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Original Research Paper

Study on the Minimum and Appropriate Instream Ecological Flow in Yitong River Based on Tennant Method

Men Baohui, Yu Tao, Kong Fanli* and Yin Hua*

National Engineering Laboratory for Biomass Power Generation Equipment, Renewable Energy Institute, North China Electric Power University, Beijing 102206, China

*Hydrology and Water Resource Bureau of Jilin Province, Changchun 130022, China

Corresponding Author: Men Baohui

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ABSTRACT

It has been very urgent situation that the Yitong River ecological environment gradually worsening and aquatic ecological environment restore, especially the city wastewater and wastewater emissions increased gradually, making the river self purification capacity decreased gradually. In order to maintain the basic ecological functions of rivers, it is very important to study the instream minimum and appropriate ecological flow. The Yitong River main control section's (Yitong Hydrology Station and Nongan Hydrologic Station) minimum and appropriate ecological flow is calculated based on Tennant method. After the Tennant method of flow standard is modified, the ecological water demand is $0.17\times10^8 m^3$, minimum in Yitong station, the suitable ecological water requirement is 0.23×10^8 m^3, respectively, representing average annual flow in Yitong station 26.3% and 36.3 %. The minimum ecological water requirement of Nongan station is 0.77×10^8 m^3, the suitable ecological water requirement is 1.13×10^8 m^3, respectively, representing the Nong2 an station mean annual runoff 21.3% and 31.3%, providing a reference for ecological regulation of Yitong river ecological protection and restoration.

INTRODUCTION

Yitong River is the largest river flowing through the city of Changchun. It is not only the mother river of Changchun, but the largest branch of Yinma river as well. With the development of economy and rapid growth of population, overloaded municipal sewage, industrial wastewater discharges and domestic and industrial garbage have become serious problems. Under the circumstance, Yitong River basin ecological balance is broken. The river gets environmental pollution and becomes a pollutant river (Li 2010). Investigation of water pollution and evaluation of water environmental quality has become one of the hotspots of the watershed study. Aiming at the water quality assessment of groundwater, Ye et al. (2007) selected the gravel aquifer of Yitong River's downstream groundwater by matter element extension method. Besides, Shi et al. (2008) provided a new intelligent method for evaluating the water quality in the literature of groundwater by BP neural network, which was compared with the evaluation results with fuzzy comprehensive evaluation method and matter element extension method. Overall, the surface water quality evaluation literature is much more than the groundwater quality assessment. In these studies, some are representative and authoritative. By indexing them, comprehensive water quality identification was made (Qu et al. 2012). Yang Jia Wei Zi and the bridge section of Yitong River Basin in Changchun area have the serious water pollution and long-term phenomenon of black odour. By establishing Bias water quality comprehensive assessment model, Bian et al. (2011) analysed and evaluated the three years monitoring sectional data of Xinlicheng Reservoir, Changchun's downtown area, Nongan and Kaoshan in Yitong River Basin. By R factor method of factor analysis method, Yang et al. (2007) evaluated the water quality of Yitong River in 2003. By water quality identification index method, Cong et al. (2012) had a water quality evaluation of Yang Jia Wei Zi section of Yitong River in Changchun from 1999 to 2008 and considered that the river has the most serious pollution in 2003. By wide-domain grey decision method and river complete mix model in small river forecast model of surface water environment evaluation forecast guide, Zhang et al. (2006) evaluated the normal-water period of water quality status in 1999 and the forecast of the river.

The water quality of river mainly depends on two aspects. One is in a certain concentration of pollutants to increase incorporation of new or improved water velocity. The other is in a certain water to reduce the amount of pollutants into the river. Thus, in order to improve the water quality of rivers, the latter mainly take measures such as controlling the total pollutants. The former, however, is how to schedule and dispatch the water and play the ecological environment function of river ecological system. In other

words, the ecological environment function is the dilution, degradation or other effects for pollutants. The accurate accountings are required, such as the amount of water needs. Moreover, the flow, namely the instream minimum ecological flow and optimal ecological flow, to meet certain ecosystem services is needed as well.

