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Research Article

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Research on eco-environmental water demand in the high-tech zone

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ABSTRACT

This paper predicts the eco-environmental water demand of a high-tech zone based on the analysis of domestic and foreign research. It selects the calculation method of lake (Throughput Lake) ecological water demand to calculate the different guarantee rate (50%, 75%, 90%) and the average years of high-tech zone eco-environmental water requirement, and puts forward the suggestions of ecological water replenishment way, based on the regional environmental status and the overall planning of high-tech zone, using the ecological water of the high-tech zone as the research issue. The results of the study are reasonable, providing not only important data support for the construction of ecological water, but also the experience for other cities' large scale ecological water system research.

Keywords: Ecological water, Eco-environmental, Water demand, Calculation method, Predicting.

INTRODUCTION

Water resources are the basic conditions for each city, and play an important role in urban development. As the main form of urban water resources, urban river system is an important source of water, and works for flood control and drainage, maintaining ecological balance and beautifying the urban environment. Therefore, people should plan urban water system reasonably in the process of the city development to promote the construction of ecological civilization city.

The high-tech zone is planning to renovate the existing river, drainage system and construct the water landscape. On the premise of meeting the requirements for flood control and drainage, people should realize the rational use of water system and shape the high quality landscape characteristics, to make water system become iconic landmark in the zone. Therefore, in order to advance the process of the city's construction, eco-environmental water demand should be reasonably analyzed.

Concept and development of eco-environmental water demand

Eco-environmental water demand means the minimum amount of water that a natural water body must consume and store to maintain eco-environmental balance. It aims to maintain the normal growth of fauna and flora in aquatic ecosystems, and to meet the quality and quantity requirements for evaporation, infiltration and purification [1]. Therefore, eco-environmental water demand requires the unification of both water quantity and quality. Namely it refers to keep the certain water quality and quantity which satisfy the maintenance of water ecosystem health and biodiversity. Urban water system needs to meet some requirements, including ecological environment, urban landscape, recreation and urban cultural value reflection, etc [2].

In the 1980s, due to the rapid development of economy, some rivers were polluted severely in our country. How to use and protect the water resources became increasingly prominent issue. In the 1990s, people began to study on eco-environmental water demand, and researches progressed fast. Liu Jing-ling etc. have analyzed the meaning of lake eco-environmental water demand and different methods of calculation. Then they estimated the eco-environmental water demand of typical lake in Haihe river basin [3]. Chen Ji-min etc. analyzed the characteristics and influencing factors of urban eco-environmental water demand, and used multi-objective theory to calculate eco-environmental water demand of Pukou district [4]. Kang Ling etc. made analysis of Hanjiang River's minimum and appropriate ecological flow by using hydrologic method. They also established an ecological scheduling model in Danjiangkou reservoir as an example [5]. Feng Xia-qing etc. analyzed the ecological water demand of Taizi River by using the fish habitat method and month-assurance rate method. Then they calculated river ecological water demand of different grades and verified the result was reasonable [6]. Besides, most cities in our country have the problems of serious water shortage and pollution, which exacerbate the contradiction between water resources shortage and urban water demand, and restrict the development of city construction.

Environmental status of the study area

The high-tech zone is located on the bottom of Jiaozhou Bay and north of the Red Island, with a total planning area of 63.44 km^2. It belongs to the north temperate and monsoon climate zone. Its annual average temperature is 12.3℃, affected by ocean and continent. In summer and autumn, it blows south wind, hot and humid. While in winter and spring, it blows north wind, and the air is dry. Its regional average annual precipitation is 676.2mm. The range of annual rainfall and distribution change largely. Rainfall in flood season (from June to September) accounts for 72.2% of annual rainfall. The terrain of overall area is flat. The type of physiognomy is flood alluvial plain and coastal swamps. The Dagu River, Moshui River and Hongjiang River enter the Jiaozhou Bay. The mainly natural river channel in the area is Yangmao Canal and Hulu Ally. The present situation of artificial drainage includes North Industrial Park Canal and the original Dongfeng saltworks Drains. The present situation of the high-tech zone water system distribution is shown in fig 1.

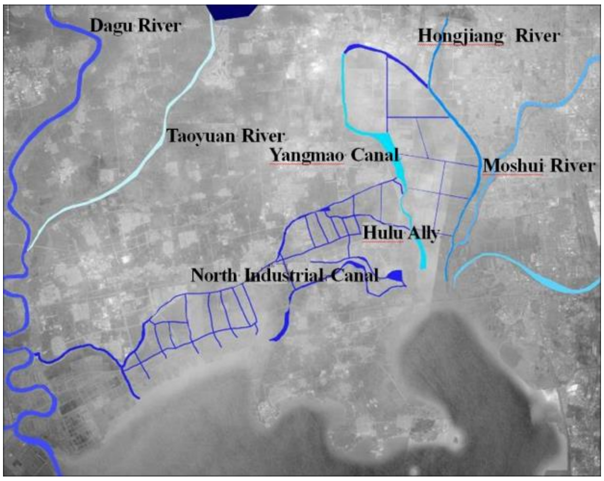

Fig. 1: Present situation of the high-tech zone water system

Calculation of eco-environmental water demand in high-tech zone

The determination of calculation method

According to the overall planning of high-tech zone, it built estuary tidal gate of Yangmao Canal in May, 2011. In 2013, the North Industrial Park gutters and eight drains will construct new flood tide gate in the estuary, and each drainage area is independent, draining into the sea nearby.

