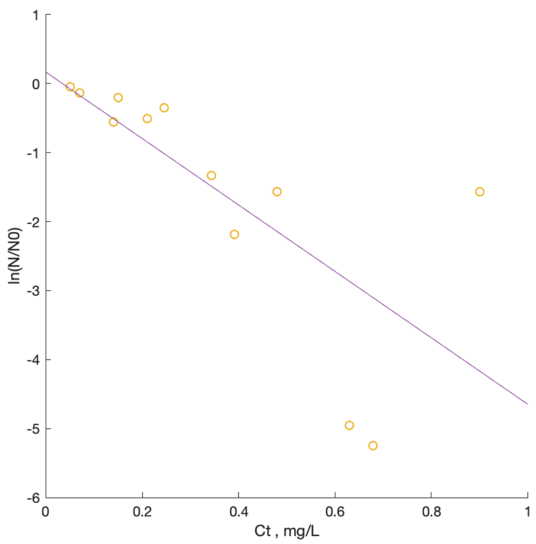
13-4

According to the Chick-Watson model

$C_{t,i} = C_i \times T_i$ and $In(N/N_0) = 2.303\ log(N/N_0)$

C , mg/L	Time	$Log(N/N_0)$	C_t	$In(N/N_0)$
0.05	1.00	-0.02	0.05	-0.05
0.05	3.00	-0.09	0.15	-0.21
0.05	4.90	-0.15	0.25	-0.35
0.05	9.60	-0.68	0.48	-1.57
0.05	18.00	-0.68	0.90	-1.57
0.07	1.00	-2.52	0.07	-5.80
0.07	3.00	-0.06	0.21	-0.14
0.07	4.90	-0.22	0.34	-0.51
0.07	9.70	-0.58	0.68	-1.34
0.14	1.00	-0.24	0.14	-0.55
0.14	2.80	-0.95	0.39	-2.19
0.14	4.50	-2.15	0.63	-4.95

The required plot is shown below, the relationship between In(N/N0) and Ct



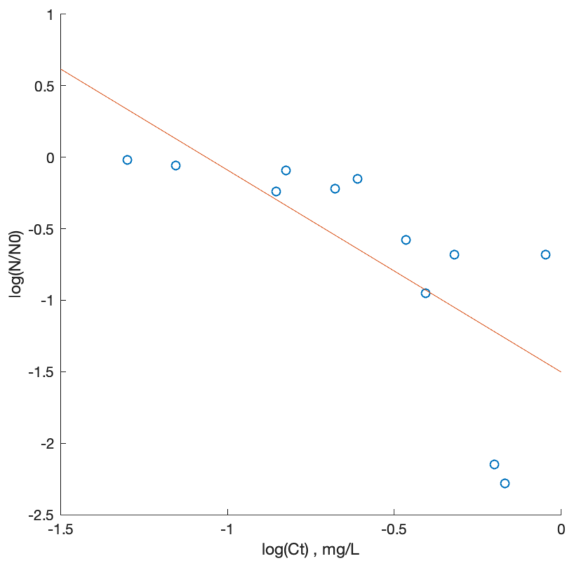
The expression of this line is $In(N/N_0) = -4.82C_t + 0.17$

Then $\Lambda_{CW} = 4.82\ L/mg{\cdot}min$

(2) Collins-Selleck models

C , mg/L	Time	$Log(N/N_0)$	C_t	$log(C_t)$
0.05	1.00	-0.02	0.05	-1.30
0.05	3.00	-0.09	0.15	-0.82
0.05	4.90	-0.15	0.25	-0.61
0.05	9.60	-0.68	0.48	-0.32
0.05	18.00	-0.68	0.90	-0.05
0.07	1.00	-0.06	0.07	-1.15
0.07	3.00	-0.22	0.21	-0.68
0.07	4.90	-0.58	0.34	-0.46
0.07	9.70	-2.28	0.68	-0.17
0.14	1.00	-0.24	0.14	-0.85
0.14	2.80	-0.95	0.39	-0.41
0.14	4.50	-2.15	0.63	-0.20

The required plot is shown below, the relationship between log(N/N0) and log(Ct)



