Water Contaminant Information Tool
Pathogen Contaminant Profile - *Comprehensive Report Format*

➢ Data Package for *Yersinia pestis*

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Introduction

The Water Contaminant Information Tool (WCIT) was developed in support of the June 12, 2002 Public Health Security and Bioterrorism Preparedness and Response Act. The Act amends the Safe Drinking Water Act (SDWA), and specifies actions community water systems and the United States Environmental Protection Agency (EPA) must take to improve the security of the nation's drinking water infrastructure.

WCIT is a password-protected, online database for tracking and managing information and research on priority traditional and nontraditional water contaminants of concern to water security. Nontraditional contaminants are those that are not significant from a regulatory or operational perspective, but that could have substantial adverse consequences on the public or utility if accidentally or intentionally introduced into the drinking water.

The purpose of WCIT is to assist in planning for, and responding to, drinking water contamination threats and incidents. As a planning tool, WCIT can be used to support vulnerability assessments, emergency response plans, and the development of site-specific response guidelines. As a response tool, WCIT can provide real-time information about specific water contaminants to inform decision makers about appropriate response actions. A secondary objective of WCIT will be to identify knowledge gaps for priority contaminants, which will in turn, inform future research efforts.

WCIT contains information on more than 800 chemical, biological, and radiochemical contaminants. A number of contaminants are only linked to field and laboratory methods. The contaminants with profiles generally have the following information, when available:

- Contaminant summary, with key information on the fate and transport
- Name and forms including synonyms, degradation products, and by-products
- Physical property measurements and chemical formulas
- Availability of the contaminant and where it is likely to be found
- Properties and processes related to fate and transport
- Basic medical information (for example, treatment, vulnerable subpopulations, and exposure route)
- Lethal doses and other toxicity data
- Analytical methods, field tests, and sampling information
- Data on the treatment of contaminated drinking water
- Early warning signs that might indicate a contaminant's presence in a water system, including color, odor, pH, and toxicity tests

- Early warning signs in the environment when water is contaminated, including impact on local wildlife
- Contaminated wastewater treatment
- Infrastructure decontamination

Pathogen Data Provided

Data supplied in this package covers information about *Yersinia pestis* related to fate and transport in the environment, and information on inactivating it in drinking water.

The tables in this data package are in the same order as the tables listed in the WCIT Contaminant Profile - Comprehensive Report Format. The sections suggested for updates or new data are indicated in the headings for each page or in the tables.

Data and citations from primary scientific research papers are provided. In some cases, some references already had codes assigned by WCIT. When a search of all WCIT references (as of March 26, 2015) did not reveal that a source was included, a notation of "NEW REFERENCE – needs new code" has been included.

Because there have been no studies on inactivating *Yersinia pestis* in wastewater or infrastructure (including biofilms), no data have been provided in this update.

***YERSINIA PESTIS* - Properties Relevant to Fate and Transport**
Table: Properties Relevant to Fate and Transport > Other Information
NEW REFERENCES – need new codes

