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Optimization of ultrasonic parameters for effective detachment of biofilm cells in an actual drinking water distribution system

Key Words:
Biofilm; Drinking water distribution system (DWDS); DNA yield; DNA quality; Ultrasound treatment

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Research Background

Ultrasound is popular in separating cells from environmental attachments. Previous researches showed that ultrasound with too high energy would rupture cells, but with too low energy was unable to separate cells. However, but studies on the optimal ultrasonic parameters for biofilm in DWDS have rarely been seen.

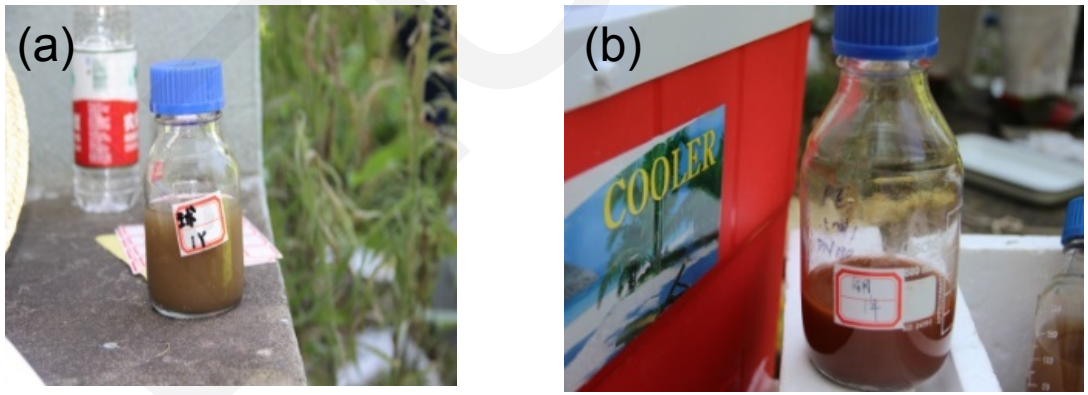


Fig.1 Biofilm samples from (a) cement-lined ductile iron cast pipe and (b) steel pipe in an actual DWDS.

Materials and Methods

Six levels from each ultrasonic parameter (Power, duration and number of ultrasound treatment)

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Pre-test (Selected monoculture biofilm)

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To narrow down the ranges

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Orthogonal experiment (DWDS biofilm)

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To determine the optimal conditions

↓

Verification (Actual DWDS biofilm)

