Ecological and environmental water demand of the lakes in the Haihe-Luanhe Basin of North China

LIU Jing-ling, YANG Zhi-feng

(State Key Joint Laboratory of Environmental Simulation and Pollution Control, Institute of Environmental Science, Beijing Normal University, Beijing 100875, China. E-mail: jl_liu@263.net)

Abstract: The purpose of this paper is to present a brief concept of the ecological and environmental water demand of lake. The present situation and affecting factors of lake ecological system in the Haihe-Luanhe Basin of North China was analyzed. The calculating method of the ecological and environmental water demand of the lake basis on the water body and the calculating method of the ecological and environmental water demand of the lake basis on the aquatic ecosystem, wetland and vegetation were compared and discussed. As the examples of Baiyangdian Lake and Beidagang Lake in Haihe-Luanhe river basin, the ecological and environmental water demand of the two lakes was calculated to be 27 $\times 10^8 \, \mathrm{m}^3$. It is 6.75 times to the water demand according to the calculating method of the ecological and environmental water demand of the lake basis on the water body. The research result indicated: (1) The calculating methods of the ecological and environmental water demand of the lake basis on the aquatic ecosystem should be better than only basis on the water body of lake. (2) The data, such as area of the vegetation kind around and in the lake, the vegetation coefficient, the evaporating amount of the vegetation and the vegetation water demand itself around and in the lake are lack and urgent need. Some suggestions for controlling and regulating the water resource of the lake in North China were proposed.

Keywords: eco-environment; water demand; lake; the Haihe-Luanhe Basin

Introduction

The Haihe-Luanhe Basin is the district facing the problem of water crisis in the North China. Water pollution issues and anthropogenic disturbance are very serious at the same time. Water deficiency, pollution and overpopulation have resulted in obvious ecological degradation and environmental problems. All of these have become the main restrict factors for sustainable water and economic development in the North China. It has attracted the attention of the environmental management departments, the water conservancy managements in the government and scientist to coordinate the relationship among economic development, water resources effective use, ecological and environmental protection as well as sustainable development. Especially there are great water conservancy engineering being built in China now. In this paper we focused on the ecological and environmental water demand of the lakes in Haihe-Luanhe Basin of the North China. This research try to offer the based data for the regulation of the water resource, the lake management and the restoration of the lake ecosystems.

1 The conception of eco-environmental water demand of lake

In China there are so many conceptions about eco-environmental water demand such as ecological water, environmental water demand, environmental and ecological water demand, ecological and environmental water needs (PSC, 1993; Tang, 1995; Jia, 1998). We defined in broad sense that the ecological environmental water demand of lake means the water demand by a natural or artificial lake to keep and restore its normal ecological system function and environmental value of benefit to human being by natural or artificial way. This conception is based on the eco-environmental present situation in China and has two aspects signification, ecological restoration and environmental protection.

The classification of eco-environmental water demand is according to the different space ruler and main body of research. According to the main body of the research the eco-environmental water demand can be divided into the eco-environmental water demand of artificial oasis, Tugayi forest, river valley forest, lake, meadow, city forest and grassland. Some reports studied on the conception and the case studies, such as eco-environmental water demand of the different vegetation and eco-environmental water demand of river basins or lakes, appeared over the past few decade (Liu, 1996; He, 1998; Li, 2000). The water is

one of the important renewable resources. Humanity has been utilized lake for a long time. The lake has been playing important role in different aspect of human life, for example irrigation, shipping, drinking, preventing flood, electricity, fishery, tourism and so on. In other word it is also a process of the eco-environmental degeneration for lake. Lake is an important aquatic ecosystem related closely with other ecosystem, global aquatic ecosystem, river basins ecosystem, river ecosystem, wetland ecosystem, forest ecosystem, grassland ecosystem, underground water system and so on. The ecological function and eco-environmental water demand of lake ecosystem has been neglected for a long time. The study on the eco-environmental water demand of lake should provide the basic science theory and applied approaches needed by environmental regulators and managers to control some types of eco-environmental problems and to reconstruct the lake landscape in an ecologically sound way for the purpose of water resources sustainable development maybe come true.

