Groundwater-table and recharge changes in the Piedmont region of Taihang Mountain in Gaocheng City and its relation to agricultural water use

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Abstract

Rapid groundwater drawdown in Gaocheng City, the alluvial plain of the Taihang Mountain in the North China Plain, has become the biggest threat to agricultural sustainability. In order to determine the factors resulting in the groundwater decline and to develop a practical plan for long-term groundwater use, water-table fluctuation data were collected over a period of 25 years. The analysis showed that although the drawdown of the water-table was mainly due to water used for winter wheat production and other crops, another reason for groundwater level decline was the tremendous decline of upstream groundwater recharge. It was estimated that, compared to the 1970s, decrease in upstream groundwater recharge in the 1990s resulted in about 1.2 m/a of groundwater level decline. Thus, decline of upstream groundwater recharge rather than agricultural water use was the main reason for the recent groundwater drawdown. On the other hand, gradually improved agricultural practices have saved a great deal of water since the 1970s. The analysis also revealed that, although the groundwater level declined during the wheat-growing season, corn-growing season and over the whole year strongly correlated with the amount of precipitation in that period, aside from one year of extremely high precipitation, precipitation did not recharge groundwater directly but affected groundwater levels through a decrease in irrigation water use. Finally, in order to maintain the groundwater balance, agricultural practices have to save about 180 mm/a of irrigation water from their present level.

Introduction

The North China Plain (NCP) is one of the most important agricultural regions in China. Each year, it produces more than 20% of China's grain (China's Agricultural Statistics Edition Committee, 1999; Huang, 1989). Water shortage is a serious problem, threatening the long-term agricultural and industrial development and even the long-term food supply of the whole of China (Liu and He, 1996, Lester and Halweil, 1998). In Haihe Plain, the northern part of the NCP, where some big cities such as Beijing, Tianjin, and Shijiazhuang are located, water/cap·a is only about 359 m^3 (calculated from the data of Liu and He, 1996), which is far lower than 1 000 m^3/cap·a, a benchmark of water scarcity recognised by world organisations and also in China (e.g. IPCC, 1996; National Sustainable Development Research Group of the Chinese Academy of Sciences, 2000). Rapid groundwater-table decline caused by overpumping of groundwater for irrigation is taking place in more than 40 000 km^2 (Chen, 1999; Hebei Department of Water Conservancy, 1998; National Bureau of Environmental Protection, 2000), which is estimated to be the largest groundwater drawdown area in the world (Chen et al., 2000). In addition, in the face of rapid population and economic growth (National State Department, 1996; National Planning Committee, 1998) to 2050, a dramatic rise in water use is expected (Liu, 2000).

The studied region, Gaocheng County (114°38'45" - 114°58'47"E and 37°51'00" - 38°18'44"N), falls inside this area (Fig. 1) and is located in the piedmont plain of the Taihang Mountain, which serves as the source of groundwater recharge. During the past 50 years, several different scale groundwater surveys have been carried out. Although most of these surveys were not sufficiently accurate, new water use plans were drawn up. In the 1960s and 1970s, most of these surveys led to optimistic plans to encourage further development of irrigation systems. After 1972, irrigation systems in the NCP were developed very quickly (Liu and Wei, 1989). By the early 1980s, small-sized cones of depression had started to form in 5% of the area while in vast areas of the central and eastern plains, groundwater depth was considered to be about equilibratory (Zhu, 1983). By the end of the 1980s, the continuous decline of the water-table, caused by the overpumping of groundwater for agriculture production, clearly suggested that agricultural practices were using too much water. Thus, agricultural water-saving technologies were gradually developed (Wang et al., 1993). However, not only did the trend in the water-table decline not change, but also the situation worsened. Sustainable development of agriculture in this region is facing huge challenges (Hebei Department of Water Conservancy, 1999).

Therefore, the objective of this study was to clarify the factors influencing fluctuation in the water-table in order to set up a more practical plan to maintain the balance of groundwater and to achieve sustainable development of agriculture in this region. Moreover, since most agricultural scientists prefer to use mm as the unit of irrigation in the agricultural field, rather than m^3/a.km^2 for the whole region, a water-saving target in mm from the present water-use level is preferred.

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