ULTRASONIC DISINFECTION OF DRINKING WATER

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Abstract

Experimental tests were performed on surface water samples after coagulation - flocculation - settling treatment steps.

The main operating parameters of sonolysis experiments were as followings: ultrasound frequency 20 kHz (constant for all tests), sonolysis time 2 - 50 min., ultrasound energy 2000 - 8000 kJ, ultrasound amplitude 20 - 80%, hydrogen peroxide doses 2 - 10 mg H_2O_2/l .

Aerobic mesophiles bacteria (37 ^{0}C) content was measured and the best removal efficiency was 97% (initial content $9x10^4$ CFU/ml) for direct sonolysis and over 99,9% for hybrid sonolysis in case of short irradiation time.

Key words: *drinking water, sonolysis, aerobic mesophiles bacteria*

1. Introduction

Several methods are currently used for disinfection in drinking water treatment plants: chorination, ozonation, UV irradiation. Drinking water treatment flows are able to remove the majority of pathogenic microorganisms (bacteria, virus, protozoa) supplying a quality water, safe as long as treatment parameters are respected an the distribution network is no breach.

Chemical disinfection usually leads to reaction byproducts depending the followings factors: disinfectant type, disinfectant amount, reaction type, water temperature (high temperature accelerates reactions and higher amount of disinfectant will be necessary), pH (in case of chlorination a high value of pH favors formation of hypochlorite diminishing the efficiency of chlorine disinfection), content and concentration of organic substances in water.[1]

Chlorinationis the oldest water disinfection method and at the beginning it was performed with *sodium hypochlorite*. The usual doses are 3 - 5 mg/l making possible to have ~ 0,4 mg/l residual chlorine to the drinking water tank output (0.5 mg/l is the limit for the entrance to drinking water pipes network). In present days, this method is applyed in small local drinking water treatment plants because of simplicity an low cost of NaOCl dosing instalations. The disadvantages are related to degradation in the air and to hazardous an corrosive characteristics and arenot able to destroy Giardia and Cryptosporidium. Application of hypochlorite involve introduction of pH correction phase with chlorchydric or sulphuric acid.

Chlorination with *gaseous chlorine* is the most common method for water disinfection and for ammonia removal (break point chlorination) having the following advantages: high reactivity and very stable (chlorides) or very reactive (chlorchydric acid) products, relatively inexpensive.[1,2,3]

Chlorine disinfection properties are based on oxidizing action of free oxygent atoms(resulted from hypochlorite acid degradation) and on chlorine sustitution reaction. Chlorine disinfection has the best efficiency in pH = 5,5 - 7,5 domain and involves two phases: reaching of chlorination threshold by continuous adding of chlorine till the "water chlorine demand" value which depends on natural organic mater - NOM, iron and manganse content and disinfection itself (for this second step the amount of chlorine is very low 0,2 - 0,4 mg/). Trihalomethanes are secondary reaction products as a result of NOM and chlorine interaction. They are toxic compound for human. WHO recommendation for drinking water is to add maximum 5 mg/l chlorine both for optimal disinfection and tohave residual chlorine content in the network.

Chlorine dioxide has similar disinfection efficiency with gaseous chlorine having some advantages: pH wide domain pH = 4 - 10, smaller reaction time,more efficient to virus and prevents biofilm formation. ClO_2 doesn't oxidize ammonia ions and has the explosion risk at > 10% concentration in the air. It is very efficient together with ozone for Giardia and Cryptosporidium removal.[1]

2. Material and method

Surface water (Ciorogarla river) samples were used for ultrasonic disinfection after coagulation (Al_2SO_4) - flocculation (anionic flocculant) - settling treatment steps. Figure 1 shows the ultrasonic reactor in closed system.

Ultrasonic frequency was 20 kHz for all tests. The main operating parameters were: ultrasonic energy 2000 - 8000 kJ, ultrasonic amplitude 20 - 80%, reaction time 2 - 50 min., oxidant doses 2 - 10 mg H_2O_2/l. The initial bacteria content was 9 x 10^4 CFU/ml.

Hydrogen peroxide was introduce in the system (hybrid sonolysis US + H_2O_2) in order to diminish the disinfection time.

Four tests were performed in order to establish the influence of ultrasonic energy, amplitude, reaction time and oxidant dose. Disinfection efficiency was reported to the residual content of *aerobic mesophiles bacteria (37 ^{0}C).*

Fig. 1. Ultrasonic reactor - closed system

3. Results and discussions

The influence of ultrasonic energy (figure 1): amplitude 60%, disinfection time 5 min.

- the increase of ultrasonic energy from 2000 kJ to 8000 kJ leads to the increase of disinfection efficiency from 44% to 78%;
- the minimum bacteria residual content was 2 x 10^4 CFU/ml for 8000 kJ ultrasonic energy test.

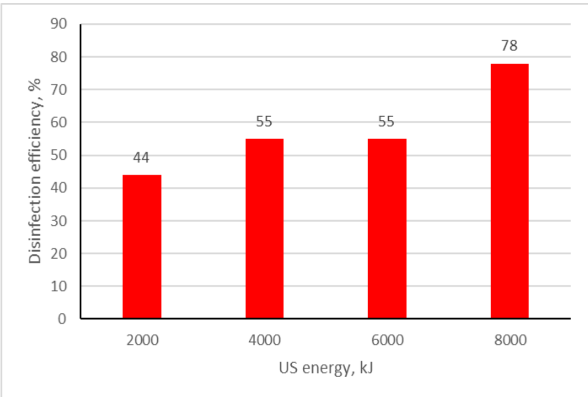

Fig. 2. The influence of ultrasonic energy

The influence of ultrasonic amplitude (figure 3): energy 8000 kJ, disinfection time 5 min.