A few studies on the instream ecological flow of Yitong River have been reported. Based on the analysis of the Yitong River natural geography and climatic condition, staging criteria of the north rivers different water periods are standardized. In addition, the minimum and appropriate ecological flow of two control sections, namely the Yitong River Yitong hydrology station and Nongan hydrologic station, are calculated by Tennant method. The article provides reference for Yitong River to play an important role as the river ecological corridors and recover the water ecological environment; it also lays the foundation for ecological operation of Xinlicheng Reservoir.

MATERIALS AND METHODS

Study area: Yitong River belongs to the second Songhua River's two tributaries, originating in the Yitong county of Jilin Province, running through the eastern city from south to north and through the Changchun city, Nongan county and Dehui city. Yitong River flows into the second Songhua River after flowing into Yinma River near Kaoshan town in Nongan county, full-length of 382km. The area of Yitong River basin is about 8713km^2, the average width of river basin is 22.7km, channel slope is 0.0003, river width is 15-30m, average flow rate is 6.25m^3/s, the maximum flow rate is 256m^3/s, the minimum flow rate is 0, the maximum water depth is 2.5m and the minimum water depth is less than 1m in usual water period (Wang 2005). There are three main hydrological stations in Yitong River, from upstream to downstream respectively at Yitong, Xinlicheng Reservoir and Nongan. Yitong hydrology station (Zhang & Liu 2012) located in the upstream of the Yitong River, Yitong Manchu Autonomous county has the position at longitude 125°18' and north latitude 43°21' with control drainage area of 574km^2. There are two branches section above, one is from the Dajianggang Qingdingzi ridge in Banshimiao Xiang, and another is from mountain south Hancong in Eighteen Gangzi in Dongfeng county. Two sources converge near Yingchengzi town in Yitong county, flows through the Yitong in Xinlicheng Reservoir, Changchun, Dehui, Nongan and other cities and counties and runs into Yinma River below Kaoshan village in Nongan county. Nongan hydrologic station (Ma 2011) is located in the territory of Nongan county of Jilin province, the section position is at longitude 125°11' and north latitude 43°42', and the area of section above control basin is 6508km^2. Xinlicheng Reservoir is located 85 km upstream in Nongan station. Xinlicheng Reservoir control area is 1977 km^2, the maximum storage capacity is 5.92×10^{8}m^3, the surface area is 76.6 km^2, the normal water level is 218.83m, the flood limit water level of reservoir is 217.80m, the safety relief amount is 400 m^3/s, the flood propagation time from reservoir to Nongan is approximately 90h, and the maximum outflow occurred on July 30, 1986 which was 250 m^3/s. The hydrological station is shown Fig. 1.

Data and materials: Yitong station average monthly flow sequence was measured from 1957 January to 2010 Decem-

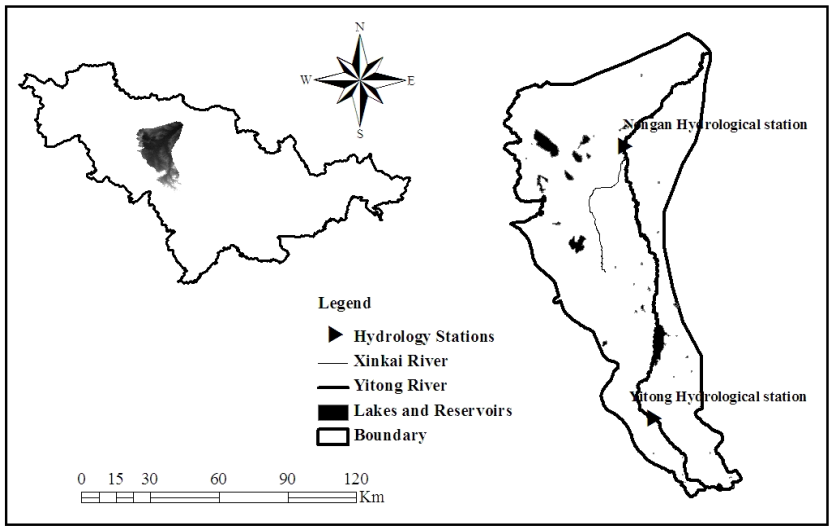


Fig. 1: The distribution of Yitong river station.

