ISSN : 0974 - 7435 Volume 10 Issue 12

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(12), 2014 [6478-6483]

Study on the problems and countermeasures of metropolis water source protection

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ABSTRACT

With the development and accelerating urbanization of China, metropolis water shortage and water pollution have become the conditionality factors of sustainable development. This paper selects 31 provincial administrative regions of water source in China as samples, giving a systematic study of the conservation status through the four aspects of water distribution, water consumption, water quality status and management status, thus analyze the main problems of water source protection, and put forward policy recommendations to strengthen the metropolitan water source protection and security.

KEYWORDS

Metropolis; Water source protection; Countermeasures.

INTRODUCTION

The total fresh water resource in China ranks the sixth in the world, while per capita consumption of 2200 m^3, approximately 1/4 of the world's per capita level, ranks the 110^{th} in the world. China has become one of the 13 water-deficient countries listed by the UN. At the same time, with the development of social economy, China water quality and water environment continue to deteriorate. Judging from the present situation of surface water quality, 50% of rivers in China, 90% of urban water is polluted by varying degrees. Thus, urban drinking water in China is faced with water shortage and water pollution. It is urgent to strengthen water resources protection especially the urban water source protection.

Summary of foreign research trends of groundwater protection

For surface water sources, non- point source pollution is the main content of urban surface drinking water source protection. Since the 1970s, pesticide transport and runoff model had gradually developed into the BMPs (Best Management Practices), risk evaluation model and region identification of contamination risk. In addition, drawing water source protection zone, the design of surface water monitoring network expert system and pollution modeling software also provided a convenient for the research and control of agricultural non-point source pollution. However, the studies of groundwater were focused mainly on vulnerability and risk assessment. In 1968, the Frenchman Margate first proposed "groundwater vulnerability" term, which gradually developed into groundwater vulnerability assessment and mapping in European countries in 1960s. In the 1990s, influence of the pollution caused by human activity became the mainstream of the world groundwater vulnerability evaluation research[1]. Yet the concept of ground water contamination risk was from the United Kingdom famous hydro geologists Brian Morris and Stephen Foster. Early research focused mainly on the superposition relationship of inherent vulnerability factors and human factors of land use, and then developed into their product relationship, later introducing the theory of disaster risk. But according to current documents, the research on this subject is still very limited.

In terms of water management research, developed countries emphasize the integration of watershed management, surface drinking water sources protection and water purification processing. A successful typical is the American river basin plan management agency. This agency collects watershed data together, figures out pollutants and their sources, uses the management measures to control, thus bring the total watershed pollution control and sewage treatment to effect. For example, the American Hays land uses satellite to provide information for the GIS of 14820 km^2 land[2]. NEPA (National Environmental Protection Administration) establishes a special fund to support state and local government water conservation projects. Enterprises and consortium also provide economic support.

Summary of water source protection research in China

Research on protection of water sources started from the "*Regulations for Preventing and Controlling Drinking Water Sources Pollution*" which is issued in 1989. Study on the non-point source pollution began from the research on the urban runoff pollution of Beijing in the 80's, and then it went on the study of agricultural nonpoint source pollution and urban runoff pollution. Great impact was made by LI Huai'en-the mechanism of watershed storm water runoff response model[3]. Current researches focus on coordinating the contradiction of regional development and ecological protection from the perspective of major functional areas. For example, LIU Yulong considered from the view of ecological compensation and made a systematic exploration. Other leading edge dynamic applications include the 3S technologies and decision support system, establishing system integration model of combining qualitative and quantitative, extended input-output model based on resource and environment. For groundwater research, domestic study on groundwater vulnerability began in the mid 1990s. At present, studies are mostly confined to the inherent vulnerability of groundwater evaluation

studies[4]. For example, LEI Jing and ZHANG Zhongcong studied Tangshan city groundwater vulnerability evaluation through numerical simulations, the principal factor analysis, GIS technology, and the modified DRASTIC method[5]. Groundwater vulnerability assessments considering the effects of human activities and pollution sources are also rare, and currently focus on the more humid regions. From the point of evaluation methods, most of the researches on groundwater vulnerability assessment use DRASTIC ideas, set up index evaluation system, use expert knowledge to determine the properties of the scoring system and weights, and apply GIS to attribute layer stack operation. There are also some scholars using fuzzy theory, numerical simulation, and statistical methods.

In the area of water management research, due to the lack of effective supervision and management measures, water source protection area do not play its rightful role, various forms of pollutions do not get the attention they deserve to, and applications of high-tech in China are still rare.

Through an overview of the domestic and international research situation, we can see that water source protection and management research in China is relatively backward and more loosely. It cannot form a complete system, especially lacks the targeted regional studies. So this paper chooses metropolis water source as sample, provides an overview in general about the present situations of metropolis water source, thus puts forward existing problems and deficiencies, and then gives out policy recommendations.