Properties Relevant to Fate and Transport		**References**
Other Information (Water)	The viable persistence of *Yersinia pestis* seeded in bottled spring water was evaluated by performing … studies that involved inoculating …different test strains into individual 500 mL reservoirs. Approx. 2 x 10^4 CFU/mL of *Y. pestis* was inoculated into each reservoir and held for sampling at 26 °C +/- 1 °C. ……9 strains (Harbin, Nepal, UNH 1A, UNH 1B, ZE94, CO92, PB6, PB6 DP, and Pexu) could no longer be recovered using a plate count assay between **79 and 138 days** post-seeding; other strains (K25 lcr, O19 Ca-6, and K25 pst) could no longer be recovered between **112 and 160 days** post-seeding. The data generated in this study demonstrate that certain strains of *Y. pestis* can remain viable in bottled water for extended periods of time. Data from both studies show that there is **variability in the viable persistence of the strains of *Y. pestis*** examined. It is also evident that all of the tested strains demonstrated extended survival times in a low-nutrient food matrix. However, ANOVA analysis did not indicate a statistical difference between virulent and attenuated strain persistence.	Torosian, S.D., Regan, P.M., Taylor, M.A., Margolin, A. 2009. Detection of *Yersinia pestis* Over Time in Seeded Bottled Water Samples by Cultivation on Heart Infusion Agar. *Canadian Journal of Microbiology,* 55(9):1125-9. **NEW CODE**
Other Information (Water)	Gilbert and Rose (2012) used culture-based procedures to determine the viability of *Y. pestis* A112 (low virulence) and *Y. pestis* AZ 94-0666 (virulent). When sterile tap water was held at **25° C,** both *Y. pestis* strains **were culturable until day 21**. When water was held at **5° C,** *Y. pestis* was **culturable for less than 2 days**.	Gilbert, S.E. and Rose, L.J., 2012. Survival and Persistence of Nonspore-forming Biothreat Agents in Water. *Letters in Applied Microbiology*, 55(3):189-194. **NEW CODE**
Other Information (Soil)	…. "we assessed the long-term preservation of live, virulent *Y. pestis* biotype Orientalis using a non-quantitative model of artificially inoculated soil and a mouse model of infection…. We herein demonstrate that *Y. pestis* 6/69M, a virulent Orientalis strain, remains viable and virulent after **40 weeks** incubation in sterilized humidified sand..."	Ayyadurai, S., Houhamdi, L., Lepidi, H., Nappez, C., Raoult, D., and Drancourt, M. 2008. Long-term Persistence of Virulent *Yersinia pestis* in Soil. *Microbiology,* 154(9): 2865-2871. **NEW CODE**

***YERSINIA PESTIS* - Properties Relevant to Fate and Transport**
Table: Properties Relevant to Fate and Transport > Other Information
NEW REFERENCES – need new codes
continued

Properties Relevant to Fate and Transport		References
Other Information (Water)	In this study, Pawlowski et al. (2011) showed that *Y. pestis* became **nonculturable by normal laboratory methods after 21 days** in 4° C sterilized tap water. In river water and artificial sea water, *Y. pestis* "**exhibited a lesser extent of decline in culturability after the 28 day period**."	Pawlowski, D.R., Metzger, D.J., Raslawsky, A., Howlett, A., Siebert, G., Karalus, R.J., Garrett, S., and Whitehouse, C.A. 2011. Entry of *Yersinia pestis* into the Viable but Nonculturable State in a Low-Temperature Tap Water Microcosm. *PLOS ONE,* 6(3): e17585. **NEW CODE**
Other Information (Water)	*Y. pestis* A1122 and other *Yersinia* spp. studied. *Y. pestis* shown to survive "**over 3 years"** in sterilized Niagara River water (NRW). In filtered NRW, however*, Y. pestis* "dropped to extinction within **265 days**" (< 1 year) because, it was overrun by a second bacterium, which was identified as *Hylemonella gracilis* – able to pass through even a 0.1 micron filter. …"observations clearly argue for the existence of a specific and sensitive interaction between *H. gracilis* and *Y. pestis*. However, we do not know the exact nature of the mechanism underlying this interaction. ….these data suggest an antagonistic relationship between these two bacteria that follows a classical predator/prey relationship … However, it is also possible that *H. gracilis* simply out-competes the surviving *Y. pestis* for recycled nutrients in the nutrient-limited microcosm, thus preventing dynamic *Y. pestis* turnover. In other words, as *Y. pestis* cells die, freeing nutrients for growth, *H. gracilis* may scavenge these nutrients more efficiently, thus preventing *Y. pestis* persistence…"	Pawlowski, D.R., Raslawsky, A., Siebert, G., Metzger, D.J., Koudelka, G.B., and Karalus, R.J. 2011. Identification of *Hylemonella gracilis* as an Antagonist of *Yersinia pestis* Persistence. *Journal of Bioterrorism and Biodefense*, S3:004. **NEW CODE**

