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Ecological engineering restoration of a non-point source polluted river in Northern China

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A B S T R A C T

River restoration is the re-establishment of a river to a state that is more reflective of its predisturbance form. To restore a river polluted by human interference, we conducted an ecological restoration study from 2009 to 2011 on parts of the Yitong River, which is a typical non-point source polluted river in Northern China. The engineering included three parts: riparian vegetation buffering strip (part 1); multi-functional ecological fishponds (part 2), and river channel enhancement zone (part 3). By monitoring and evaluating the pollution indices of the study area's inlet and outlet, we found that the ecological engineering could significantly enhance the reduction rate of NH_3-N, COD, and BOD_5, which had increased from −14.29%, 1.81%, and −0.5% before restoration to 66.29%, 10.81%, and 7.25% in 2011 (post-restoration), respectively. The diversity of planktonic algae became rich, and in particular the species number representing clean water increased from 1 before restoration (2009) to 8 after the restoration (2011). Our results indicate that ecological engineering can significantly reduce non-point source pollution and improve the water quality, biodiversity, and economic benefits, and it is therefore an effective scientific approach for restoring the integrity of the river ecosystem and achieving continuous social and economic development.

1. Introduction

Polluted water has long disrupted Chinese ecosystems, as enormous economic progress in China has occurred at the expense of river ecosystem service. To improve the river water quality and restore the ecosystem to health, it is important to control the pollution source, adjust the river ecosystem structure, conduct water flow regulation, and improve the river's self-purification capacity (Dong et al., 2009). The studies on techniques of source pollution control have been given more attention and presented many achievements (Han and Zhu, 2001; Katko et al., 2005; Mrayyan and Hussein, 2004). In contrast, due to limitations in technology and economics, it has been difficult to carry out non-point source pollution control in the wide suburban regions. In developing countries, non-point source pollution has become one of the important causes of damage to river ecosystems (Zhang et al., 2004; Lu et al., 2007; Tu et al., 2010). Although the goal of many restoration projects is mitigate negative effects, not all are focused on the ecological function of the system, especially reduction of river pollution. For instance, deep pools and shallows have been built using groyne to provide living space for aquatic organisms; waterfall facilities have been built to promote water flow and vitality; hard revetments have been removed to improve the hydraulic connectivity between river and riverside (Zhao et al., 2008; Mi et al., 2010). These measures could improve the structure of the river system, in varying degrees, but those projects were completed mostly in urban areas; in fact, there has been little focus on non-point source polluted rivers in rural areas.

The river ecosystem is a unique link for all land ecosystems within the basin, by which a complex, open, and dynamic system is formed. Ecological river restoration focuses on restoring and/or improving river ecosystem structure and function, that is, on improving the ecological integrity of the system (Murdock, 2011). However, this type of restoration has been largely ignored in past research, especially in terms of river hydrology restoration. In particular, coordination between the ecological restoration of

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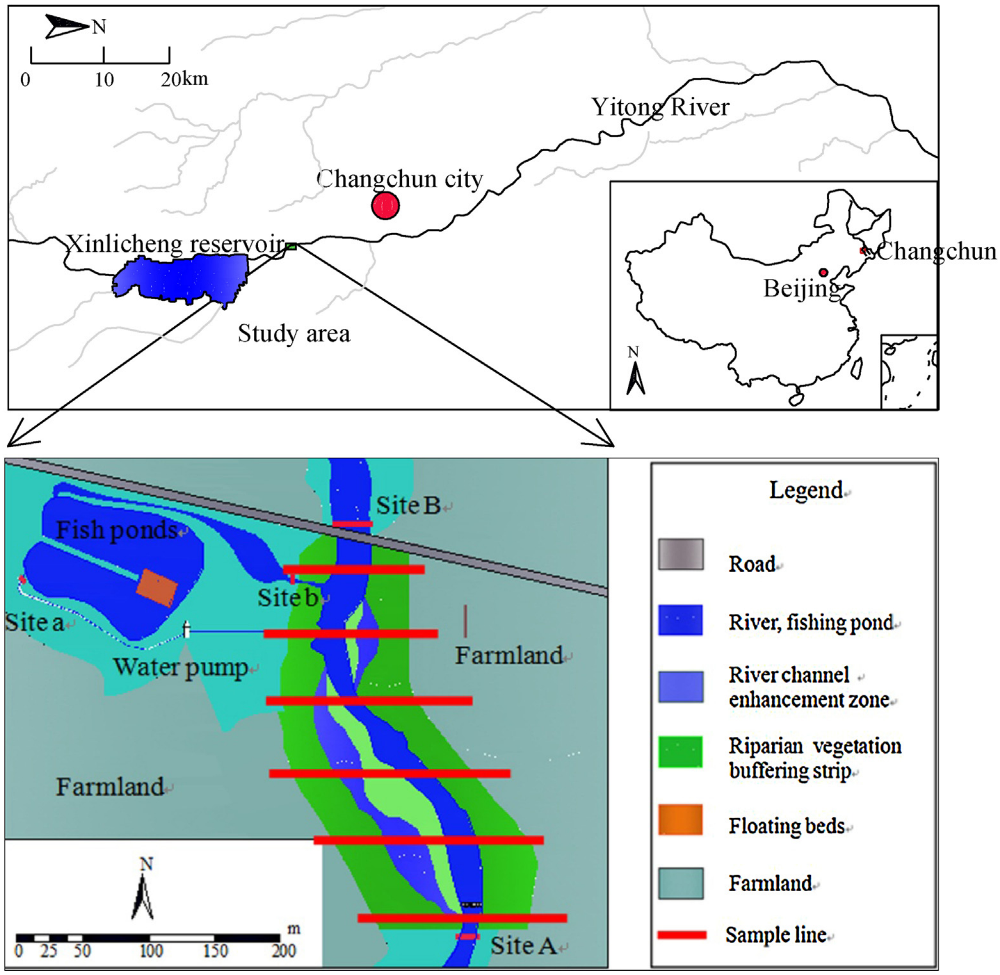