THE INVESTIGATION AND ANALYSIS OF CURRENT SITUATION OF CHINESE METROPOLIS WATER SOURCE

In order to study the status of metropolitan sources in China and the existing problems, this paper uses 58 water source samples from China's 31 provincial-level administrative centers. These cities bring together the most advanced elements of development, they are important growth poles.

Type and distribution of water sources

Water under formation can be divided into three major types which are rivers, lakes and reservoirs and groundwater. There are 25 river water sources in the study sample, 23 lake and reservoir water sources, 10 groundwater sources. As shown in Figure 1.

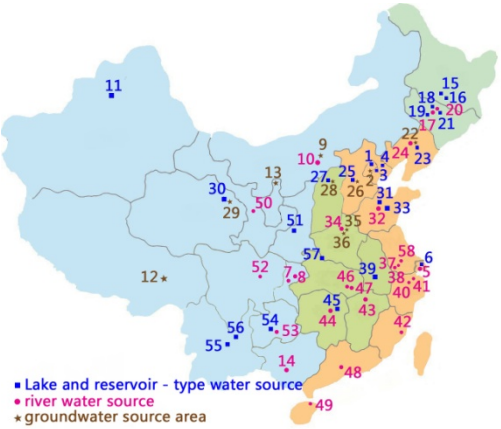

Figure 1 : The Type and Location map of China metropolitan water source

Metropolitan water source water demand analysis in China

The 58 water sources which depend on rivers, lakes and reservoirs and groundwater as water resource supply for 31 provincial administrative centers of 250 million people, which accounted for 19.2% of the national total population. The total water supply is 106.134 billion m^3 per year, accounted for 17.4% of national total amounts. From the point of water supply source, mostly are surface water and groundwater is complementary, and with the growth in water demand, groundwater development is on the rise.

From the point of consumption, industrial and domestic water gradually increase, while agricultural water overall declines due to the effect of climate and actual irrigation area. From the point of average per capita water consumption, the national per capita rise from 442m^3 in 2006 to 454 m^3 in 2011, which showed a growth in national per capita water demand. The perspective of water consumption in major cities is from the lowest 12.75 m^3 in Urumqi to 247.1 m^3 in Sining. The large gap showed the uneven distribution of water resources. Considering the country's ten thousand Yuan GDP water consumption, from 329 m^3 in 2006 to 129 m^3 in 2011, this decrease indicated increasing water use efficiency. Major cities' ten thousand Yuan GDP water consumption varied from 20.64 m^3 to 466.88 m^3, which shows that the gap of urban water efficiency is large, part of the cities have plenty of spare water. As shown in Figure 2 and figure 3.

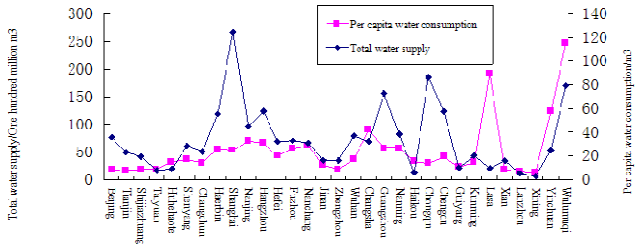

Figure 2 : The water situation chart of major cities in China in 2011; Source : The city water resources bulletin, 2011, part of the data are processed

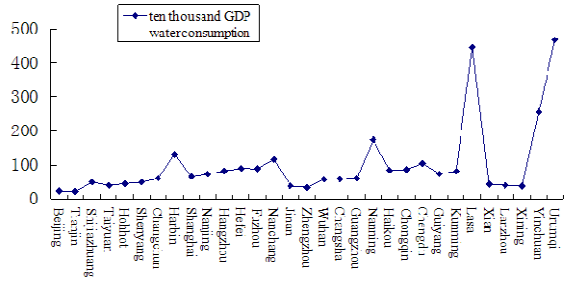

Figure 3 : Ten thousand Yuan GDP water consumption chart of major cities in China in 2011; Source : the national economy and social development bulletins of cities in 2011, data are processed.

Chinese metropolis water source quality survey

(1) Quality of surface water. At present, the main basis of drinking water sources quality evaluation is "*Surface Water Environment Quality Standard*" (GB3838-2002). This standard divides water quality into five categories, including I-III class for eligible drinking water sources, and IV, V for industrial and agricultural water and recreational water.

According to water resources bulletins and water quality annual report, it can be seen: metropolitan river water quality has improved, II class water proportion rises year by year, while III class water reduces. In addition, water quality of reservoirs and lakes are not optimistic. I, II, III water ratios decrease, IV, V increase and worse V water is basically stable. All kinds of water quality situation in 2011 are shown in TABLE 1.