Through the analysis above, there is only Yangmao Canal will flow into the zone when closing the tidal gates, and the rest are regional rainfall runoff. The water should meet requirements of flood control and landscape, without the habitat water demand, mainly for surface evaporation and leakage loss. In the preconditions of meeting water self-purification and landscape entertainment, it needs to consider the quantity of water exchange. In order to meet the requirements of flood control and drainage in flood season, it needs to release on the water into the downstream waters directly, without the ecological flow downstream river. High-tech Zone is equivalent to a throughput lake, so this study selects the calculation method of lake (Throughput Lake) ecological water demand to forecast eco-environmental water demand of the high-tech zone.

Calculation method of lake (Throughput Lake) ecological water demand

According to *The Assessment Guidelines of River Ecological Water Demand (Trial),* without considering the time difference caused by water conversion process, inflow ecological water demand is equal to the sum of lake itself and outflow ecological water demand.

Wrh=Whq+Wch (1)

Explanation of symbols:
Wrh——Inflow ecological water demand in test time. It is the runoff volume entering the lake, which is required for sustaining the ecological system of a lake.
Whq——Lake ecological water demand in test time. It is the water consumption for sustaining the ecological system of a lake.
Wch——Outflow ecological water demand in test time. It is the lake outlet volume which is required for sustaining the ecological system of a lake.

Water balance of lake is shown in Fig 2.

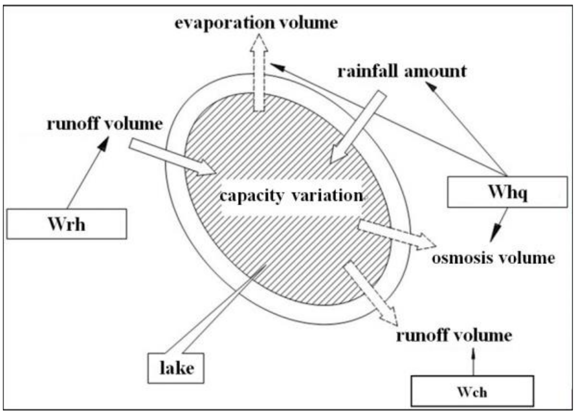

Fig. 2: Lake water balance

According to the figure of lake water balance, inflow ecological water demand of Throughput Lake is equal to the sum of lake itself and outflow ecological water demand. Lake ecological water demand can be calculated by the relationship among evaporation capacity, osmosis volume and rainfall amount. Outflow ecological water demand is water variation caused by regulation and storage of flood control and drainage.

Calculation of the eco-environmental water demand in high-tech zone

Surface evaporation volume: Calculation formula of surface evaporation volume is shown below.

$W_v = 0.1 \times A \times E_w$ (2)

Explanation of symbols:
W_v——surface evaporation volume, $10^4 m^3$.
A——Surface area, km^2, under the condition of meeting the requirement of landscape level 2.0 meters, the corresponding surface area is 6.082 km^2.
E_w——surface evaporation volume，mm.

Table-1 Statistics of water surface evaporation volume

month	evaporation volume (mm)	Surface area (km^2)	evaporation volume (10^4m^3)
January	27.3	6.082	16.60
February	33.9	6.082	20.62
March	69.7	6.082	42.39
April	110.2	6.082	67.02
May	138.4	6.082	84.17
June	136.5	6.082	83.02
July	105.5	6.082	64.17
August	98.9	6.082	60.15
September	82.9	6.082	50.42
October	69.7	6.082	42.39
November	42.4	6.082	25.79
December	26.4	6.082	16.06
Total	941.8	6.082	572.80

Quoting average evaporation data of Jihongtan reservoir, it calculates the water surface evaporation volume of each month as follows (**Table-1**).

Surface rainfall amount: Calculation formula of the surface rainfall is shown below.

$$Q_r = 0.1 \times A \times p \quad (3)$$

Explanation of symbols:
Q_r——surface rainfall amount，$10^4 m^3$.
A——surface area，km^2，under the condition of meeting the requirement of landscape level 2.0 meters, the corresponding surface area is 6.082 km^2.
p——unit area rainfall，mm.

According to the precipitation stations near the high-tech zone, it adopts three stations' arithmetic average rainfall, including Shanjiaodi, Nuocheng and Jimo. For getting the different guarantee rate and the average annual precipitation of the high-tech zone, it adopts the 57 years average precipitation (from1952 to 2008) of the three stations mentioned above to do calculation (**Table-2**).