***YERSINIA PESTIS* - Properties Relevant to Fate and Transport**
Table: Properties Relevant to Fate and Transport > Other Information
NEW REFERENCES – need new codes
continued

Properties Relevant to Fate and Transport		References
Other Information (Soil)	"As part of a fatal human plague case investigation, we showed that the plague bacterium, *Yersinia pestis*, can survive for at least **24 days** in contaminated soil under natural conditions….It is unclear by what mechanism *Y. pestis* was able to persist in the soil…These results are preliminary and do not address 1) maximum time plague bacteria can persist in soil under natural conditions, 2) possible mechanisms by which the bacteria are able to persist, or 3) whether the contaminated soil is infectious…	Eisen, R.J., Petersen, J.M., Higgins, C.L., Wong, D., Levy, C.E., Mead, P.S., Schriefer, M.E., Griffith, K.S., Gage, K.L., and Beard, C.B. 2008. Persistence of *Yersinia pestis* in Soil under Natural Conditions. *Emerging Infectious Diseases*, 14(6):941-943. **NEW CODE**

***YERSINIA PESTIS* - Drinking Water Treatment Effectiveness**

Table: Treatment Process Performance Summary – CHLORINE (recommend replacing current WCIT contents with the following information)

Disinfection – *Chlorine* [Rose, L. J., Rice, E.W., Jensen, B., Murga, R., Peterson, A., Donlan, R.M., and Arduino, M.J. 2005. Chlorine inactivation of bacterial bioterrorism agents. *Applied Environmental Microbiology*, 71(1): 566-568.] [1] JAEM2	
Drinking Water Treatment Performance [2]	Ct values for a 3-$\log_{10}$ reduction *of Yersinia pestis* ranged from 0.04 to 0.7. *Y. pestis* A1122 showed a Ct value of 0.7 for a 3-$\log_{10}$ reduction at 5 °C and a Ct value of 0.6 for a 3-$\log_{10}$ reduction at 25 °C. *Y. pestis* Harbin showed a Ct value of 0.04 for a 3-$\log_{10}$ inactivation at 5°C and at 25°C. The pH was 7 in this bench scale study.
Study Conditions Summary	The initial inoculum ($\log_{10}$ CFU) was 6.1 for *Y. pestis* A1122 at 5 °C and 6.4 at 25 °C; for *Y. pestis* Harbin at 5 °C and 25 °C it was 6.6 (for both). The effect of each chlorine concentration was tested in triplicate by using chlorine demand-free buffer (0.05 M KH2PO4; pH 7) and maintained at 5 and 25°C. Free available chlorine (FAC) and total chlorine were monitored by using DPD colorimetric analysis. The reported Ct values represent the mean of the Ct values calculated for each chlorine concentration. [3]
Process Performance Considerations	A 1992 survey of samples from 283 water utilities using chlorine reported a median residual of 1.1 mg/liter, and a median contact time of 45 min from the first point of use - from treatment facility to first access point in the water distribution system (median Ct value = 49.5) [Water Quality Disinfection Committee. 1992. Survey of water utility disinfection practices. *J. Am. Water Works Assoc.* 84(9): 1-128 **NEW REFERENCE – needs new code**.]. …. This study shows that viable *Yersinia pestis* would be reduced by more than 3 orders of magnitude under these median conditions if pH (7) and temperatures were similar to those in the present study.
Contaminant Byproducts	None mentioned.
Rating [4]	**Note: Needs to be assigned.**

[1] WCIT Reference "JAEM2" (Do not use "AEM7" or "JAEM-9" – they are incorrect variations on the "JAEM2" citation)

[2] In original WCIT in this section – mentions "methods of spore preparation" - **Note that *Yersinia pestis* <u>does not form spores.</u>**

[3] Decay curves were generated for each organism by using the $\log_{10}$-transformed data of the mean CFU counts at each time, temperature, and chlorine concentration. Linear regressions …..were performed to estimate the time needed for a 99 or 99.9% reduction in viable counts. The Ct values were calculated by multiplying inactivation times for a given temperature and percent inactivation by the chlorine concentration at that time. The reported Ct values represent the mean of the Ct values calculated for each chlorine concentration.