The expression of this line is $In(N/N_0) = -1.41\ log(C_t) - 1.50$

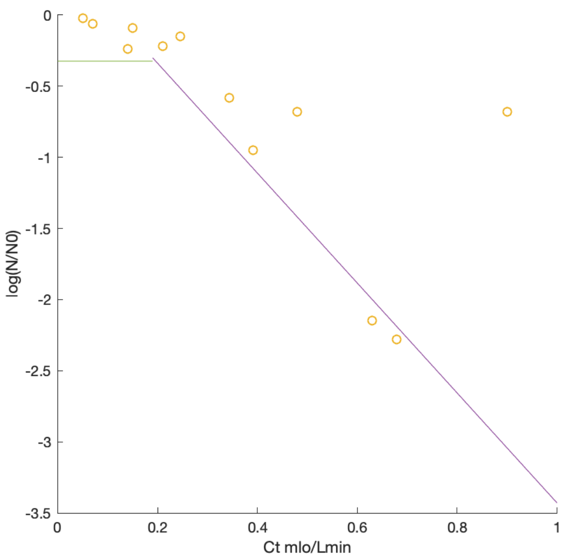
Then $\Lambda_{CW} = 1.41\ L/mg{\cdot}min$

As shown in this example, the Collins-Seeleck model was used effectively to model declining rate disinfection. Based on numerous studies, it has been found that the Collions-Selleck model can be used for a variety of organism-disinfectant combinations where both a declining rate of disinfection and a lag in disinfection are important.

(3) Rennecker-Marinas model

C , mg/L	Time	$Log(N/N_0)$	C_t	Model
0.05	1.00	-0.02	0.05	-0.32
0.05	3.00	-0.09	0.15	-0.32
0.05	4.90	-0.15	0.25	-0.32
0.05	9.60	-0.68	0.48	-1.42
0.05	18.00	-0.68	0.90	-3.04
0.07	1.00	-0.06	0.07	-0.32
0.07	3.00	-0.22	0.21	-0.32
0.07	4.90	-0.58	0.34	-0.89
0.07	9.70	-2.28	0.68	-2.19
0.14	1.00	-0.24	0.14	-0.32
0.14	2.80	-0.95	0.39	-1.08
0.14	4.50	-2.15	0.63	-2.00

The required plot is shown below, the relationship between log(N/N0) and log(Ct)



Through the calculation by MATLAB

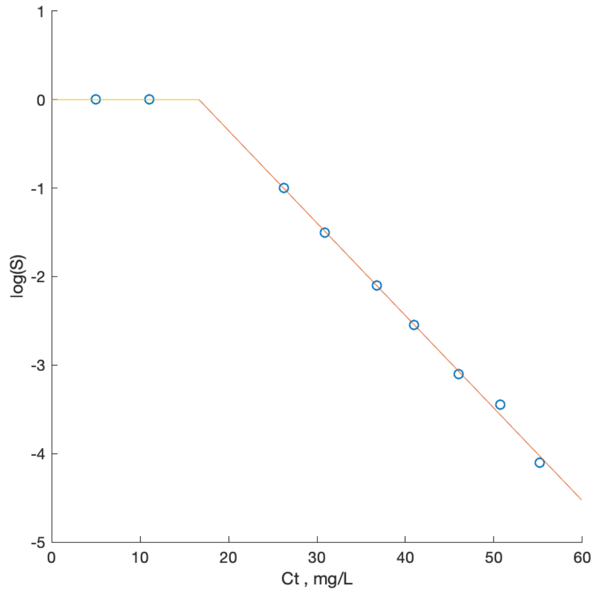
The lag coefficient $b = 0.324\ mg/L$

The coefficient of lethality $\Lambda_{CW} = (slope \times 2.303) = 8.89\ L/mg{\cdot}min$

13-5

C , mg/L	Time	$Log(N/N_0)$	C_t
1	5	0	5
1.1	10	0	11
1.05	25	-1	26.25
1.03	30	-1.5	30.9
1.05	35	-2.1	36.75
2.05	20	-2.55	41
2	23	-3.1	46
2.03	25	-3.45	50.75
5.02	11	-4.1	55.22

According to the Rennecker-Marinas model



Through the calculation by MATLAB

The lag coefficient $b = 16.64\ mg/L$

The coefficient of lethality $\Lambda_{CW} = (slope \times 2.303) = 0.23\ L/mg{\cdot}min$

13-7

According to the result of the 13-5

The relationship between the C_t and $log(N/N_0)$, based on the model of Rennecker-Marinas

$$f(log(N/N_0)) = \begin{cases} 0 & 0 < C_t < 16.64\ mg/L \\ -0.10C_t + 1.174 & C_t > 16.64\ mg/L \end{cases}$$

