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Study on Law of Groundwater Evolution under Natural and Artificial Forcing with Case study of Haihe River Basin

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The evolution of groundwater is one of the key problems of water cycle study. It is a result of joint effect of natural condition and human activities, but until now the driving forces of groundwater system evolution were not fully understood due to the complexity of groundwater system structures and the uncertainty of affecting factors. Geology, precipitation and human activity are the main factors affecting the groundwater system evolution and interact each other, but the influence of such three factors on groundwater system are not clarified clearly on a macroscopic scale.

The precipitation changes the volume of water recharge and the groundwater pumping effect the discharge of groundwater. Another important factor influencing balance of groundwater storage is the underlaying that affects the renewablility of groundwater. The underlaying is decided mainly by geological attributes but also influenced by human activited. The macroscopic environment of groundwater evolves under the natural and anthropic factors. This paper study the general law of groundwater evolution among the factors based on the case study in Haihe River Basin, a typical area with dramatic groundwater change under natural precipitation attenuation and gradually increase of water suuply.

Haihe River Basin is located in north-China, covers an area of 320,041 km2 with over 40% plain areas. The plain area of Haihe Basin is densely populated with many large and medium-sized cities, including metropolis of Beijing and Tianjin, and concentrated irrigated areas, playing important roles in China's economy and food production. It is the unique basin where groundwater occupies majority of total water supply in China. Long-term groundwater over-exploitation causes a series of ecological and environmental problems that threats the sustainable development.

In this paper, the historical process of groundwater balance in Haihe Basin is divided into three phases by decrease of rainfall and increase of water pumping. The different problems caused by groundwater shrinkage are summarized. The volume of recharge from natural precipitation and artificial water cycle, natural evaporation and groundwater exploitation are analyzed based on water balance. Through the historical data analysis the changing trend of coefficients of groundwater balance discovers the evolution of groundwater. The general law is concluded with deeper analysis displays the contribution of natural and artificial factors causing deterioration of groundwater balance. A general law of groundwater evolution is put forward to describe the affection of both natural and anthropogenic factors with a relation curve.

Considering the water demand of future socio-economic development in Haihe River Basin, the prospective of future vision of groundwater cycle is analyzed by the law of groundwater evolution. Iterated scenario analysis based on comparison of ameliorative function on groundwater balance to point out reasonable control on groundwater exploitation and rational water allocation under the condition of completion of South-to-North Water Transfer Project that could bring more than 7 billion m3 into Haihe River Basin from Yantze River. Finally, the advantages and disadvantages are concluded through the case study and the farther research in this field is pointed out.