Table 1: The Tennant method recommended base flow standard.

Qualitative description of flow values and the corresponding habitat	Recommended base flow standard (the percentage of average flow rate)	
	The general water period (October-March)	Fish spawning breeding season (April-September)
Maximum	200	200
Optimum range	60-100	60-100
Very good	40	60
Good	30	50
Better	20	40
General or poor	10	30
Poor or minimum	10	10
Severe degradation	<10	<10

Table 2: The recommended standard calculation of Yitong river ecological flow using Tennant method.

Qualitative description of flow values and the corresponding habitat	Recommended base flow standard (the percentage of average flow rate)	
	General water period (October-April)	Special water period (June-September)
Maximum	200	200
Optimum range	60-100	60-100
Very good	40	60
Good	30	50
Better	20	40
General or poor	10	30
Poor or minimum	10	10
Severe degradation	<10	<10

ber and Nongan station monthly average flow series was measured from 1956 January to 2010 December and shown in Fig. 2.

Methods

Tennant method: Tennant is also called Montana method, proposed by Tennant (Tennant 1976, Tennant 1976) in 1976 first. This method uses a percentage of average annual flow as a recommended flow (Men 2008); different percentage is used in different months.

The corrected standard calculation: Table 1 gives the formulated base flow standard according to the American rivers, which need to modify when is applied to the Yitong River. The Yitong River basin belongs to the north temperate continental monsoon climatic zone. Its characteristics are dry and windy in spring, hot and rainy in summer, rain and little fast cooling in autumn, cold and dry in winter. January-July temperature increases and July-December temperature declines. Annual precipitation is 369.9~667.9mm with an average annual precipitation of 583.5mm. The distribution of precipitation is uneven throughout the year, rainfall is concentrated in June to September, accounting for 80% of the annual precipitation. Heavy rain occurs in July and August, continuous rainfall days are quite a lot. Runoff is mainly from precipitation recharge, runoff and precipitation have obvious dependence, water is mainly concentrated in the flood process. Annual runoff distribution is consistent with the precipitation concentration distribution. Runoff is mainly concentrated in June to September, more than 75% of the total runoff (Cao 2011). In view of the weather conditions, a year is divided into two calculation periods, June-September is special water period and October to April is general water period. The specific circumstances are given in Table 2.

ANALYSIS AND RESULTS

According to the Yitong river ecological flow given in Table 2, the minimum ecological flow is selected: general water period (October-April) is 10% of the average flow, special water period (June-September) is 30% of the average flow. Select the appropriate ecological flow: general water period (October-April) is 20% of the average flow, special water period (June-September) is 40% of the average flow. Accordingly, the minimum ecological water requirement of Yitong station is 17000000 m^3, the suitable ecological water requirement is 23000000 m^3, the stand average annual