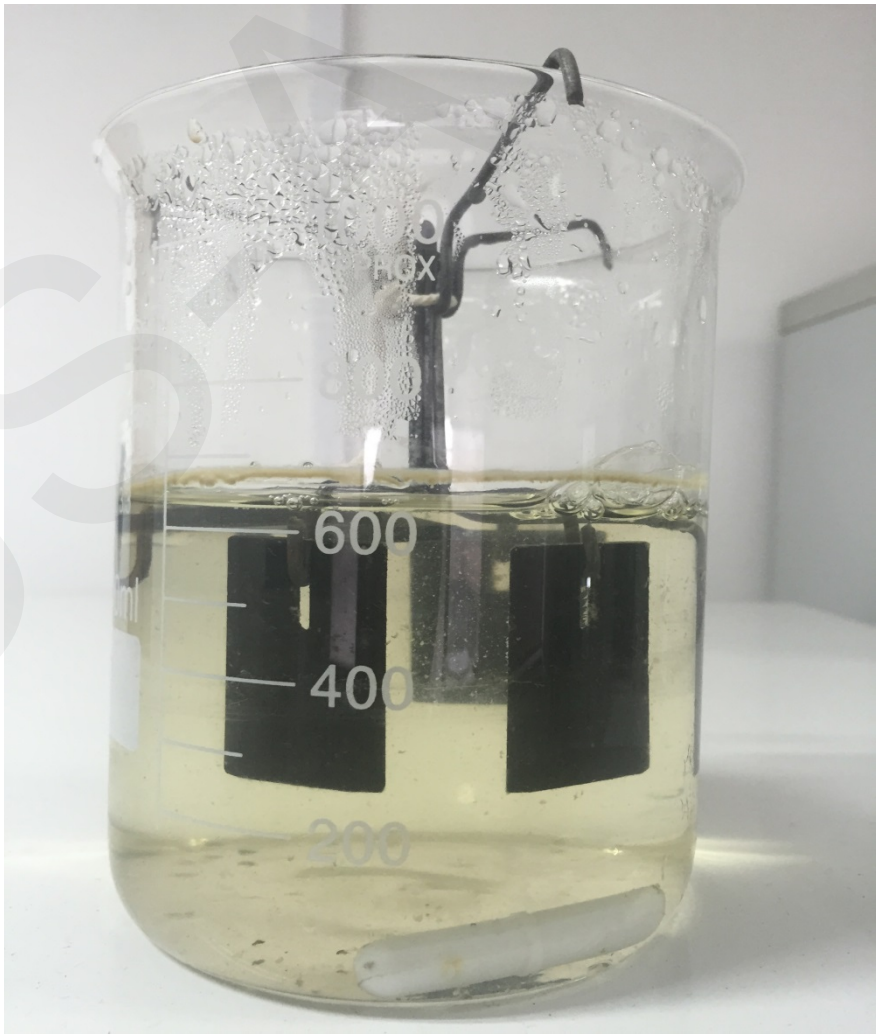


Fig. 2 Picture of the reactor.

Representative Results

■ **Range analysis after orthogonal experiment.**

Compare to other conditions, 15 ultrasound treatments with 13 W of power for 1 min each time is the optimal condition for biofilm detachment.

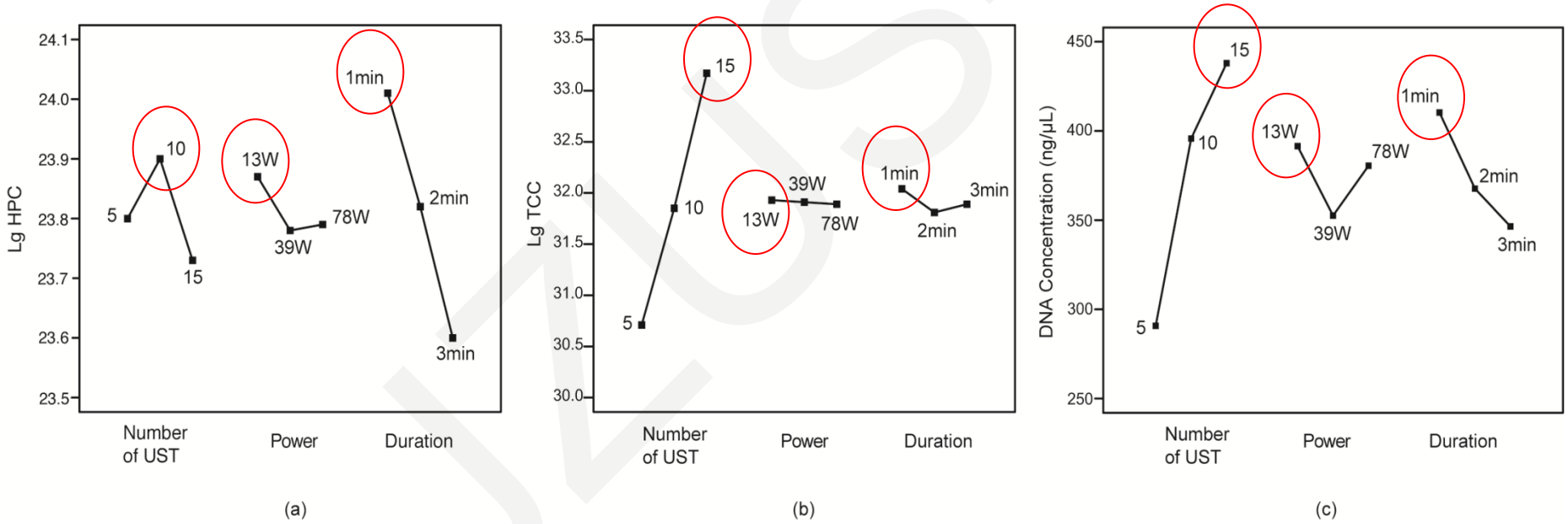


Fig. 3 Effects of number of ultrasound treatment, power and duration on (a) heterotrophic plate count, (b) total cell count and (c) DNA concentration.

Representative Results

■ **Verification using biofilm from an actual DWDS.**

The present optimal UST, which does not lose DNA quality, can increase the amount of extractable DNA by at least 4.78 times compared to samples without UST.

Table1 DNA extraction in samples from an actual DWDS with optimal UST and without UST.

