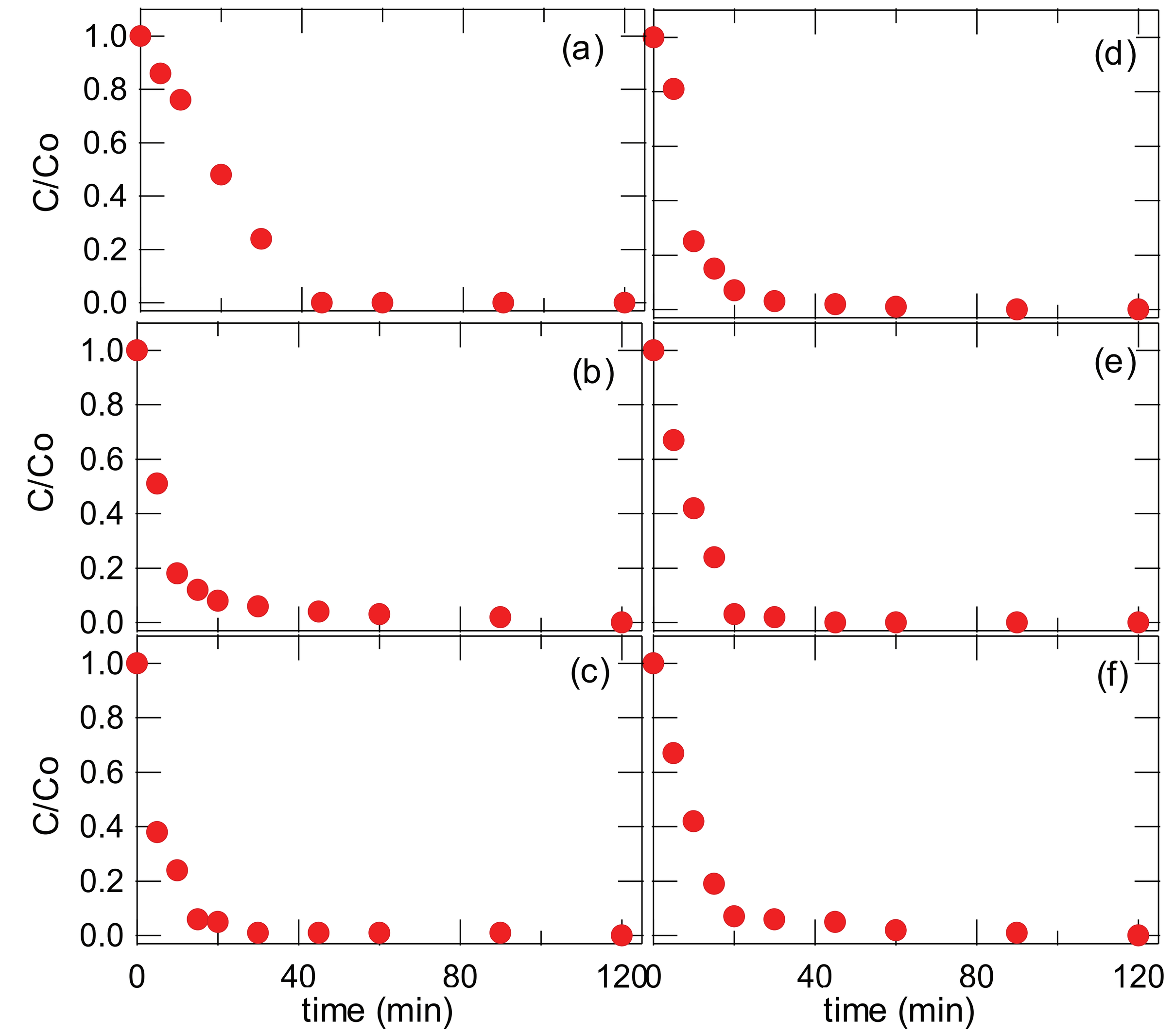


Fig. 2. Effect of ultrasound on *E.coli* CN13 inactivation as a function of time at 133 W input power with fa=582 kHz with different initial concetrations: a) $1.2x10^2$, b) $2.8x10^3$, c) $2.0x10^4$, d) $2.0x10^5$, e) $1.4x10^6$, f) $3.4x10^6$ cfu/mL.