$log(N/N_0)$	C_t	Model result	Varies
0.00	5.00	0.00	0.000000
0.00	11.00	0.00	0.000000
-1.00	26.25	-1.00	0.000014
-1.50	30.90	-1.49	0.000109
-2.10	36.75	-2.10	0.000001
-2.55	41.00	-2.54	0.000027
-3.10	46.00	-3.07	0.001077
-3.45	50.75	-3.56	0.012872
-4.10	55.22	-4.03	0.004835

$$r^2 = 1 - \frac{\Sigma[Data - Model]^2}{\Sigma[Data - Data_{avg}]^2} = 0.98$$

As we can seen in the data sheet, when the C = 2.03 mg/L is the most varies.

13-12

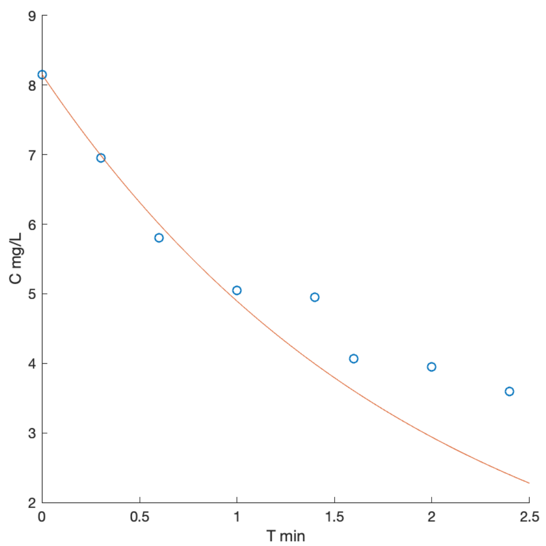
Fit the data to the first-order decay model and to the parallel first-order decay model, based on the Gurol and Singer 1982 model

For the first-order

T min	C mg/L	$\frac{dC}{dT}$	$\frac{dC/dT}{-C}$
0.00	8.15	0.00	0.00
0.30	6.95	-4.00	0.58
0.60	5.80	-3.83	0.66
1.00	5.05	-1.88	0.37
1.40	4.95	-0.25	0.05
1.60	4.07	-4.40	1.08
2.00	3.95	-0.30	0.08
2.40	3.60	-0.88	0.24
			$k_{avg} = 0.509\ min^{-1}$

Based on the first-order decay model

$$C = C_0 e^{-0.509 \cdot T}$$

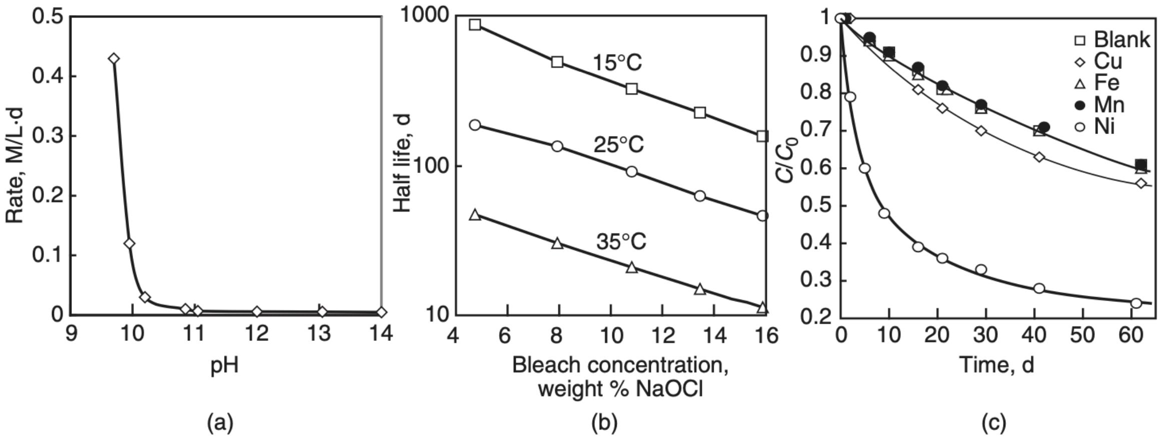


Another alternative is the parallel first-order decay model proposed by Hass and Karra (1984b, in which it is assumed that decay may proceed through two mechanisms, etch first order but involving a different component of the chlorine residual.