[4] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-$\log_{10}$] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-$\log_{10}$] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-$\log_{10}$] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-$\log_{10}$] inactivation of pathogens. **"Unknown"** means unknown.

YERSINIA PESTIS - Drinking Water Treatment Effectiveness

Table: Treatment Process Performance Summary- CHLORINE DIOXIDE

NEW REFERENCE – needs new code

Disinfection – *Chlorine Dioxide* [Shams, A.M., O'Connell. H., Arduino, M.J., and Rose, L.J. 2011. Chlorine dioxide inactivation of bacterial threat agents. *Lett. in Appl. Microbiol.* 53(2):225-230.] **NEW REFERENCE – needs new code.**	
Drinking Water Treatment Performance [5]	Two strains of *Y. pestis* were inoculated (10^6 CFU/ml) into a ClO_2 solution with an initial concentration of 0.25 mg/L at pH 7 or 8 at 5 °C or 25 °C. At 0.25 mg/L in potable water, both strains were inactivated by at least three orders of magnitude within 10 min. These strains "would be inactivated by at least 3-$\log_{10}$ while still in the treatment plant under the temperature and pH conditions used in this study." Even with the efficacy reduced at 5 °C, the disinfectant was sufficiently effective.
Study Conditions	Test solutions were prepared by adding an appropriate aliquot of concentrated ClO_2 stock solution to chlorine demand-free buffer (0.05 mol KH_2PO_4, adjusted to either pH 7 or 8 with 1 mol NaOH). ClO_2 test solutions (99 ml) were dispensed into three sterile amber glass flasks (250 ml) with glass stoppers. A positive control of 100 ml ClO_2 test solution and a negative control of 99 ml 0.05 mol KH2PO4 were prepared. All solutions were allowed to adjust to the required temperatures (5 °C or 25 °C) before testing began. Test solutions were inoculated by the addition of 1.0 ml of the bacterial suspension to each test flask and the negative control flask for a final test concentration of 10^6 CFU/ml.
Process Performance Considerations	These strains "would be inactivated by at least 3-$\log_{10}$ while still in the treatment plant under the temperature and pH conditions used in this study." Even with the efficacy reduced at 5 °C, the disinfectant was sufficiently effective…. In general, the efficacy of ClO_2 is considered to be better at lower water temperatures and higher pH (which is in contrast to optimal conditions for FAC) and that ClO_2 is an equal if not a better disinfectant than FAC ….At pH 7, the statement ….holds true, except when Ct values of FAC and ClO_2 are compared at pH 7, FAC appeared to be more effective (lower Ct values) than ClO_2 in reducing viability of *Y. pestis* Harbin by 3-$\log_{10}$ (NOTE: FAC data is from "JAEM2" = Rose et al. (2005).
Contaminant Byproducts	"Some disadvantages to the use of ClO_2 are the formation of the by-products chlorite and chlorate (maximum limit <1.0 mg/L), a higher production cost than chlorine and the need for specialized equipment on site, and it can cause unpleasant odors in homes near the treatment plant."
Rating [6]	**Note: This needs to be assigned**

[5] Decay curves were generated for each organism, temperature and pH tested using the log10-transformed data of the mean CFU counted at each sampling time. The time required to reduce viability of each organism by 2- and 3-$\log_{10}$ was estimated by linear regression … Because ClO_2 concentrations are expected to decline over the course of the experiment, the ClO_2 concentration at the time of a given log10 reduction was estimated by linear regression. The Ct values were calculated by multiplying the inactivation times by the estimated ClO_2 concentration at the specific inactivation time. Ct values for a 3-log10 reduction were compared using the Student's t-test and ⁄ or ANOVA with a significant $P \leq 0.05$.

[6] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-$\log_{10}$] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-$\log_{10}$] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-$\log_{10}$] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-$\log_{10}$] inactivation of pathogens. **"Unknown"** means unknown.