2   The present situation of lake ecological system in the Haihe-Luanhe Basin of North China

The lakes in the North China region became less in both number and area because of the water deficiency. The most of the lakes in the North China region have dried up. The fresh water lakes can be divided the natural lake, urban lake and reservoir. The natural lake, urban lake and reservoir are in middle or serious degree pollution and the eutrophication. We thought the most of the lakes in North China were the damaged ecosystem. The damaged ecosystem was affected by the factors as follows:

2.1   Population

The most of the lake regions in the North China as same as the river basin were densely populated area. The population of the North China region is 31.236 million, the density 601 person/km^2 and the population pressure index 0.40. The population density of the North region is much more than the average population density of China, 129 person/km^2(SDRG, CAS, 2000).

2.2   Water resource shortage and reasonless utilization

The water resource averaged amount of the North China region is 696.12 m^3/person, the biomass 15.52 ton/p and the water resource pressure index 0.72. It is shown that North China region is the region of the most of water resource shortage. There are three big river basins, Haihe-Luanhe, Yellow River and Huaihe River in the North China. There are more than 10 lakes in North China before, but now the most of lakes have become dried-up or smaller and smaller. The Haihe-Luanhe basins are the district of the most lacking of the water resource. There are only two lakes, Baiyangdian Lake and Beidagang Lake. Baiyangdian Lake is the famous lake in the North China. The vegetation around it has been destroyed and cover rate lessened from 50% of the Tang Dynasty to 1% now. Its area has been lessened from 561.6 km^2 in 1950 to 362.8 km^2 in 1986, the nearest data maybe 82 km^2 and often dried-up(Wang, 1989).

2.3   Pollution

The water quality of lakes in North China has become worse and worse. The water pollution is resulted of industrial waste water, living sewage, chemical fertilizer and pesticide. The non-point pollution is much more seriously than the point pollution. For example, the water quality of Baiyangdian Lake has deteriorated because the great demand of industrial and living sewage are flowed into it, especially sewage of Baoding City.

Generally modern lake management has to face to four problems: pH changing, eutrophication, oxygen-lack and toxicant. All of these are that we must deal with. At the same time water resources regulation and supply are related with fresh water ecosystem includes underground water, river, lake, pond, marsh and wetland. The lake is closely related with other ecosystem. The ecology services value of the lake is not only the lake itself but also the closed relationship with other ecosystem. In fact the ecology services value of the lake was much more than the calculating demand. The ecology services value of the lake and related ecosystem accounted for 24% of the total ecology services value all over the world. The more and more seriously has the water crisis become, the more and more costly has the ecology services value of the lake and related ecosystem been(Constanza, 1997).

3   The calculating methods of the eco-environmental water demand of the lake

3.1   The calculating methods of the eco-environmental water demand of the lake basis on the ruler of water amount balance between the water body and water cycle

According to the water cycle eco-environmental water demand of the lake was generally considered to keep aquatic, saline and aquatic ecosystem. As the ruler of water amount balance under the natural condition without taking out water the consumed water demand of the lake should be:

$$\Delta W = P + R_i - R_f - E + \Delta W_g . \tag{1-1}$$

Where, ΔW is the changing amount of the lake holding; P is the precipitation; R_i is the water amount of entering the lake; R_f is the water amount out of the lake; E is the evaporating amount; ΔW_g is the changing amount of underground water.

As for keep the eco-environmental function of the lake we want not to change the water amount of the lake then $\Delta W = 0$. If we supposed the underground water amount kept developing balance then $\Delta W_g = 0$. Because in North China the evaporating water amount is greater than the precipitation, we can make formula (1-1) into the fellow simply(Li, 2000):

$$W_l = \sum_{i=1}^{n} A_i (E_i - P_i) . \tag{1-2}$$

Where, W_l is the eco-environmental water demand of the lake; A_i is the area of the lake; E_i is the evaporating amount; P_i is the precipitation.

It was convinced that the eco-environmental water demand of the lake mainly was used for keeping the water demand balance of the lake and consumed the evaporating water amount. In the case study, there are two lakes, Baiyangdian Lake and Beidagang Lake in Haihe-Luanhe Basin. The water areas were 336 km^2 and 350 km^2. The evaporating water amount was 1100 mm. The precipitation was 550 mm. According to the formula (1—2) the eco-environmental water demand of the lakes in Haihe-Luanhe Basin was calculated to be 4×10^8 m^3(Li, 2000).

