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Microbiological inactivation test Sensiblue

KWR
Watercycle
Research
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1 Method description

1.1 Introduction

Sensiblue is a small appliance for households, small offices, boats and caravans that purifies water with the aid of small amount of salt. As the water runs through the appliance, its flow produces a small amount of electricity that activates the salt to produce small amounts of chlorine, which in turn disinfects the water. So the amount of chlorine produced is proportional to the water flow. According to the supplier there is a threshold value of 2,5 l/min at which chlorine production starts and at 10 l/min the maximum amount of chlorine is produced. The free chlorine concentration that is produced is approximately 0,3 ppm.

According to the supplier the appliance is typically used in situations in which the local drinking water quality is unreliable, when own resources are used such as rain water/ground water or when drinking water is stored in tanks for a longer period like in boats, caravans or campers.

1.2 Inactivation test

To show the effectiveness of the Sensiblue appliance KWR performed an inactivation test with two types of micro-organism, *E. coli* bacteria and F-specific bacteriophages MS2, at such concentration levels that a 5 log removal can be determined.

The following method was used:

- Installation of a Sensiblue at the laboratory of KWR in Nieuwegein with instructions from the supplier.
- Start the Sensiblue with drinking water and run for 60 minutes on drinking water. Then switch the supply to a suspension with micro-organisms that is prepared in advance.
- Take a sample of the suspension flowing in and analyse on *E. coli*, MS2 bacteriophages.
- Set the water flow at 10 l/minute. Run for 2 minutes.
- Collect 2 liter of the water that is running out of the system in a flask and take a small sample for analysis of free chlorine.
- Take samples from the volume in the flask after 15 and 60 minutes, neutralise with sodium thiosulphate and analyse for *E. coli*, MS2 bacteriophages.

The test was performed on Wednesday May 23rd. For the test drinking water from the location in Nieuwegein was used. The characteristics of this water can be found in the appendix (production location Tull en 't Waal Vitens).

1.3 Analytical methods

Method for *E. coli* is equivalent to NEN-EN-ISO 9308-1 "Detection and enumeration of *Escherichia coli* and bacteria of the coli group – Part 1: Method with membrane filtration".

Method for F-specific RNA bacteriophages is equivalent to ISO 10705-1 "Water Quality – Detection and Enumeration of Bacteriophages, part 1 : Enumeration of F-specific RNA Bacteriophages", February 1997.

Method for free chlorine is equivalent to NEN-EN-ISO 7393-1"Determination of free chlorine and total chlorine – Part 1 Titrimetric method using N,N-diethyl-1,4 phenylenediamine.

2 Test results and conclusion

2.1 Results inactivation test

The test results are shown in table 1.

TABLE 1 RESULTS INACTIVATION TEST SENSIBLUE

	***E. coli* bacteria**	**F-specific RNA bacteriophages**	**free chlorine**
	cfu/l	pfu/l	mg/l
influent	$2.3*10^5$	$4.7*10^6$	
effluent 0 min			< 0,03
effluent 15 min	< 1	$2.9*10^5$	
effluent 60 min	5	$1.2*10^3$	
blanc water	< 1	< 100	< 0,03

pfu = plaque forming units; cfu = colony forming units

Additional information:

- Conductivity of the drinking water was 350 µS/cm, the conductivity of the water leaving the Sensiblue after 1 hour running fluctuated between 380 and 440 µS/cm suggesting sufficient production of free chlorine in the apparatus.
- Before and during the test, the supplier did his own measurements of free chlorine using a DPD chlorine test kit. With this method a concentration in the effluent (0 min) of approximately 0,24 mg/l free chlorine was measured. This value is higher than the value measured by KWR. The only explanation for the difference in the content of free chlorine between both methods is that the time lap from sampling to analyse of the sample at KWR is slightly longer (although the sample was transported to the chemical lab almost immediately and analysed shortly after arrival).

2.2 Calculation log removal

The log removal was calculated from the results in table 1. The results are shown in table 2.

TABLE 2 CALCULATED LOG REMOVALS FROM INACTIVATION TEST SENSIBLUE

	***E. coli* bacteria**	**F-specific RNA bacteriophages**
effluent 15 min	> 5.4	1.2
effluent 60 min	4.7	3.6

3 Discussion and conclusion

F-specific RNA bacteriophages are adequate model organisms for human enteric viruses in water and give an indication of the removal efficiency for these types of viruses. With the Sensiblue removal efficiencies for these types of viruses are in the order of magnitude of log 1.2 to log 3.6 after 15 minutes and 1 hour hold up time respectively.

E. coli bacteria are adequate model organisms of faecal contamination in general and of the potential presence of pathogens associated with wastewater or sewage sludge in water sources. Even after a short hold-up time of 15 minutes after treatment in a Sensiblue more than 5 log removal efficiency is found in this test. This corresponds to the high sensitivity of these type of bacteria for disinfection with chlorine.

