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The impact of water temperature on water quality indexes in north of Liaodong Bay

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ABSTRACT

The north of Liaodong Bay is one of the most severely polluted areas in Bohai Sea. Because the self-purification capacity from the sea water exchange process is limited, the pollutants from the land and river sources cannot be completed degraded and an obviously contaminated zone was formed in the north of Liaodong Bay. Therefore the self-purification capacity from biological process is essential for maintaining ecosystem balance. Marine heterotrophic bacteria play an important role in degradation of the dissolved organic matters and constitution of the primary production in the coastal areas. The shift of water temperature between winter and summer is about 28 °C in the north of Liaodong Bay, which causes changes in the self-purification capacity of the sea area. Certain indexes of water quality in Liaodong Bay were investigated in order to detect how these indexes response to the changing of water temperature. The experimental results show that COD, DO and the concentration of fecal coliform vary a little with the changing of water temperature; TBC increases dramatically when the water temperature is over 16 °C; and TBC in summer is 30 times more than that in winter. By this study, the paper provides a reference to assess the environmental purification capacity of the sea area during different seasons.

1. Introduction

The Bohai Sea is located at 37–41°N, 117.5–121.0°E, where the mean water depth is about 18.0 m. About 13,810 km^2 has been polluted to some extent, making up 18% of the Bohai Sea area (Fig. 1). Among which, the north of Liaodong Bay is one of the most severely polluted areas. The main pollutants include inorganic nitrogen, active phosphates and Petroleum (Dong et al., 2010), which have been identified as the primary contaminants by the Environmental Protection Agency of China (Luo et al., 2010). The Bohai Sea belongs to the medium monsoon climate area with cold and dry winters. Cold waves with strong northern winds often attack the sea area in winter, and the mean air temperature is usually under −15 °C in January), therefore, sea ice in Liaodong Bay is very heavy in winter (Ding, 1999; Kong and Chen, 2013) (Fig. 2). Due to the middle latitude, cold wave, shallow water and the semi-closed pattern of the sea area, the water temperatures in summer and in winter are obviously different, which is reflected in the fact that the temperature range of the surface sea water is from 27 °C to −1.7 °C (Zhang et al., 2013).

The enclosed tidal residuals are unfavorable condition for pollutant transport in the north of Liaodong Bay (Wei et al., 2001, 2002). The self-purification capacity from the sea water exchange process cannot afford to treat the pollutants from the land and river sources, the obviously contaminated zone was formed in the north of Liaodong Bay. From Fig. 1, the pattern of the distribution of water quality is related to the local discharge of land-source pollutants. In fact, the pattern does resemble that of the tidal residuals field in the north of Liaodong Bay. Therefore the self-purification capacity from biological factors is essential for a balanced ecosystem in the north of Liaodong Bay.

Marine heterotrophic bacteria play an important role in degradation of the dissolved organic matters and constitution of the primary productivity in the coastal areas, marine heterotrophic bacterial productivity makes up 10–80% of marine primary productivity, especially the percentage was up to 90 in some special sea area (Kirchman et al., 1995; Zhao, 2007). Even if in deep sea, the unique bacterial community is dominated by halophilic bacteria. Though long time adaptation to the environment, salt-adapted enzymes characterized by a high catalytic efficiency achieved in the deep sea water are the most critical metabolic requirement (Battisti, 1988; Luo et al., 2006). Microorganisms play an important role in environmental self purification at Liaodong Bay at the same time. Biodegradation is affected by the background surroundings, such as pH and temperature. The study of the direct introduction of selected bacteria to the soil sample from the wetland at Liaodong clearly demonstrated that the direct inoculation was an