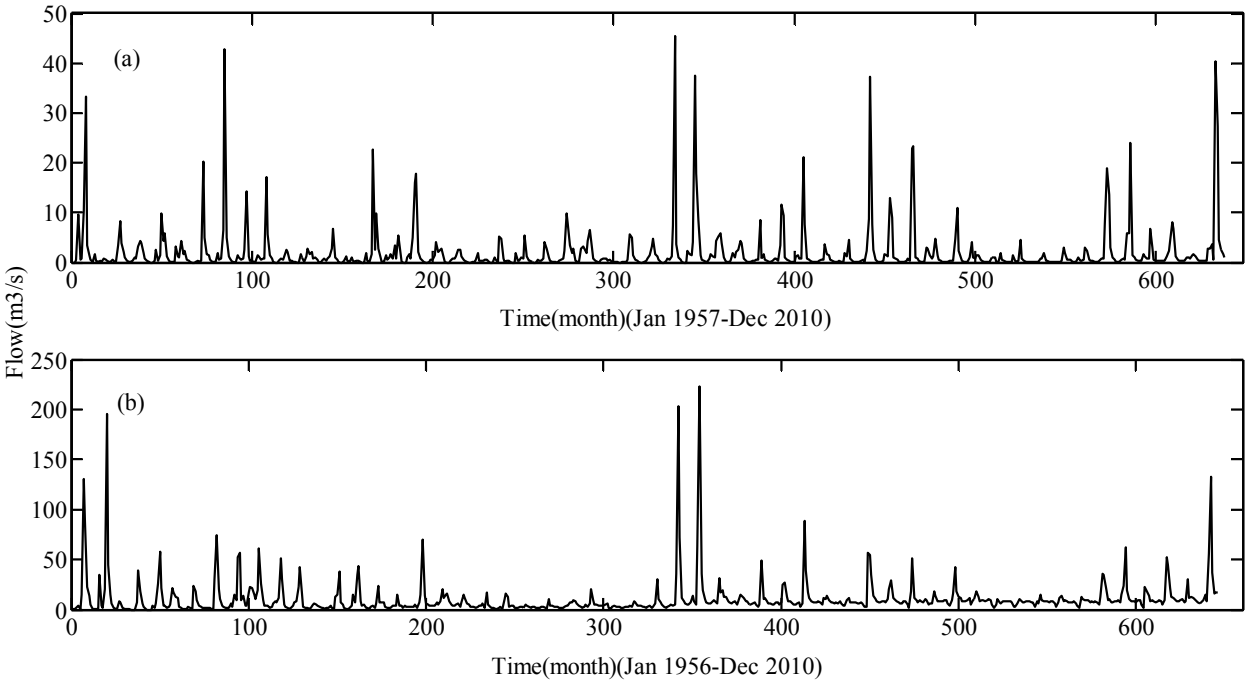
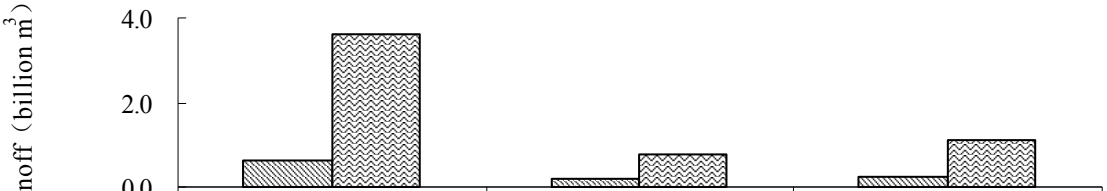


Fig. 2: The Yitong hydrology station (a) and Nongan hydrologic station (b) measured monthly average flow process.



	average runoff	minimum ecological runoff	suitable ecological runoff
Yitong	0.65	0.17	0.23
Nongan	3.61	0.77	1.13

Fig. 3: Calculation of minimum ecological runoff and suitable ecological runoff in Yitong River.

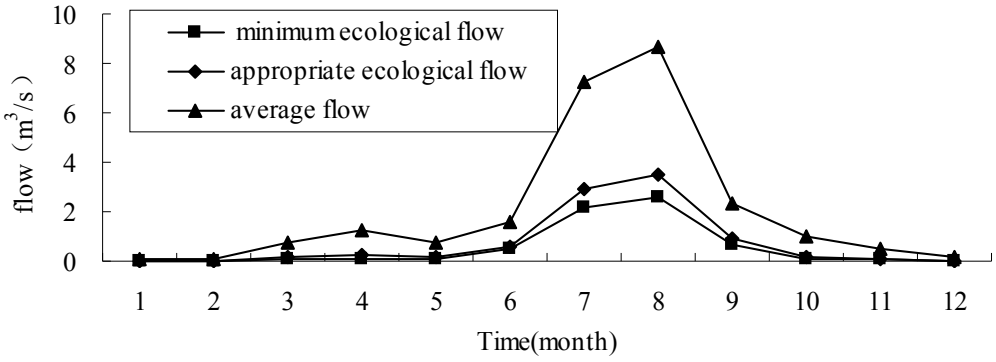


Fig. 4: The Yitong station minimum and appropriate ecological flow distribution in a year.

