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Influence of geographic setting on thermal discharge from coastal power plants

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ABSTRACT

Characteristics of thermal discharge from three coastal power plants were studied in China. The three plants, Zhuhai Power Plant, Chaozhou Power Plant and Huilai Power Plant, are located in estuary, bay and open sea, respectively. The water temperatures and ocean currents surrounding the outlet of the three power plants were monitored. The results show that the temperature rise became smaller as the spread of thermal discharge moved toward the open sea, which confirms the results of previous studies. The results also indicated that the influence range of thermal discharge from a coastal power plant is determined by geographic setting. The temperature rise range of the Chaozhou Plant, which is located in a bay, was the largest, followed by that of the Zhuhai Plant located in an estuary, and the temperature rise range of the Huilai Plant located in an open sea was the smallest.

Considering coastal economic development and convenience of power plant water supply, the number of large thermal power plants in coastal areas has been rising in recent years in China. Coastal thermal power plants use sea water for cooling, discharging heated sea water back to the sea, which is a concern because these thermal effluents may cause undesirable changes to the marine environment (Lin and Zhan, 2000; Jin et al., 2003; Rousch et al., 2004; Araujo and Garcia, 2005; Chao et al., 2011). The increase in nearshore temperature caused by power plant thermal discharge affects phytoplankton community by increasing metabolic rates of organisms and reducing dissolved oxygen concentration (Poornima et al., 2005). The thermal discharge is influenced by currents (both velocity and direction), which have greater effects in winter due to low current speed (Zhang et al., 2013).

Research mostly focused on thermal discharge's influences on marine organisms and ecological environment (Saravanan et al., 2008; Chen et al., 2012; Li et al., 2014). These studies focused on simulation of thermal discharge diffusion using physical and numerical models (Webb and Nobilis, 1994; Hamrick, 2000; Poornima et al., 2001; Florentina and Joel, 2006; Yu et al., 2006; Zhu, 2008; Miao et al., 2010; Xu et al., 2010). Some studies pointed out that if the coastal power plant site selection is unreasonable, it will have harmful effects on marine ecological environment (Wu et al., 2005; Chen et al., 2008; Sun et al., 2008). But, studies of effects of coastal power plants on the ecological environment in different areas are limited. Based on field surveys of temperatures near three power plants, which are located in estuaries, bay and open sea, respectively, this study examines diffusion characteristics of thermal discharges in coastal plants in these three different areas. The main results are useful for site selection of future coastal power plant from the viewpoint of marine ecological environment protection.

1. Methods

1.1. Background of the plants

Located in the southwest of the Nanshui Peninsula of Zhuhai-Jinwan District, the Zhuhai Power Plant is about 6 km away from Gaolan Island (Fig. 1). The total capacity of the plant includes 2 × 700 MW + 2 × 600 MW + 2 × 1000 MW coal-fired power-generating units, and four units were built during the first stage of construction (January, 2008), with a total installed capacity of 2 × 700 MW + 2 × 600 MW and cooling water flow rate of 94.45 m^3/s. The units of 2 × 1000 MW were built in the second stage of the construction (November, 2010), with cooling water flow rate of 64.76 m^3/s. Circulating water pump house is arranged in the harbor basin of the coal wharf, just south of the plant. Units #1–4 and #5–6 all use the water from the basin. The thermal discharge is expelled at the northern end of the west bank barrier by drainage and open channel, which is about 60-m wide, 600-m long and 1-m deep. The power plant takes in surface water and uses surface discharge.

Located in the middle of Dacheng Bay, the Chaozhou Power Plant faces the sea in the south and is 10 km away from Nanao Island (Fig. 1). The planned capacity includes 2 × 600 MW + 2 × 1000 MW + 4 × 1000 MW supercritical coal-fired units, and 2 × 600 MW + 2 × 1000 MW was built in the first stage of the construction, which has been in operation with the drainage volume of 116 m^3/s.