Table-2 Surface rainfall statistics of different frequencies

month	unit area rainfall (mm)	Surface area (km^2)	Average annual rainfall ($10^4 m^3$)	50% guaranteed rate of rainfall (10^4mm)	50% guaranteed rate of rainfall ($10^4 m^3$)	75% guaranteed rate of rainfall (10^4mm)	75% guaranteed rate of rainfall ($10^4 m^3$)	90% guaranteed rate of rainfall (10^4mm)	90% guaranteed rate of rainfall ($10^4 m^3$)
January	8.2	6.082	4.99	1	0.61	1.1	0.67	0	0.00
February	10.9	6.082	6.63	19.3	11.74	7.7	4.68	0.6	0.36
March	17.5	6.082	10.64	40.4	24.57	7.9	4.8	26.1	15.87
April	32.6	6.082	19.83	17.5	10.64	5.5	3.35	29.1	17.7
May	42.8	6.082	26.03	20.4	12.41	8.8	5.35	38.9	23.66
June	76.8	6.082	46.71	55.4	33.69	69.6	42.33	42	25.54
July	170.3	6.082	103.58	185.3	112.7	237.6	144.51	116.6	70.92
August	177.5	6.082	107.96	206.4	125.53	102.7	62.46	88.6	53.89
September	71.4	6.082	43.43	30.7	18.67	8.6	5.23	15.1	9.18
October	35.8	6.082	21.77	31.5	19.16	23.8	14.48	38.6	23.48
November	22.8	6.082	13.87	11.8	7.18	0	0.00	9.5	5.78
December	9.6	6.082	5.84	9.3	5.66	26.7	16.24	14	8.51
Total	676.2	6.082	411.26	629.00	382.56	500	304.10	419.1	254.90

Seepage quantity: According to the ecological water system planning, watercourses, drains and flood storage area have carried out embanking on both sides, so water leakage is mainly vertical leakage. Analyzing geological and hydrological conditions of high-tech zone, its landform type belongs to coastal accumulation plain, with upper for littoral silt and silty clay. Groundwater type is quaternary pore water, buried depth between 1.0 and 2.8 meters, elevation of water level between 0.5 and 0.7 meters and annual variation range about 1 to 2 meters. Assuming the surface water and groundwater are in balance, the following formula can calculate the seepage quantity, without considering the influence of regional groundwater funnel and seawater intrusion.

$$Wg = k \times t \times A' \quad (4)$$

Explanation of symbols:
Wg——seepage quantity, $10^4 m^3$.
k——seepage coefficient, 1×10^{-8}m/s.
t——seepage time, 3.1536×10^7s.
A'——infiltration area, km^2.

Through measurement, the bottom of ecological water system in high-tech zone covers an area of 4.932 km^2. Substituting the data, seepage quantity of high-tech zone is 1.5554 million m^3.

Purifying and circulating water demand: In order to maintain the ecological functions of water, water storage shall conduct regular cycle of water body. Combined with water exchange coefficient of Beijing Liuhai eco-purification water, the cycle time of high-tech zone ecological water purification is determined in October, November, March, April, May and June each year, and monthly cycle water amounts for 20% of the total storage capacity.

Total eco-environmental water demand: According to the results of various factors, it gets the different frequencies' eco-environmental water demand of high-tech zone (**Table-3**).

Table-3 The calculated results table of eco-environmental water demand (Unit: million m^3)

Guaranteed rate / Factor	50%	75%	90%	Annual average
Evaporation	572.80	572.80	572.80	572.80
Rainfall	382.56	304.10	254.90	411.26
leakage	155.54	155.54	155.54	155.54
purification cycle	1426.5	1426.5	1426.5	1426.5
Total water demand	1772.28	1850.74	1899.94	1743.58

The results show that the different guarantee rate (50%, 75% and 90%) and the average years eco-environmental water demands are 1772.28 million m^3, 1850.74 million m^3, 1899.94 million m^3 and 1743.58 million m^3, in which the evaporation accounted for 26.58%, the seepage quantity accounted for 7.22%, and the purification cycle demand accounted for 66%.

CONCLUSION

（1）This paper studies the calculation methods of ecological water demand, and selects the lakes (Throughput Lake) calculation method of ecological water demand to calculate the various factors of ecological water in high-tech zone, and obtains the different guarantee rate (50%, 75% and 90%) and the average years eco-environmental water demand of the high-tech zone, namely 1772.28 million m^3, 1850.74 million m^3, 1899.94 million m^3 and 1743.58 million m^3, providing important basic data for the construction of ecological water system.

（2）Based on the high-tech zone drainage planning, the drainage system implements rainfall-sewage separation. Rainwater runoff in confluence area flows into ecological water system by means of rainwater pipe network or inflow directly. According to the above ideas, ecological water replenishment of high-tech zone should give priority to the rational use of regional stormwater runoff, followed by other water sources for technical and economic comparison, preferred less investment, adequate and high quality water.

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