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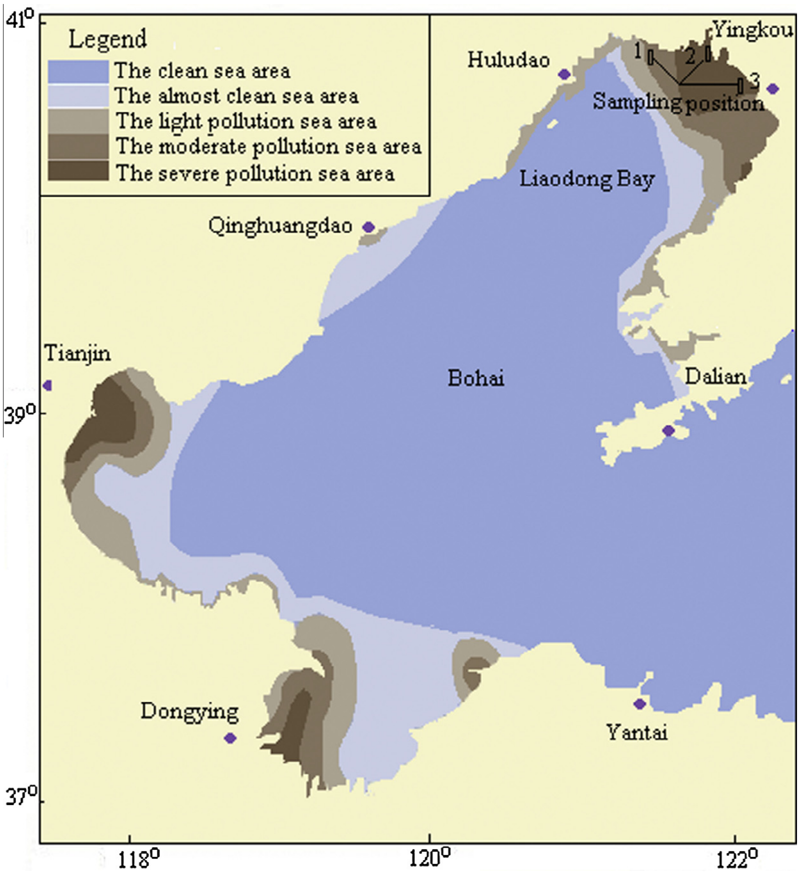

Fig. 1. Distribution of water quality in the Bohai Sea in summer of 2009 (The National Marine Environment Bulletin 2009).

effective way for bioremediation of the polluted environment (Ye et al., 2006).

Now more attention of marine self-purification capacity is drawn on changes of biological chemical conditions due to different water temperature in the north of Liaodong Bay. The seasonal variation of sea water temperature leads to different biological and chemical status, which means that the change of water temperature can have an effect on the marine self-purification capacity and water quality as well as marine primary productivity in this sea area. Regular tendencies of DO (dissolved oxygen) and TBC (total bacteria count) changing with the shift of water temperature in Liaodong Bay are determined in this paper.

2. Methods

The sampling positions were located by GPS. The water samples were taken from the surface layer (15 cm) at Liaodong Bay. In addition, the samples were obtained by penetrating the ice cover with an ice auger in winter (Fig. 3). The samples were put into colorless sampling bottles within 4 h (APHA,1992), and these bottles were preserved at an light-avoiding place and were remained unsealed, till the samples were tested.

DO is measured either in milligrams per liter (mg/L) or in percent saturation. Milligrams per liter are the amount of oxygen in a liter of water. Percent saturation is the amount of oxygen in a liter of water relative to the total amount of oxygen that the water can hold at that temperature (Kolawole et al., 2009).

The COD reflects the maximum oxygen uptake requirement of the process water. For all organic matter to be completely oxidized, an excess amount of potassium dichromate (or any oxidizing agent) must be provided (Clair et al., 2003). Once the oxidation is completed, the amount of excess potassium dichromate must be measured to ensure that the amount of Cr^{3+} can be determined accurately. To do so, the excess potassium dichromate is titrated with ferrous ammonium sulfate (FAS) until the entire excess oxidizing agent has been reduced to Cr^{3+}. Typically, the oxidation–reduction indicator, Ferroin, is added during this titration as well.

Once all the excess dichromate has been reduced, Ferroin indicator changes from bluish green to reddish brown. The amount of ferrous ammonium sulfate added is equivalent to the amount of excess potassium dichromate added to the original sample. COD can be also determined by boiling the water sample, with CO_2 ratio read by the infra-red analyzer. A solution of 1.485 g 1,10-phenanthroline monohydrate was added to a solution of 695 mg $FeSO_4\cdot 7H_2O$ in water, and the resulting red solution is diluted to 100 mL. COD is calculated by the formula: $\mathrm{COD} = 8000(b - s)n/V$, where b is the volume of FAS used in the blank sample, s is the volume of FAS in the original sample, n is the normality of FAS, and V is sample volume. If milliliters are used consistently as volume units, the result of COD calculation is given in mg/L.

The test of fecal coliform's concentration follows these steps. A 100 mL volume of a water sample is pushed through a membrane filter (0.45 μm pore size) via a vacuum pump. The filter is placed on a petri dish containing M-FC agar and incubated for 24 h at 44.5 °C (112.1 °F). This lifted temperature causes heat shocks for non-fecal bacteria and suppresses their growth. As the fecal coliform colonies grow, they produce an acid (through fermenting lactose) that reacts with the aniline dye in the agar, which gives the colonies blue color (Howell et al., 1996).

After performing a series of experiments, some index of water-quality were examined.

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