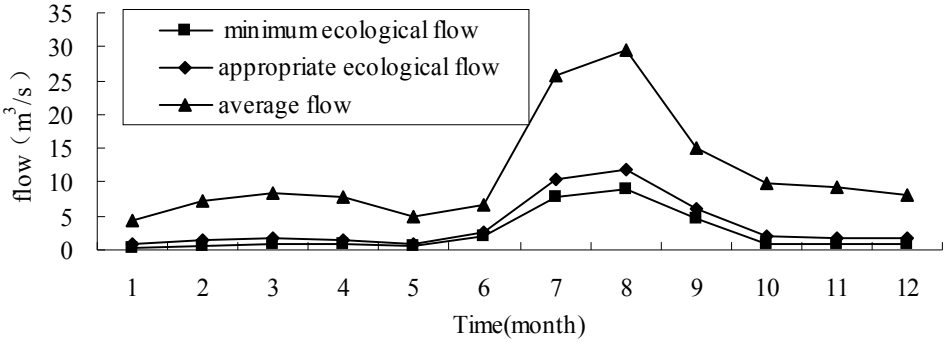


Fig. 5: The Nongan station minimum and appropriate ecological flow distribution in a year.

runoff is 26.3% and 36.3% respectively; the minimum ecological water requirement of Nongan station is 77000000 m^3, the suitable ecological water requirement is 113000000 m^3, the Nongan station average annual runoff 21.3% and 31.3% respectively.

According to the minimum and appropriate ecological flow principle, get the minimum ecological flow and appropriate ecological flow process in Yitong station and Nongan station (Fig. 4 and Fig. 5). Yitong station minimum ecological flow range is 0.01-2.6 m^3/s, and the appropriate ecological flow range is 0.01-3.47m^3/s. Nongan station minimum ecological flow range is 0.42-8.88m^3/s, and the suitable range of ecological flow is 0.85-11.84m^3/s. As can be seen from the minimum ecological flow and change process of the appropriate ecological flow, the change trend of ecological flow and the mean monthly flow are basically the same, this is Tennant method itself determines. The Yitong River is frozen in general water period, and special water period is mainly the north river water period, also the most active period of the river aquatic organisms and aquatic plants inhabiting.

Figs. 4 and 5 show the minimum ecological flow, even in the annual dry season. In the upper reaches of the Yitong river, flow is 0.01m^3/s, and the flow downstream of the river can reach 0.42m^3/s, instream flow water has an important role to play in the river corridor function. If we can make water allocation according to the above and the appropriate ecological flow, it can avoid the current status of this seasonal river, and this has important practical significance in the relief of river water quality gradually deteriorating, and ecological service function gradually ease.

DISCUSSION AND CONCLUSIONS

According to the average monthly flow data for many years of Yitong and Nongan hydrologic station, the minimum and appropriate ecological flow of Yitong River is calculated by Tennant method, the concrete results are as follows:

1. Based on Yitong natural geographical and climatic conditions, the recommended flow standard based on the Tennant method was modified: June to September is the special water period, October to May of the following year is the general water period. In the special water period, the minimum ecological flow is 30% of the year's average monthly flow, appropriate ecological flow is 40% of the year's average monthly flow. In the general water period, the minimum ecological flow is 10% of the year's average monthly flow, and the appropriate ecological flow is 20% of the year's average monthly flow.
2. In accordance with the revision of recommended standard flow, we got the calculation of Yitong station. The minimum ecological water requirement is 0.17 billion m^3, the appropriate ecological flow is 0.23 billion m^3. For Nongan station, the minimum ecological water requirement is 0.77 billion m^3, and the appropriate ecological flow is 1.13 billion m^3.
3. By calculating the data of Yitong and Nongan stations, the minimum and the appropriate ecological flow in every month of the year are obtained. It provides Yitong River with data support and scientific basis to achieve the change of water ecological environment and restoration of the ecological schedule.

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