- the increase of ultrasonic amplitude from 20% to 80% leads to the increase of disinfection efficiency from 67% to 78%;
- the minimum bacteria residual content was 2 x 10^4 CFU/ml for 60 - 80% ultrasonic amplitude test.

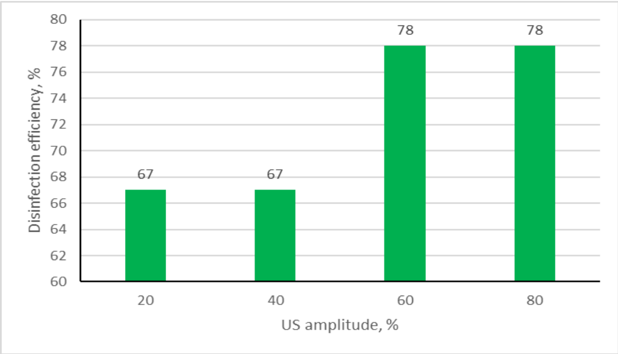

Fig. 3. The influence of ultrasonic amplitude

The influence of disinfection time (figure 4): energy 8000 kJ, amplitude 80%

- the increase of disinfection time from 2 min. to 50 min. leads to the increase of disinfection efficiency from 67% to 97%;
- the minimum bacteria residual content was 3 x 10^3 for 50 minutes disinfection time and 1 x 10^4 CFU/ml for 15 minutes.

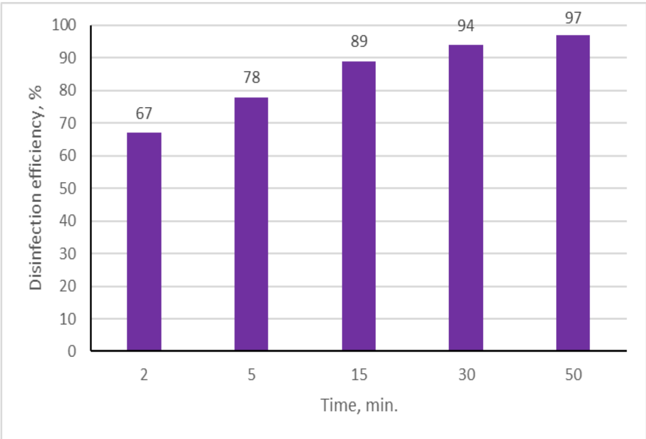

Fig. 4. The influence of disinfection time

The influence of hydrogen peroxide dose (figure 5): energy 8000 kJ, amplitude 80%, disinfection time 15 min.

- the increase of peroxide dose from 2 mg H_2O_2/l to 10 mg H_2O_2/l for thesame disinfection time leads to the increase of disinfection efficiency from 94% to 99.9%;
- the minimum bacteria residual content was < 100 CFU/ml for 10 mg H_2O_2/l dose.

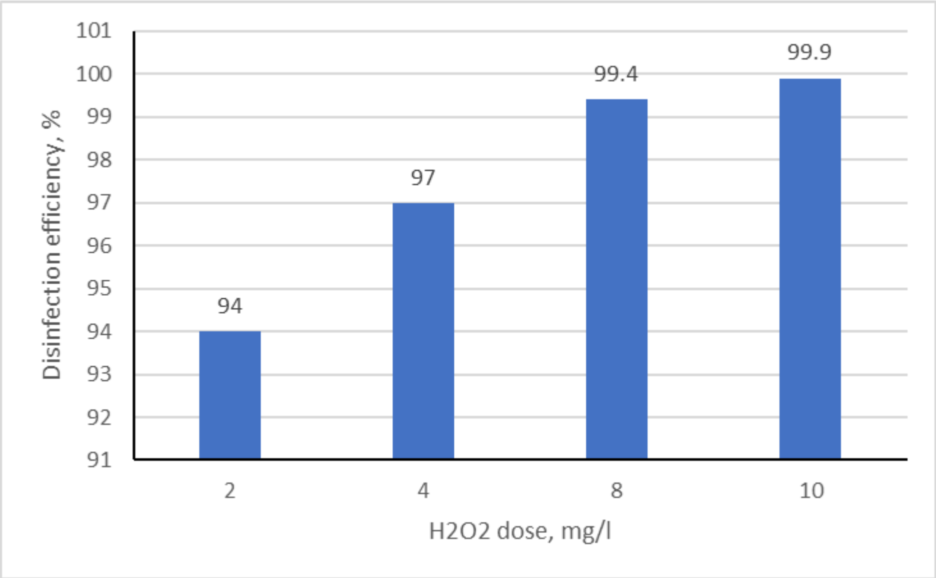

Fig. 5. The influence of hydrogen peroxide dose

4. Conclusions

The experimental tests of ultrasonic disinfection and hybrid sonolysis US + H_2O_2 emphasyzed that ultrasonic treatment of drinking water can remove bacteria content (aerobic mesophiles bacteria) up to 3 x 10^3 CFU/ml for long disinfection time - 50 minutes. Hydrogen peroxide adding (10 mg H_2O_2/l dose) allow the decreasing of bacteria residual content to < 100 CFU/ml for 15 minutes disinfection time.

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