Effects of residual chlorine on the mortality, grazing and respiration of *Labidocera euchaeta* (Copepoda)

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Abstract

In this study, the authors investigated the effects of residual chlorine on mortality, grazing and respiration of *Labidocera euchaeta* in laboratory. The grazing rate was evaluated by subtraction method of food concentration and respiration rate was measured using oxygen electrode. It was found that the lethal effect of residual chlorine on *L. euchaeta* increased with enhanced concentration and prolonged duration. The medium lethal concentration (LC₅₀) of chlorine for *L. euchaeta* in 24 h was about 0.58 mg/L and the safe concentration was about 0.21 mg/L. However, the grazing and respiration of *L. euchaeta* decreased by 32.6% and 18.9% when exposed to 0.2 mg/L residual chlorine for 4 h. It indicated that the physiological activities of zooplankton could be suppressed by the residual chlorine less than the safety concentration. Therefore, both survival and physiological activities of the organisms living in the thermal (nuclear) power plant discharging waters should be considered when carrying out the ecological risks assessment.

Key words: copepod, grazing, *Labidocera euchaeta*, residual chlorine, respiration, zooplankton

1 Introduction

Large amount cooling water for condensing boiler steam is used in the thermal power stations, the water passes through a system of condenser tubes (Porinima et al., 2006). In addition to the elevated temperature, the effluent discharges often contain biocides (commonly hypochlorite) to control biofouling of the cooling water system, such as mussels or bacteria (Nebot et al., 2006; Taylor, 2006). This water is initially screened through filters with approximately 1 cm meshes to remove materials which may otherwise block the condenser tubes. Therefore, the water in the cooling water system of power station contains holoplanktonic organisms and meroplanktonic organisms (Bamber and Seaby, 2004).

In the past, the effects of entrainment passage on planktonic organisms, with its extreme pressure, temperature and biocide concentration, have been studied at power stations, data on the survival of those organisms are available or detectable (Jiang et al., 2008; Liao et al., 2008; Zeng et al., 2005; Choi et al., 2002; Thiyagarajan et al., 2000; Bamber, 1995). Once the zooplankton species and abundances changed due to the effects of the residual chlorine from power station, the adjacent ecosystem may be weakened because the biodiversity is the base of ecosystem stability (Finke and Denno, 2004; Stenseth and Mysterud, 2002; Cushing, 1972).

Copepods are primary consumers and the most dominant zooplankton species in the ocean (Camus and Zeng, 2009; Feinbeg and Dam, 1998), are natural prey items for many developing larvae, postlarvae and juvenile fish and crustaceans (Chen et al., 2006; McKinnon et al., 2003; Pinto et al., 2001; Sun and Fleeger, 1995), typically account for 50% or more of their stomach contents (Stottrup, 2000). They linked the primary producer and secondary consumers by grazing and metabolism (Cushing, 1990; Klein Breteler et al., 1990), furthermore, their grazing plays an important role in shaping phytoplankton population dynamics during the blooms (Schulkes et al., 2006; Schnetzer and Caron, 2005; Mayzaud et al., 2002;).

*Labidocera euchaeta* Giesbrecht (Copepoda) is the dominant species in estuary and coastal waters of China, especially in the waters with lower salinities.
(Xu and Gao, 2009; Lin and Li, 1990). Most of the previous studies focused on the lethal effects of residual chlorine on the marine organisms with acute toxicity test (Jiang et al., 2008; Huang et al., 1999). However, the undetectable mortality in short residual chlorine exposure does not mean no toxic effects on the tested organisms. The physiological activities, such as grazing (Säwström et al., 2009; Nejstgaard et al., 2007; Turner et al., 1985) and respiration (Elena and Dominique, 2010; Coull and Vernberg, 1970) were more sensitive to stress factors than mortality. Therefore, the suppression of low residual chlorine on the physiological activities of the organisms could be detected in a short duration though they were not killed at all.

The increase of both temperature and contamination of residual chlorine had negative effects on zooplanktons (Nielsen et al., 2007; Dammaagd and Davenport, 1994; Marumo et al., 1992; Hart and McLaren, 1978). The effects of temperature on L. euchaeta have been reported (Jiang et al., 2009; Xu and Gao, 2009; Lin and Li, 1991). However, the effects of residual chlorine on L. euchaeta, especially on its physiological activities, have rarely been documented according to our knowledge. In this study, we investigated the toxic effects of residual chlorine on the mortality, grazing and respiration of L. euchaeta in order to provide more reasonable evidences for formulating the discharge standards of cooling water.

2 Materials and methods

2.1 Zooplankton sampling and preculture in the laboratory

Zooplanktons were collected with a plankton net (mesh diameter 0.112 mm) by horizontal hauling at surface water in the central area of Xiamen Bay (24°26’.778″N, 118°02’.363″E). The zooplankton was harvested at night in September 2009, when L. euchaeta was abundant and dominant in the area. After the samples were transported to the laboratory, they were separated by using mesh of 0.50 mm pore size (most of the organisms with body width more than 0.50 mm was L. euchaeta at this period) within 1 h. Then L. euchaeta was picked out and temporarily reared in an aquarium (5 L) at 20 °C and 40 µmol m⁻² s⁻¹ of cool-white light (12 L: 12 D) with the seawater (filtered with 0.22 µm filters) collected from the sampling site. A mixture (about 4.0×10⁴ cells/ml) of Chlorella vulgaris and Dicrateria sp. with similar amount was used to feed them. The dejection and dead individuals were removed, and half of the water was replaced with the same temperature seawater everyday to assure water quality. Healthy (actively moving around) individuals were used for the following experiments.

2.2 Preparation of residual chlorine solution

To completely consume reducible substance in seawater, certain amount of NaClO was added to the filtered seawater to reach 2 mg/L before the experiments starting according to documents (Jiang et al., 2008; Huang et al., 1999). The chlorine concentration in seawater was measured by using a residual chlorine analyzer (HANNA HI93701, Italy). When the chlorine concentration attenuated to 0.01 mg/L, the setting chlorine concentration was obtained by adding certain volume of 1 g/L NaClO solution to it.

2.3 Acute lethal experiment (24 h)

Thirty to fifty healthy L. euchaeta individuals were randomly selected from the temporarily reared aquarium and were transferred to a 100 ml beaker which contains 80 ml chlorine solution. The chlorine concentration was set as 0 (control), 0.1, 0.2, 0.3, 0.4, 0.6 and 0.8 mg/L and triplicates for each chlorine level. All the treatments was kept in darkness at 20 °C, then the dead individuals were counted and mortality was calculated at 2, 4, 6, 8, 10, 12, 16 and 24 h, respectively. The mortality was fitted by using polynomial regression equation (Y = ax² + bx + c). The residual chlorine concentration was measured again at the end of experiments to get the average chlorine levels throughout.

2.4 Calculating of medium lethal concentration (LC₅₀) and safety concentration (cₛ)

The average concentration of residual chlorine at the beginning and the end of experiments was set as weighting chlorine concentration. When the weighting chlorine concentration was plotted with the mortality at 24 h chlorine treatments, the LC₅₀ was got from the polynomial regression equation with 50% mortality of L. euchaeta. The safety concentration (cₛ) was calculated according to the equation of Mattice and Zittel (1976), i.e. cₛ = LC₅₀×Fₛ, where Fₛ(=0.37) is the abbreviation of safety factor.

2.5 Testing effects of chlorine on grazing of L. euchaeta

To eliminate the disturbance of dejecta chipping on the measurement of cell density, L. euchaeta were pre-starved for 24 h to clean up alimentary canal.