The Influence Of Temperature On Full-Scale Inactivation Of Aerobic Endospores by Ozone

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INTRODUCTION

The surrogates (e.g., *Escherichia coli*) commonly used to monitor drinking water treatment are useless indicators of ozonation efficiency, as they are too sensitive to oxidants. Therefore, alternative indicators have been proposed (Toenniessen and Johnson, 1970; Payment and Franco, 1993). Among these, the endospores of aerobic bacteria (ABE) appear as the most appropriate. In addition to having a resistance to ozone comparable to that of *Cryptosporidium* oocysts (Owens et al., 2000; Kaymak and Haas, 2005), ABE are non-pathogenic, occur abundantly in surface waters (Rice et al., 1996; Facile et al., 2000) and are easily enumerated.

Along with water turbidity, pH and natural organic mater, temperature is the parameter that influences ozone disinfection more importantly (Elovitz et al., 2000; Dow et al., 2006). According to Driedger et al. (2001) and Larson and Mariñas (2003) the temperature influences the Chick-Watson equation rate constant (k) of ABE inactivation according to the Arrhenius relation.

However, most studies on this subject were done under conditions not reflecting site-specific kinetics of inactivation and, in addition, there is a need to differentiate the temperature effects on disinfection by ozone (Finch et al., 2001; Dow et al., 2006).

In this study the impact of temperature on ABE inactivation by Beliche drinking water treatment plant (DWTP) primary disinfection with ozone was examined over a three-month period. The DWTP, with a treatment capacity of 12 960 m^3/day, is located in Algarve (Portugal) and treats surface water. During the study, the influent raw water temperature decreased gradually from 19.1ºC to 12.9ºC. However, its matrix composition did not vary significantly.

METHODOLOGY

Raw and ozonated water samples (18) were analysed for ABE, Heterotrophic Plate Counts (HPC), temperature, pH, Total Organic Carbon (TOC), turbidity and residual ozone by using normalised methods. Ozone doses were estimated according to the USEPA CT_{10} concept (USEPA, 2003). Owing to the contactor geometry a conservative baffling factor of 0.5 was adopted.

To isolate the effect of temperature, only the samples which turbidity did not deviate by more that one standard deviation value (0.4 NTU) from the average (1.3 NTU) were used to compute the plotted k values (Fig. 1).

RESULTS AND CONCLUSIONS

Contrarily to HPC, ABE were invariably detected in ozonated water (≤50 mL). The inactivation of ABE (0.4 log to 1.6 log) occurred at temperature dependent rates and approached the Arrhenius relationship (Fig. 1).

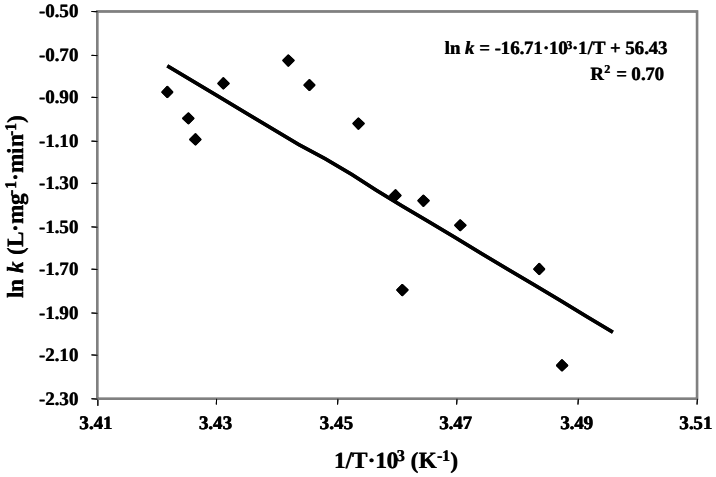

Figure 1. Arrhenius plot of aerobic endospores inactivation rate constants (pH = 7.4 ±0.1).

Contrarily to Mazoua and Chauveheid (2005), and in accordance with Owens et al. (2000), Drieger et al. (2001), Larson and Marinas (2003), and Dow et al. (2006), our results show that, like *Cryptosporidium* oocysts (Rennecker et al., 1999; Finch et al., 2001), ABE inactivation by ozone is strongly impacted by temperature. Accordingly, in winter coldest days (~13 ºC) Beliche typical ozonation doses (3.37 ± 0.80 mg·min·L^{-1}) may yield ABE inactivation efficiencies (66.1%; 0.5 log) ca. 33% lower than those (99.5%; 0.5 log) of summer warmest days (~21ºC).

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