Appendix I

Drinking water characteristics
Production location Tull en ‘t Waal

(In Dutch)

Vitens Laboratorium
Snekertrekweg 61
8912 AA Leeuwarden
relatiebeheer@vitens.nl

Pb. Tull en `t Waal
Reinwater Uitgaand

Periode : JAN - SEP 2017

Analysenaam	Eenheid	Gemiddelde	Minimum	Maximum	Aantal	Min.Wet	Max.Wet
Temperatuur in situ	°C	13.2	12.9	13.5	39		25.0
Zuurstof	mg/l	9.9	8.2	10.7	39	2.0	
Troebeling	FTE	0.23	<0.1	1.3	40		1.0
Zuurgraad (pH)	pH	8.01	7.88	8.13	39	7.00	9.50
Verzadigingsindex (SI) *		0.11	-0.11	0.25	39	-0.20	
Totaal Anorganisch Koolstof berekend	mg C/l	31	28	34	3		
Corrosie-index		0.11	0.093	0.13	3		
Theoretisch afzetbaar CalciumCarbonaat 90°	mmol/l	0.28	0.18	0.41	39		
Geleidingsvermogen bij 20 °C (EGV)	mS/m	24.2	20.7	27.0	39		125
Koolstofdioxide	mg/l	2.9	1.8	3.7	39		
Koolstofdioxide agressief	mg/l	<1	<1	<1	39		
Waterstofcarbonaat	mg/l	153	124	180	39	60	
Chloride *	mg/l	10	9	11	3		150
Sulfaat	mg SO4 / l	<2	<2	<2	3		150
Natrium (Na), na aanzuren	mg/l	13.7	12.8	14.6	3		150
Kalium (K), na aanzuren	mg/l	1.16	1.13	1.19	3		
Silicaat	mg Si / l	8.78	8.78	8.78	1		
Calcium (Ca), na aanzuren	mg/l	35.7	27.3	44.5	39		
Magnesium (Mg), na aanzuren	mg/l	5.96	5.32	6.55	39		
Totale Hardheid ****	mmol/l	1.13	0.90	1.35	39	1.00	
Totale Hardheid ****	°D	6.4	5.1	7.6	39	5.6	
Ammonium	mg NH4 / l	<0.03	<0.03	<0.03	10		0.20
Nitriet	mg NO2 / l	<0.01	<0.01	<0.01	10		0.10
Nitraat	mg NO3 / l	<1.0	<1.0	1.05	3		50.0
Fosfaat-ortho	mg PO4 / l	0.07	0.07	0.07	1		
IJzer (Fe), na aanzuren	mg/l	0.015	<0.01	0.025	10		0.200
Mangaan (Mn), na aanzuren	mg/l	<0.005	<0.005	<0.005	10		0.050
Aluminium (Al), na aanzuren	µg/l	17.1	10.9	31.8	21		30.0
Antimoon (Sb), na aanzuren	µg/l	<1	<1	<1	1		5.0
Arseen (As), na aanzuren	µg/l	<0.5	<0.5	<0.5	3		10.0
Barium (Ba), na aanzuren	µg/l	13.3	13.3	13.3	1		
Boor (B), na aanzuren	µg/l	21.6	19.8	22.9	3		500
Cadmium (Cd), na aanzuren	µg/l	<0.10	<0.10	<0.10	1		5.00
Chroom (Cr), na aanzuren	µg/l	<0.5	<0.5	<0.5	1		50.0
Koper (Cu), na aanzuren	µg/l	<0.5	<0.5	<0.5	1		2000
Kwik (Hg), na aanzuren	µg/l	<0.02	<0.02	<0.02	3		1.00
Lood (Pb), na aanzuren	µg/l	<0.5	<0.5	<0.5	1		10.0
Nikkel (Ni), na aanzuren	µg/l	<1.0	<1.0	<1.0	1		20.0
Seleen (Se), na aanzuren	µg/l	<0.5	<0.5	<0.5	3		10.0
Zink (Zn), na aanzuren	µg/l	<2.0	<2.0	<2.0	1		3000
Cyanide, totaal	µg/l	<2	<2	<2	3		50
Fluoride	mg/l	<0.05	<0.05	<0.05	3		1.0
Kleurintensiteit (455 nm)	mg Pt/Co/l	5.6	5.1	6.0	3		20
UV-extinctie	1 / m	4.8	4.6	4.9	3		
Totaal Organisch Koolstof (TOC)	mg/l	1.6	1.5	1.7	3		
Koloniegetal 22 °C **	kve/ml	5	<1	240	39		100
Coliformen 37° C ***	kve/100 ml	<1	<1	<1	39		0
Escherichia coli 37 °C ***	kve/100 ml	<1	<1	<1	39		0
Enterococcen ***	kve/100ml						
Clostridium perfringens ***	kve/100 ml	<1	<1	<1	3		0
Aeromonas 30 °C	kve/100 ml	<10	<10	<10	10		1000
Legionella	kve/l	<100	<100	<100	3		100

* *De norm is vastgesteld als rekenkundig jaargemiddelde.*
** *Het gemiddelde van Koloniegetal 22 °C is berekend als een geometrisch gemiddelde, ook de norm is een geometrisch jaargemiddelde.*
*** *Het gemiddelde van de Coliformen 37° C ,Escherichia coli 37 °C,Enterococcen en Clostridium perfringens wordt als mediaan weergegeven.*
**** *Normwaarde geldt uitsluitend bij toepassing van ontharding.*