$$r_d = -xk_{d1}C - (1-x)K_{d2}C$$

13-16

According to the Fig 13-15 from the text book,

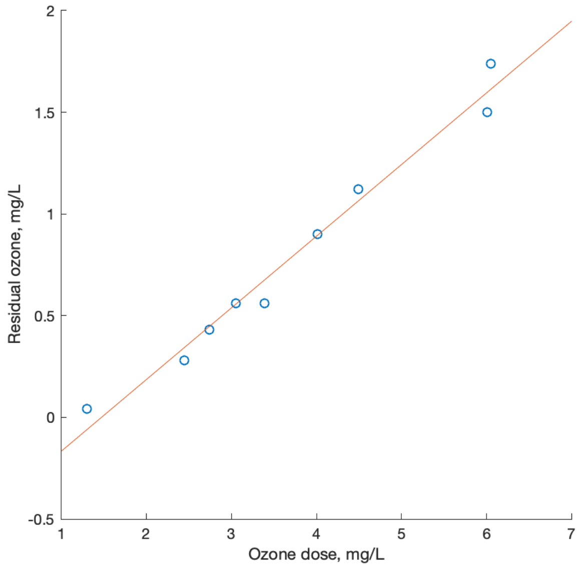


Factors that influence decay of sodium hypochlorite: (a) effect of pH on rate of decay of hypochlorite; (b) effect of temperature and concentration on decay of hypochlorite; and (c) effect of trace metals on rate of decay of hypochlorite. (Data from Gordon et al., 1993, 1995a,b.)

Under some conditions, the strength of hypochlorite can decline significantly in just a few days. In fact, stability is one of the major issues that must be addressed in both designing and operating a hypochlorite facility. A utility should not consider using hypochlorite unless it is prepared to dedicate time and energy to a regular program of monitoring and controlling its decay. Of considerable significance is the fact that, when hypochlorite does decay, chlorate ion is one of the principal by-products of the reaction. The stability of hypochlorite is affected by the strength of the solution, the storage temperature, the pH, and the contamination of heavy metals, which can catalyze its decay. Light is also a problem. As a general rule, the rate of decay is accelerated by (1) higher concentration, (2) higher temperature, (3) lower pH, (4) exposure to sunlight, and (5) the presence of certain heavy metals, notably copper and nickel.

13-18

Plot a curve of the ozone residual versus ozone dose



$$C_{residual} = 0.35C_{dose} - 0.52 = 0.35 \times (C_{dose} - 2.08)$$

the best-fit line parameters from the plot are a = 0.35 and $C_{demand} = 2.08\ mg/L$

When the $C_{residual} = 1\ mg/L$ and plug into the line then we can get

$$C_{dose} = 4.34\ mg/L$$

13-24

Review of the use of light emitting diode (LED) UV lamps for disinfection

Newly emerging LED UV lamps for disinfection is becoming a promising alternative technology for water treatment due to its many advantages. According to the research by Kai song et al 2015, the UV equipments not only shows a higher removal efficiency in the wastewater treatment but also it decrease the residual chemical disinfection materials in the system. On the other hand, the UV lamp have some shortages. Based on the article (Autin et al 2013), they states that the life-span of these UV lamps are usually 10000hrs and requires a amount of energy to maintain due to a low wall plug efficiency of around 15 - 35%. Commercial visible LEDs have been available for nearly 50 years and have diverse applications, especially in the lighting industry, due to the increasingly higher efficiency and lower cost (Ibrahim et al., 2014). Recently, the newly emerging UVLEDs have followed a similar track and are expected to be economically viable in the coming years (Harris et al., 2013).

Reference

[1] Song, K., Mohseni, M., & Taghipour, F. (2016). Application of ultraviolet light-emitting diodes (UV-LEDs) for water disinfection: A review. *Water research*, *94*, 341-349.

[2] Autin, O., Romelot, C., Rust, L., Hart, J., Jarvis, P., MacAdam, J., Parsons, S.A., Jefferson, B., 2013. Evaluation of a UV-light emitting diodes unit for the removal of micropollutants in water for low energy advanced oxidation processes. Chemosphere 92 (6), 745e751.

[3] Harris, T.R., Pagan, J., Batoni, P., 2013. Optical and fluidic co-design of a UV-LED water disinfection chamber. ECS Trans. 45 (17), 11e18.

[4] Ibrahim, M.A.S., MacAdam, J., Autin, O., Jefferson, B., 2014. Evaluating the impact of LED bulb development on the economic viability of ultraviolet technology for disinfection. Environ. Technol. 35 (4), 400e406.