3.2   The calculating methods of the eco-environmental water demand of the lake basis on the aquatic ecosystem, wetland and vegetation

The complicated relationship of the lake and other ecosystem had been discussed above. The aquatic ecosystem of the lake kept the closed relationship with wetland system. The research of the eco-environmental water demand of the lake should considered the ecosystem substantially disturbed by human activities such as environmental pollution, climate change or land disturbance. Restoration of damaged ecosystems is an ecological engineering, an additional aspect of applied ecology, but different from other fields such as hydrology, biology and environmental engineering. In nature there is a transition zone, called wetland, between any lake and land but no boundary line. The most important component of the zone is plant, especially aquatic plant system. It includes standing plant, floating plant and submerged plant. The aquatic plant system has been played the important role in regulating water, water supply, environmental protection and keeping the balance of aquatic ecosystem. We thought the calculating methods of the eco-environmental water demand of the lake should be basis on the aquatic ecosystem especially aquatic plant system because the eco-environmental water demand of the natural vegetation was largest of all kind the eco-environmental water demand(Jia, 2000). According to the ruler of plant physiological ecology and ecological engineering the formula (1—2) would be made into:

$$W_l = \sum_{i=1}^{n} A_i (E_i - P_i) + \sum_{i=1}^{n} K A_{pi} (E_{pi} - P_i) + \sum_{i=1}^{n} A_{vi} W_{vi} + \sum_{i=1}^{n} K A_{wpi} E_{wpi} . \tag{1-3}$$

Where, W_l is the eco-environmental water demand of the lake; A_i is the water area of the lake; E_i is the evaporating amount; P_i is the precipitation; A_{pi} is the area of the vegetation kind around the lake; K is the vegetation coefficient; E_{pi} is the evaporating amount of the vegetation; W_{vi} is the vegetation water demand itself around the lake; A_{wpi} is the area of the vegetation kind in the lake; E_{wpi} is the evaporating amount of aquatic plants.

The water areas were 336 km^2 and 350 km^2. The precipitation was 550 mm. The area of the aquatic plants in water is supposed to the perimeter of the lake (km) × 0.006 km zone. The area of the vegetation around the lake is supposed to the perimeter of the lake (km) × 0.050 km zone. K is supposed to 2.64 (Jia, 1998). The dominant species of the aquatic plants is reed (*Phragmites sp*.). Its the evaporating amount is about 1588 mm/a. The dominant species of the vegetation around the lake is grassland. It's evaporating amount is 1100 mm/a. The aquatic plants water demand themselves is supposed to be 3/4 of their biomass. The vegetation water demand itself around the lake is supposed to be 1/2 of its biomass (Larcher, 1997). According to the formula (1-3), the eco-environmental water demand of the two lakes was calculated to be 27 × 10^8 m^3. It is 6.75 times to the demand according to the formula (1-2). Then the eco-environmental water demand of the lake basis on the aquatic ecosystem, wetland and vegetation in Haihe-Luanhe basins should be times the eco-environmental water demand of the lake only basis on the water body. This is only preliminary rough estimate. The eco-environmental water demand of lake depends on its eco-environmental condition and special feature of vegetation. The on-the-spot investigation and large numbers of data in different season are needed.

4   Conclusion

In fact the eco-environmental water demand of the lake system is a complicated problem involving many aspects. Especially the population, community and species of vegetation maybe different in the different district. The vegetation coefficient K is determined by that the evaporation from ground water of growing plants region divided into the evaporation from ground water of no growing plants region. The K, A_{vi}, W_{vi}, E_{pi} and E_{vi} value of the different kind vegetation and different season are changed in great range and must be decided on the result of the experiment. In the arid district the minimum of above data is very important for water resource management, eco-environmental construction, urban lake ecological restoration and water conservancy design.

