Abstract

With the quality of water declining due to pressures from a growing population and industry, the increasing demand on water resources, and the controversies regarding the use of commonly used disinfectants in water treatment processes, it is necessary to research new water treatment processes. A potential process is the Cav-ox process which involves a combination of ultraviolet irradiation, addition of hydrogen peroxide and hydrodynamic cavitation. Cavitation is the formation and collapse of vapour cavities in a liquid. The collapse or implosion of these cavities creates high localised pressures and temperatures. Cavitation can be induced ultrasonically, hydrodynamically, optically and on a particle level. Hydrodynamic cavitation occurs when the flow conditions create pressure variations in a fluid. Ultrasonic cavitation involves the transmission of sound waves through a fluid resulting in alternate compression and rarefraction of a fluid due to pressure fluctuations, creating vapour cavities. In water, the implosion of the vapour cavities results in the formation of hydroxyl radicals. Ultrasonic cavitation can be used as a means of cell disruption and homogenisation and has been considered as a method of disinfection when combined with ultraviolet radiation. As the effects of ultraviolet irradiation and hydrogen peroxide on microorganisms are well known, the object of this investigation was to determine the potential of hydrodynamic cavitation (generated in a nozzle) for the treatment of potable water. Hydrodynamic cavitation can frequently be generated in existing systems without the need for additional power supply.

Initially a hydrodynamic cavitation rig was designed, built and evaluated in terms of nozzle flow characteristics, sound emission, cavitation number, hydrogen peroxide production and bactericidal effect. The cavitation numbers ranged from 0,5 to 0,03 and the sound pressure levels reached 82 dB at 4 000 Hz. At the same frequency, 58 dB of sound was emitted by the ultrasonic bath. Hydrogen peroxide production by the cavitation rig was below the detection limit of 0,06 mg/ℓ whereas 0,1 mg/ℓ of hydrogen peroxide was produced by the ultrasonic bath. The effect of hydrodynamic cavitation on raw water bacteria was determined by pumping raw water, obtained from Wiggins Water Treatment Plant, through the cavitation rig. Standard microbiological techniques were used to monitor any changes in the number of viable colony forming units over various periods and intensities of hydrodynamic cavitation. Control experiments were undertaken in which raw water samples were treated in an ultrasonic bath.

Hydrodynamic cavitation was found to be inappropriate for the inactivation of raw water bacteria for water treatment as no reduction in colony forming units was detected. However, scanning electron micrographs indicated that clumps of bacteria in matter became dispersed when hydrodynamically cavitated. Significant inactivation of raw water bacteria (1,6 to 2 log

reduction units) occurred after treatment in the ultrasonic bath. It was further concluded that due to differences in scale and residence time, the results from hydrodynamic cavitation were not directly comparable with those obtained from ultrasonic cavitation.

Experiments combining hydrodynamic cavitation and ultraviolet radiation were undertaken in order to assess whether the dispersal of bacterial clumps would enhance bacterial inactivation by ultraviolet radiation. It was concluded that there was no significant enhancement of inactivation compared to only ultraviolet radiation. UV alone reduced the population from 1,5 to 2,2 log units, and the combination processes resulted in similar log reductions (between 1 and 2 log units). The effect would be more pronounced in water containing a higher concentration of suspended aggregates.