TABLE 1 : China's various types of source water quality position in 2011

	I, II, III (%)	IV (%)	V (%)	Worse V (%)
river water quality	64.2	12.9	5.7	17.2
lake water quality	58.8	12	4.5	24.7
Reservoir water quality	81.1	11	3.4	4.5

Data sources : national water resources bulletin in 2011

From the administrative divisions in 2011, according to the provincial administrative region statistics (excluding the Yangtze River and the Yellow River), in 2011, there are 8 provinces whose I ~ III class river lengths accounted for more than 80% of the evaluation River length, and nine between 60% ~ 80%, seven between 40% ~ 60%, five between 20% ~ 40%, less than 20% of the two. Annual national provincial administrative region's major rivers' water quality evaluation resulted in 2008 is shown in Figure 4.

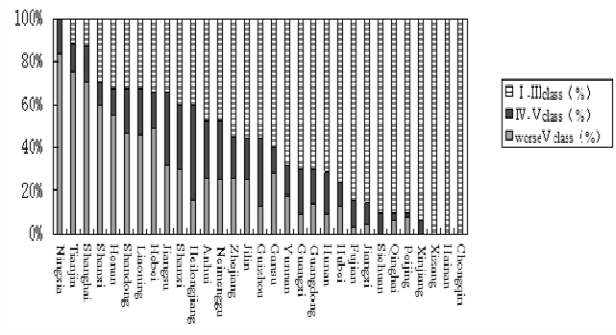

Figure 4 : River water quality contrast figure of provincial administrative region in 2008; Data source : Water quality report of 2008

(2) Quality of ground water. In 2011, nine provinces of Beijing, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Hainan and Ningxia, Guangdong adopted the groundwater quality standard (GB/T14848-93), and made a groundwater quality classification assessment about 857 monitoring wells under the jurisdiction. Results showed that I ~ II class monitoring wells are suitable for various uses accounted for 2.0% of the total number, III class is suitable for centralized drinking water and industrial and agricultural water monitoring wells for 21.2%, IV-V class monitoring wells are 76.8%. The main pollutions were total hardness, mineralization and ammonia nitrogen, etc.

In nine provincial administrative regions, the water quality monitoring wells in Hainan is given priority to II class, Shanghai, Beijing is given priority to III class, Heilongjiang, Jiangsu mainly to IV class, Jilin, Liaoning, Guangdong, Ningxia's water quality monitoring wells are mainly to V class.

Administrative system affects water source situation

Depending on the management of institutions and laws and regulations, we can divide water source protection mechanism into three categories: A class, with both water quality protection and full-time management agency, such as Miyun reservoir, B class, with either protection or full-time management institutions, such as Jiajiang water source, and C class, without protection rules and regulations or professional institution, such as Ample reservoir.

The results show that more than half of water sources lack sound management and protection system. Class A water accounts for only 41% of total number of water source, Class B water accounted for 32%, C class accounted for 27%. This shows that the water source management level of China needs to be improved.

THE MAIN PROBLEMS OF METROPOLIS WATER SOURCE IN CHINA

Metropolis water source protection problems

(1) Water supply growth can hardly catch up with economic growth. As the result of population growth, the national per capita water consumption is increasing, which contributed more to the water supply gap; City's water supply gap is big. Some cities have plenty of spare water resources while some even cannot meet the demand of local residents. Thus, reasonable deployment of water under the

premise of water saving is very essential. Improving existing water source project while planning new ones, as a result, we can improve the ability of water supply.

(2)From the point of the composition of water consumption, the rapid growth of industrial and domestic water occupied agriculture and ecological environment water use; What's more, excessive extraction of groundwater has caused serious ecological and environmental problems, leading to land subsidence and seawater intrusion. Thus formulating scientific and rational countermeasures to unified planning is beneficial for realizing the reasonable utilization of water resources.

(3) Point source pollution and non-point source pollution are widely distributed, which poses a potential threat to water source. The surrounding ecological environment has a great influence on water source protection. For example, overgrazing and deforestation make soil erosion and river sediment. Thus, it is very essential to set up specialized management institutions[6].

Existing problems of metropolis water source protection in the aspect of legal system and management system.

There is a lack of relevant laws, regulations and professional management institutions in China. Water source protection laws and regulations standards are still not perfect in China, unable to form a security system with both engineering measures and non-engineering measures. This kind of water accounts for about 60% of the total number of census water sources[7,8]. Thus it is useful to Strengthen self-construction of the management organization, and establish a long-term mechanism of ecological protection and compensation of the water sources. Improving drinking water safety laws and regulations and the Standard Evaluation System are the basis of benign running of water source.

CONCLUSION

According to the investigation of water quantity, water quality and management system above, we can conclude two problems: one is the water source protection problems, mainly concentrated in water quantity and water quality protection, the other one is water management issues, including administrative regulations and management institutions. At the same time, due to the city water source special regional characteristics and its importance, there are many difficulties in the process of water source protection, thus strengthen the national water research and conservation is urgent.

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