## US Inactivation kinetics

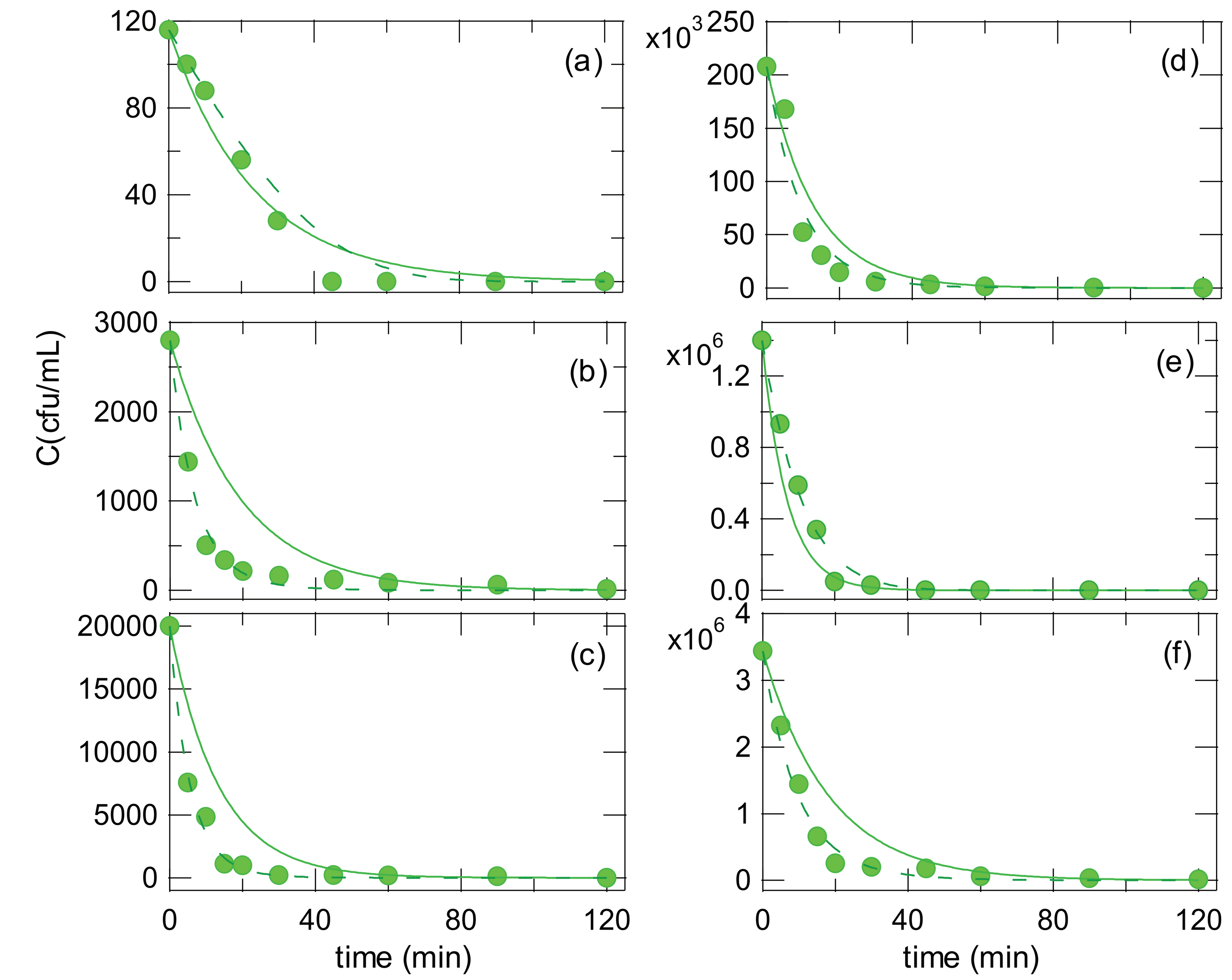


Fig. 3. *E.coli* CN13 concentration data (symbols) and fitted models (curves). The solid and dashed curves correspond to constant and time-dependent rate inactivation, respectively. a) $1.2x10^2$, b) $2.8x10^3$, c) $2.0x10^4$, d) $2.0x10^5$, e) $1.4x10^6$, f) $3.4x10^6$ cfu/mL.

## Conclusions

- Inactivation occurs very effectively by the use of US at frequency of 582 kHz.
- The time required to kill 90% of the organisms was approximately 20 min.
- The experimental data of the inactivation by US were satisfactorily represented by a pseudo-first order expression with time-dependent rate coefficients.
- The experimental data were represented better with the time-dependent rate coefficients than the constant coeficients.
- The inactivation rates varied between 0.043 - 0.077 $min^{-1}$ for the constant rate λ, except for the experiment with $C_o = 1.4x10^6$ cfu/mL, whereas the $\lambda_o$ is greater than 0.1 $min^{-1}$ for most of the experiments conducted.