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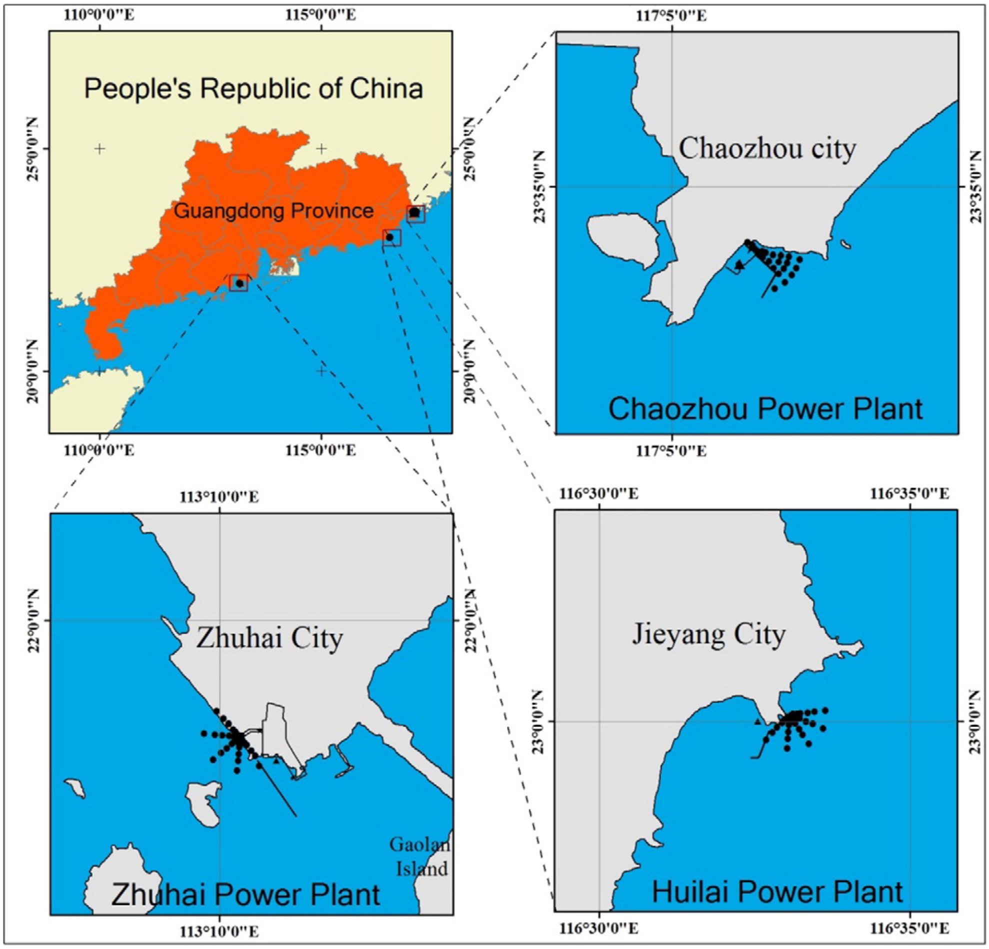

Fig. 1. Geographical location maps and survey stations of each plant.

The plant gets water from the basin on the west side of the plant, and the thermal discharge goes out to the levee through surface drainage and seeps from beneath the levee.

Located in the east of Jing Bay, 2 km away from eastern Jinghai town of Huilai County, the Huilai Power Plant faces the sea in the east, south and west, with hills to the north (Fig. 1). The planned capacity of the Huilai Plant includes 2 × 600 MW + 2 × 1000 MW + 4 × 1000 MW supercritical coal-fired units. The construction scale of the first stage is 2 × 600 MW + 2 × 1000 MW, and the 2 × 600 MW units have been built and put into use, and the water discharge is 48.64 m^3/s. The construction of the other two units of 1000 MW each has started. The plant diversion and drainage water is constructed at one time according to the planned total capacity. The water intake, which is bell-mouth shaped, gets water from the already-built comprehensive wharf basin. The circulating water and thermal discharge are expelled to the southern sea of the plant by underground drainage.

1.2. Sampling sites and methods

1.2.1. Sampling sites

To understand the diffusion characteristics of thermal discharges in different coastal areas, three plants were selected: Zhuhai Power Plant, Chaozhou Power Plant and Huilai Power Plant. They are located in an estuary, bay and open sea, respectively. Surveys of water temperatures near these plants were conducted.

The water temperatures surrounding the outlet of the Zhuhai Power Plant were monitored during July 12–13, 2009 (neap tide), July 29–30, 2009 (spring tide) and January 5–6, 2010 (spring tide). The outlet of thermal discharge of the plant was used as the origin (Station Z2), from which five monitoring sections fanned out. Sites along every monitoring section were 200 m apart, but the sampling spacing was reduced to 100 m near the outlet. Six sites were used along each section (Fig. 2A). In addition, temperature monitoring site R1 was placed at the intake.

The water temperatures surrounding the outlet of the Chaozhou Power Plant were monitored during November 19–20, 2009 (neap tide) and January 22–23, 2010 (spring tide). Layout of monitoring sites was centered around the outfall of the power plant, and the sites had different distances from the outlet. The sites along each monitoring section were generally 200 m apart, except when near the outlet where it was 100 m apart. (Fig. 2B).

The water temperatures surrounding the outlet of the Huilai Power Plant were monitored in September 2009 (spring tide) and September 2010 (neap tide). The origin of the monitoring station was the outlet, from which five monitoring sections fanned out. There were seven sites along each section. The sites along each monitoring section were generally 200 m apart, except when near the outlet where it was 100 m apart. The outermost site was 300 m away from the sixth site (Fig. 2C).

Water temperature observation was taken only at the surface when the water depth was less than 5 m. When the water depth was deeper than 5 m, both surface and bottom water temperatures were surveyed. (surface layer refers to the one that is 0–0.5 m below the sea surface, and the bottom layer refers to the water within 1 m from the bottom of the sea.) The temperatures were observed for 26 h continuously, and data were recorded once every two hours.

Water temperature was determined using oceanographic reversing thermometer. The reversing thermometer was mounted on the Water Sampler when used to observe temperatures. After 7–10 min of