Fig. 1. Location and range of the study area (Site A is the inflow sample site of the studied river section; Site B is the outflow sample site of the studied river section; Site a inflow sample site of the fish pond; Site b is the outflow sample site of the fish pond).

rivers and the development of society and the economy has seldom been considered, which, in turn, has limited the self-purification—and consequently the maintenance of rivers, especially in developing countries.

The Yitong River is an important branch of the Songhua River, with a full length of 342.5 km and a total basin area of 8440 km^2 (Zhu, 2007) (Fig. 1). The Yitong River is also an important water source for Changchun City, the capital of Jilin Province. In the early 1960s, a large reservoir was constructed in the upstream of Yitong River. Due to increase of water quantity consumption in Changchun at the end of 20th century, there was a sharp decrease in the downstream flow (Fig. 2). Until recent years, when water flow has been regulated, the water flow increased during the summer season. The Yitong Basin is also a major food-producing region in Northeastern China, with a large area of land receiving fertilizers and pesticides. Due to lack of, or damage to, riparian vegetation, an excessive amount of fertilizers and pesticides is brought directly into the river by surface runoff, which in turn exacerbates the river pollution (Fig. 2). Hence, the Yitong River is one of the heavily polluted branches of the Songhua River (Cong, 2010; Tang et al., 2010). Based on the geographical, hydrological, and water quality characteristics of the river, as well as the fish ponds and residents in the riparian, we selected a typical region of this area to carry out ecological restoration engineering of the river. By constructing a riparian vegetation buffering strip, multi-functional ecological fishponds, and a river channel enhancement zone, we developed an economical, efficient, and multi-functional river water quality repair system. Our study provides a demonstration for water quality improvement of non-point source polluted rivers and the continuous utilization of local resources in northern China.

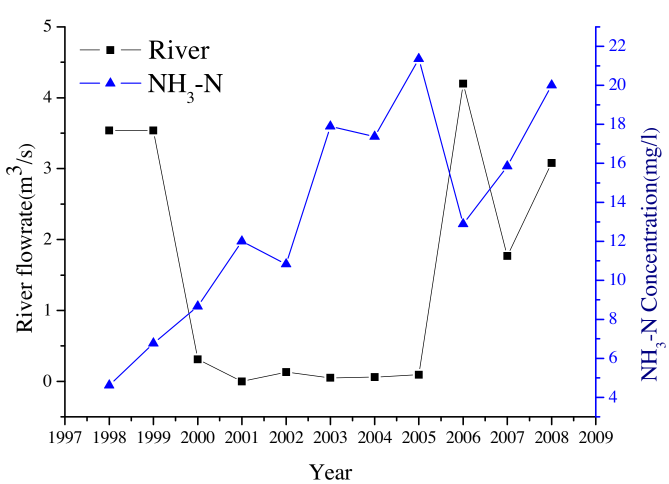

Fig. 2. River flow rate and NH_3-N concentration change of Yitong River (1997–2009) (river flow rate was measured on the site of the Xinlicheng reservoir dam, which is a hydrographic station, and concentration of NH_3-N was measured at 5 km downstream of the study area, which is the site for regular water quality monitoring).