***YERSINIA PESTIS* - Drinking Water Treatment Effectiveness**

Table: Treatment Process Performance Summary – MONOCHLORAMINE (recommend replacing current WCIT contents with the following information)

Disinfection – *Monochloramine* [Rose, L. J., Rice, E.W., Hodges, L., Peterson, A., and Arduino, M. J. 2007. Monochloramine inactivation of bacterial select agents. *Applied Environmental. Microbiology,* 73(10): 3437-3439.] [7] **AEM-22**	
Drinking Water Treatment Performance	At 25 °C: *Yersinia pestis* A1122 isolates demonstrated a 2-$\log_{10}$ inactivation at a Ct value of 27.6 and a 3-$\log_{10}$ inactivation at a Ct value of 33.1; Y. *pestis* Harbin isolates demonstrated a 2-$\log_{10}$ inactivation at a Ct value of 21.9 and a 3-$\log_{10}$ inactivation at a Ct value of 25. Under typical conditions in distribution systems (see Process Performance Considerations), *Y. pestis* can be reduced by 3-$\log_{10}$ within 45 min if the water temperature is 15 °C or higher and the pH is maintained at 8.
Study Conditions Summary	Suspensions of *Y. pestis* were adjusted to 10^8 colony forming units (CFU) in 0.05 M KH2PO4 buffer at pH 8.0…In the present study, …. strains of *Y. pestis* were exposed to preformed monochloramine. Aliquots of 3 ml were removed from the test flasks at given times and placed immediately into tubes containing sodium thiosulfate to neutralize the disinfectant. Serial dilutions and spread plating were performed, plates were incubated at 25°C. CFU were counted and checked for up to 7 days after treatment. These studies were conducted at three temperatures representative of a range found within water distribution systems, 5 °C, 15 °C, and 25 °C (pH 8 for all temperatures). Ct values were calculated for 2-$\log_{10}$ and 3-$\log_{10}$ inactivation by linear regression of the appropriate segment of the decay curve.
Process Performance Considerations	The American Water Works Association found the median time to the first point of use to be 45 min for the 283 distribution systems responding to a survey [Water Quality Disinfection Committee. 1992. Survey of water utility disinfection practices. *J. Am. Water Works Assoc.* 84(9): 1-128 **NEW REFERENCE – needs new code**]. A second survey indicated that the median (and target) concentration was 2 mg/liter monochloramine at the average residence time in the responding distribution systems [Seidel, C.J., McGuire, M.J., Summers. R.S., and Via, S. 2005. Have utilities switched to chloramines? Results from the AWWA Secondary Disinfection Practices Survey. *J. Am. Water Works Assoc.* 97(10): 87-97 **NEW REFERENCE – needs new code**] … Authors estimated that an organism with a 3-$\log_{10}$ Ct of 90 would be inactivated by 3 $\log_{10}$ before the median first point of use (45 min) if introduced early in the distribution system when the monochloramine concentration is at least 2 mg/liter. *Y. pestis* can be reduced by 3-$\log_{10}$ within 45 min if the water temperature is 15 °C or higher and the pH is maintained at 8. With the Ct of *Y. pestis* Harbin at 25, then it would require 12.5 min to achieve a reduction of 3 $\log^{10}$ in a distribution system if water temperature and pH were similar to these test parameters (25 °C and pH 8). In general, monochloramine is a less effective disinfectant for all organisms tested when they are exposed at lower temperatures.

[7] WCIT Reference "AEM-22" (Note that "Rose" is an incomplete citation for AEM-22 listed in master WCIT reference list. Recommend deleting it.)