Natural wetland and aquatic plant system around the lake mostly has been damaged. Because the concept was offered that the eco-environmental water demand means the minimum water demand by the natural or artificial water body to keep its normal ecological system function and environmental value of benefit to human being the calculation of the eco-environmental water demand of the lake should be basis on the eco-environmental water demand of the area of the lake, the evaporating amount of the water body and the precipitation furthermore the area of the vegetation kind around and in the lake, the vegetation coefficient, the evaporating amount of the vegetation and the vegetation water demand itself around and in the lake.

Briefly the research of eco-environmental water demand of the lake will be serviced for the rational utilization and management of the water resource. Aimed at the sustainable development of the water resource, the suggestion and solutions are proposed:

(1) We should not divide the management of lake and the area around it and construct the lake resources protecting zone. In the developed countries around the lake protecting zones have been fixed to enhance the ability of the lake of controlling, regulating and purifying water. In the North China the most of the eco-environment around the lakes have been damaged by the activity of human being and arid climate. This suggestion should give us a new idea and benefit improving the management of the lake in the North China. It maybe change water resources traditional management model of artificial cutting apart into the modern management model of the ecological wholeness. We suggest that the lake protective zone should be at least 50 ~ 100m width around lake and 6m in lake, especially reservoir, damaged natural lake and urban lake. It will be of benefit to reconstruction of landscape, management of the aquatic ecosystem and control of environmental pollution especially non-point pollution.

(2) The calculating methods of the eco-environmental water demand of the lake basis on the aquatic ecosystem should be even more practical and applied meaning than only basis on the water body of lake. The study on eco-environmental water demand of the lake system is necessary as same as a complicated problem involving many aspects. The eco-environmental water demand of vegetation is much more than the eco-environmental water demand of lake itself. Especially the natural vegetation kinds maybe different such as cattails, reeds, rushes, bulrush, sedges, cannas, water hyacinths, duckweed, etc and complicated

relationship such as aquatic plant, grassland shrub and forest even animals. The K, E_{pi} and W_{ni} value of the different kind vegetation are changed in great range and must be decided on the result of the on-the-spot experiment. The data of the experiment of the different regions in China were needed urgently.

(3) In North China the problem confronted at present are the coexistence of water resource shortage and the extravagance of water resource; the damage to ecological environment resulted from over-exploitation of water resource; the deterioration of water environment and the rapid worsening of water pollution. In order to controlling, regulating the water resource and purifying the contaminants in the environment. It is needed to design effective and ecologically sound engineering, such as green water conservancy, ecological water conservancy and artificial wetland around the lakes.

References:

Constanza R, d' Arge R, de Groot R *et al* ., 1997. The value of the world's ecosystem services and natural capital[J], Nature, 387: 253—260.

He D W, Cheng J S, 1998. Present state and prospect of the water environmental management in China[J]. Advanced of Environmental Science, 6 (5): 20—26.

Jia B Q, Ci L J, 2000. The primary estimation of water demand by the eco-environment in Xinjiang[J]. Acta Ecologica Sinica, 20(2): 243—250.

Jia B Q, Xu Y Q, 1998. The conception of the eco-environmental water demand and its classification in arid land taking Xinjiang as an example[J]. Arid Land Geography, 21 (2): 8—12.

Larcher W, Xu Z X (transl.), 1997. Eco-physiology of plant[M]. Beijing: China Agriculture University Press, 170—202.

Liu C M *et al* ., 1996. China 21st water problem tactics[M]. Beijing: Science Press.

LI L J, Zhen H X, 2000. Study on the eco-environmental water demand of river system in Hai-Luanhe basin[J]. Acta Geography Sinica, 55 (4): 495—500.

The Sustainable Development Research Group of the Chinese Academy of Science (SDRG), 2000. Sustainable development report[M]. Beijing: Science Press.

The Profession Standard of P. R. China(PSC), 1993. Environmental effective assessment standard of river basin planning (SL45-92)[S]. Beijing: Water and Electric Conservancy Publisher.

Tang Q C, 1995. The oasis development and rational utilization of water resource[J]. Arid Land Resource and Environment, 9(3): 107—111.

Wang H D, Dou H S, Yan J S *et al* ., 1987. China lake resources[M]. Beijing: Agriculture Press.