Pipe material	Pipe age (Year)	Sampled area (cm^2)	With optimal UST		Without UST	
			HPC (CFU/cm^2)	DNA amount (μg)	HPC (CFU/cm^2)	DNA amount (μg)
Cement-lined ductile iron cast	3	1256	4.01×10^4	0.326	8.89×10^3	0
Cement-lined ductile iron cast	7-8	6280	3.22×10^4	2.15	2.32×10^4	0
Cement-lined ductile iron cast	7-8	3140	1.39×10^4	0.46	3.28×10^3	0.09
Steel	1-2	1256	7.83×10^4	3.2	4.19×10^3	0.67
HDPE	1	1256	5.84×10^3	2.01	3.18×10^3	0.08
HDPE	7-8	6280	3.84×10^4	1.34	1.61×10^3	0.05

Conclusions

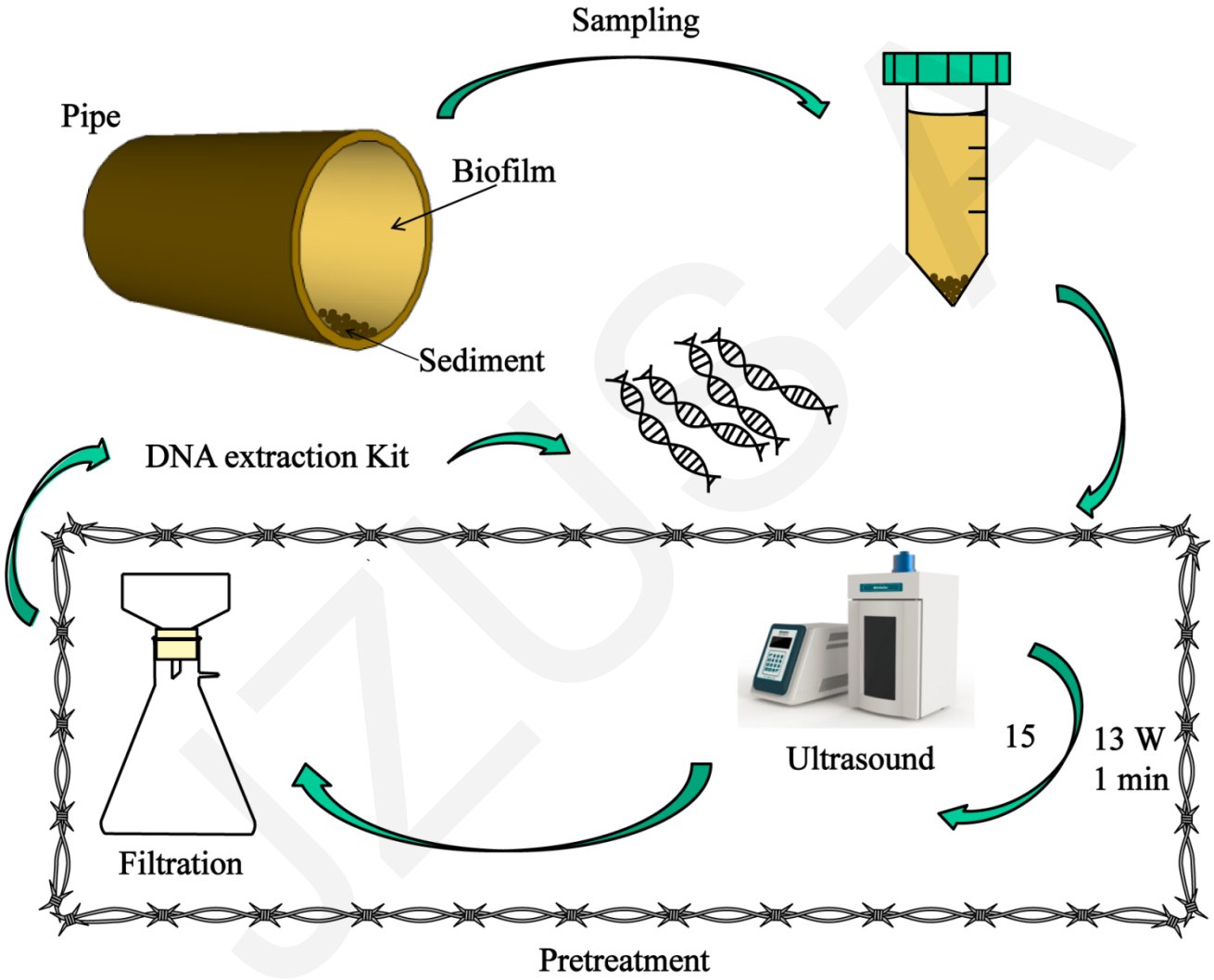


Fig. 4 The optimal ultrasound treatment for drinking water biofilm.