YERSINIA PESTIS - Drinking Water Treatment Effectiveness

Table: Treatment Process Performance Summary – MONOCHLORAMINE (recommend replacing current WCIT contents with the following information)
continued

Contaminant Byproducts	Monochloramine, though a less effective disinfectant than free chlorine, is being used increasingly as a secondary disinfectant because it is effective against microbial regrowth in the distribution systems and because of the tendency to form lower levels of the disinfection by-products (DBPs) closely regulated by the Disinfectants and Disinfection By-Product Rules. Fewer taste and odor complaints from consumers also make monochloramine use attractive. Disadvantages include problems with controlling excess ammonia to avoid nitrification and the need to control pH for better efficacy. Many treatment facilities have opted to use chloramines for residual disinfection and to alternate between FAC and monochloramine to control nitrification problems and biofilm formation, to boost disinfection efficacy, and to reduce DBPs.
Rating [8]	**Note: This needs to be assigned.**

[8] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-$\log_{10}$] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-$\log_{10}$] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-$\log_{10}$] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-$\log_{10}$] inactivation of pathogens. **"Unknown"** means unknown.

***YERSINIA PESTIS* - Drinking Water Treatment Effectiveness**
Table: Treatment Process Performance Summary - ULTRAVIOLET
NEW REFERENCE – needs new code

Disinfection – *Ultraviolet* [Rose, L.J. and O'Connell, H. 2009. UV Light Inactivation of Bacterial Biothreat Agents. *Applied and Environmental Microbiology,* 75(9):2987-2990.] NEW REFERENCE – needs new code.	
Drinking Water Treatment Performance	The inactivation results for *Y. pestis* reflect findings similar to those of other waterborne pathogenic organisms, such as *Escherichia coli*, *Shigella sonnei*, *Yersinia enterocolitica*, and *Campylobacter jejuni* … UV irradiation was performed by using a collimated beam apparatus equipped with a low-pressure lamp (254 nm): The fluence (mJ/cm^2) for 3-log$_{10}$ inactivation for *Y. pestis* A1122 was 3.7 and 4.9 for 4-log$_{10}$ inactivation. The fluence (mJ/cm^2) for 3-log$_{10}$ inactivation for *Y. pestis* Harbin was 3.2 and 4.1 for 4-log$_{10}$ inactivation.
Study Conditions Summary	Two *Y. pestis* strains were adjusted to 10^8 CFU/ml in Butterfield buffer (3 mM KH_2PO_4, at pH 7.2). … The suspensions were diluted 1:100 in Butterfield buffer for final test concentrations. Five milliliters of each suspension were placed into a small petri dish (50-mm diameter) along with a small sterile stir bar, and the petri dish was placed on a stir plate…. UV irradiation was performed by using a collimated beam apparatus equipped with a low-pressure lamp (254 nm). Each irradiation test was conducted at room temperature (23 ± 2°C) in triplicate. After 10-fold serial dilutions, the suspensions were plated and counted at 3 to 5 days…. A linear regression of the fluence response data determined the fluence required for 2-, 3-, and 4-log$_{10}$ inactivation.
Process Performance Considerations	None discussed.
Contaminant Byproducts	None mentioned.
Rating [9]	**Note: This needs to be assigned.**

[9] **"Highly effective"** means there are quantitative or qualitative data that suggest complete or almost complete removal (equal to or greater than 99.999% [5-log$_{10}$] or greater inactivation of pathogens. **"Effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.99% [4-log$_{10}$] inactivation of pathogens. **"Minimally effective"** means there are quantitative or qualitative data suggesting significant but not complete removal (equal to or greater than 99.9% [3-log$_{10}$] inactivation of pathogens. **"Not effective"** represents data or expert judgment that the process will not be effective (less than 99.9% [less than 3-log$_{10}$] inactivation of pathogens. **"Unknown"** means unknown.

YERSINIA PESTIS - Drinking Water Treatment Effectiveness

Table: Disinfection Values – CHLORINE (recommend replacing current WCIT contents with the following because of incorrect [C mg/L] values in the current WCIT)

Disinfection Values - *Chlorine*

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference (JAEM2) [10]
99.00	0.5	0.42	–	5	7	A1122 – initial inoculum 6.1 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	0.7	0.42	–	5	7	A1122 – initial inoculum 6.1 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.00	0.4	0.37	–	25	7	A1122 – initial inoculum 6.4 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	0.6	0.37	–	25	7	A1122 – initial inoculum 6.4 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.00	0.03	0.06	–	5	7	Harbin – initial inoculum 6.6 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	0.04	0.06	–	5	7	Harbin – initial inoculum 6.6 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.00	0.03	0.08	–	25	7	Harbin – initial inoculum 6.6 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.
99.90	0.04	0.08	–	25	7	Harbin – initial inoculum 6.6 (log_{10} CFU)	Rose, L. J., Rice, E.W., et al. 2005. *Appl. Environ. Microbiol*. 71(1): 566-568.

[10] WCIT Reference "JAEM2" (Do not use "AEM7" or "JAEM-9" – they are incorrect variations on the "JAEM2" citation)

***YERSINIA PESTIS* - Drinking Water Treatment Effectiveness**
Table: Disinfection Values – CHLORINE DIOXIDE
NEW REFERENCE – needs new code

Disinfection Values - *Chlorine Dioxide*

Inactivation (%)	Ct Value (mg-min/L)	ClO_2 mg/L	T (min)	Temp (°C)	pH	Notes Inoculum 10^6 CFU/ml	Reference
99.00	0.4	0.25	–	5	7	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.5	0.25	–	5	7	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.2	0.25	–	25	7	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.2	0.25	–	25	7	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.4	0.25	–	5	7	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.5	0.25	–	5	7	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.3	0.25	–	25	7	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.3	0.25	–	25	7	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.2	0.25	–	5	8	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.3	0.25	–	5	8	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.02	0.25	–	25	8	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.03	0.25	–	25	8	A1122	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.1	0.25	–	5	8	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.90	0.2	0.25	–	5	8	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
99.00	0.04	0.25	–	25	8	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.
9.90	0.06	0.25	–	25	8	Harbin	Shams, A.M., O'Connell, H. et al. 2011. *Lett. Appl. Microbiol.* 53(2):225-230.

YERSINIA PESTIS - Drinking Water Treatment Effectiveness
Table: Disinfection Values – MONOCHLORAMINE

Disinfection Values - *Monochloramine*

Inactivation (%)	Ct Value (mg-min/L)	C (mg/L)	T (min)	Temp (°C)	pH	Notes	Reference (AEM-22) [11]
99.00	92.0	–	–	5	8	A1122	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	115.6	–	–	5	8	A1122	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	71.4	–	–	15	8	A1122	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	86.4	–	–	15	8	A1122	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	27.6	–	–	25	8	A1122	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	33.1	–	–	25	8	A1122	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	80.7	–	–	5	8	Harbin	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	91.4	–	–	5	8	Harbin	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	33.5	–	–	15	8	Harbin	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	40.8	–	–	15	8	Harbin	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.00	21.9	–	–	25	8	Harbin	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.
99.90	25.0	–	–	25	8	Harbin	Rose, L.J., Rice, E.W. et al. 2007. *Appl. Environ. Microbiol*. 73(10): 3437-3439.

[11] WCIT Reference ”AEM-22” (Note that “Rose” is an incomplete citation for AEM-22 listed in master WCIT reference list. Recommend deleting it.)

***YERSINIA PESTIS* - Drinking Water Treatment Effectiveness**
Table: Disinfection Values – ULTRAVIOLET
NEW REFERENCE – needs new code

Disinfection Values - *Ultraviolet*

Inactivation (%)	Fluence (mJ/cm^2)	C (mg/L)	T (min)	Temp (°C)	pH	Notes Inoculum 10^8 CFU/ml	Reference
99.90	3.7	–	–	23 ± 2	7.2	A1122	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.
99.99	4.9	–	–	23 ± 2	7.2	A1122	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.
99.90	3.2	–	–	23 ± 2	7.2	Harbin	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.
99.99	4.1	–	–	23 ± 2	7.2	Harbin	Rose, L. J. and O'Connell, H. 2009. *Appl. Environ. Microbiol*. 75(9): 2987-2990.

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