Water Resources Management
in the Fen River Basin

Hidefumi IMURA

Graduate School of Environmental Studies
Nagoya University

1. Introduction

While the Yellow River basin is facing a severe shortage of water resources problems, the situation differs vastly from one area to another. It is usually accepted the whole Yellow River basin can be divided into three areas, namely upper, middle, lower river basin. In our study, the middle river basin was divided into the basins of the Yellow River, the mainstream, the Wei River, a tributary, and the Fen River, another tributary (See Fig. 1) for the purpose of analyzing the local situation in more detail. That is to say, Yellow River basin was divided into 5 areas, namely the upper, middle, lower basins of the mainstream, and basins of the Wei River, a tributary and the Fen River, another tributary to conduct a comparative analysis of the relations between natural conditions, socio-economic conditions, etc. and the supply and demand of water resources.

Since the Fen River basin, branching out from the middle river basin is located in semi-arid land, the volume of water as a whole is decisively little. In particular, as a result of the industrialization and urbanization since the 1980s, the shortage of water resources has become more and more serious. Severe shortage of water resources is coupled with water pollution of surface and ground waters due to insufficient flow volume in the rivers. Various water-saving measures are adopted especially in Tai Yuan City, such as reuse of treated sewage water, and great efforts have also been made to solve the problem by transferring water from the mainstream of the Yellow River. Such circumstances are very suggestive in many senses when the problem for the whole of the Yellow River basin is examined. For this reason, the research team of Nagoya University and Tsinghua University conducted a survey on Tai Yuan, the central city in the Fen River basin and its surrounding area in February 2005. The following is our report on the survey.

2. Overview of Fen River Basin and Tai Yuan City

(1) Overview of Fen River basin

The Fen River, one of the major tributaries of the Yellow River, has the second largest scale, next only the Wei River, in terms of the basin area. Furthermore, its basin, 716 km in overall length and 39,400 km² in area, belonging to Shanxi Province, has a size roughly comparable to that of Kyushu, Japan.

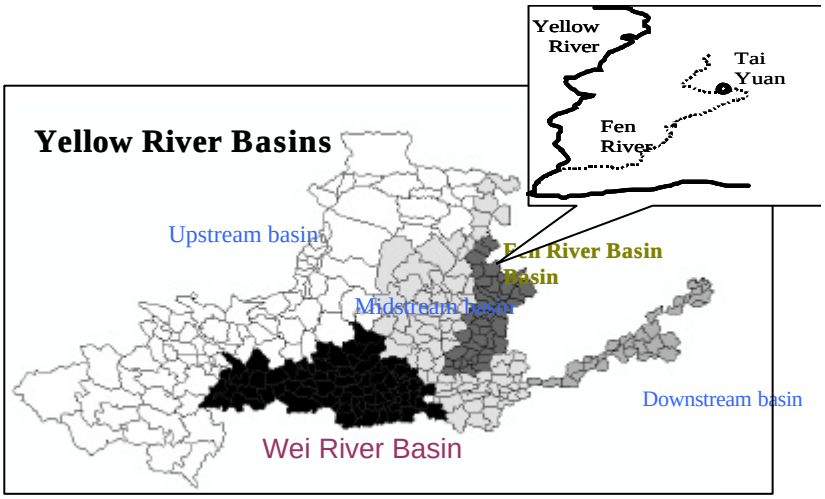

Fig. 1: Segmentation of Yellow River basin and location of Tai Yuan

(2) Overview of the state of economy and society

About half of the non-agricultural populations, GDP, Gross Industrial Product in the Fen River basin are concentrated in Tai Yuan City, the provincial capital. GDP per capita of Tai Yuan City is around twice as much as that of the whole Fen River basin. In addition, it is the main industrial city in Northwestern China, where industries such as iron and steel, machinery and chemical industry use large amount of coal which produced in this region.

(3) Overview of the water resources

The precipitation averaged over many years is 468.4 mm. The annual volume of water resources per capita is 243 m³, which is extremely small, accounting for 10.6% of the national average and 33.7% of the average of the Yellow River basin. This situation is particularly severe even when compared to that of the entire basin of the Yellow River which is facing a serious water shortage.

3. Survey of Tai Yuan City

(1) Items of survey and institutions visited for survey

Our survey was conducted for the objectives stated below:

- To grasp the actual state of water resources and water use in Tai Yuan City.
- To identify trends in the water price under the influence of the Wanjiazhai Water Diversion Project.
- To grasp the discharge and treatment of sewage water.
- To understand how the fund for constructing a sewage water treatment plant is collected and how the water price mechanism is established.
- To grasp the water saving policy and the state of reusing of waste water

In order to attain the objectives mentioned above, interviews were conducted at the Taiyuan Environment Protection Bureau, Taiyuan Saving Water Bureau, Taiyuan Water Resources Management Bureau, Taiyuan Municipal Engineering Administration Bureau, Hexi Eizhongbu Sewage Treatment Corporation and Yangjiabao Sewage Treatment Plant. In addition, on-site surveys were conducted at Yangjiabao Sewage Treatment Plant, Hexi Eizhongbu Sewage Treatment Corporation, Nanyan Sewage Treatment Plant, Taiyuan Iron And Steel Company Sewage Treatment Plant (industrial waste water treatment plant) and the Water Saving and Irrigation District Office.

(2) Water resources and water environment

Figure 2: Artificial tourism area on the Fen River (left) Discharge of waste water

The Fen River runs across Tai Yuan City from north to south, though complete desiccation of the surface water in the urban district of Tai Yuan City occurred about 10 years ago. Moreover, domestic waste water is increasing year by year and now exceeds the volume of discharged industrial waste water. On the other hand, although the domestic waste water increases in volume, its treatment rate is less than 50%. As a result, while the Tai Yuan Municipal Government created a pretty artificial tourism area on the Fen River with water stored in the upstream basin, waste water is discharged in the downstream basin.

(3) Wanjiazhai Water Diversion Project

The daily life water and industrial water used in Tai Yuan City are dependent mainly on groundwater. The annual volume of groundwater exploitation is 460

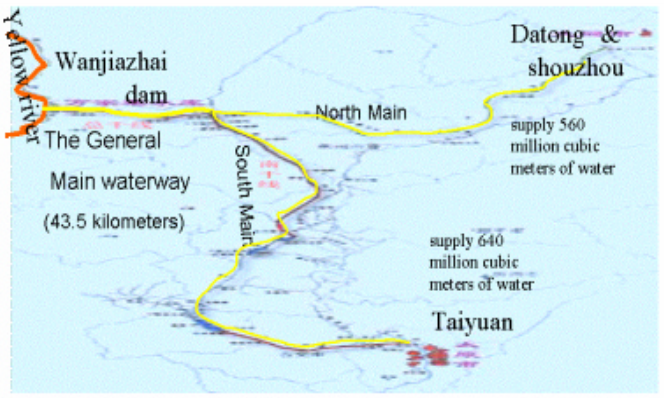

Fig. 3: Wanjiazhai Water Diversion Project

Data and Figure source:
http://www.sxga.com.cn/xiezuodanwei/yinhuang/index.htm
http://www.tidi.ac.cn/sj/sj_icon/yinhuang/yh_bz_photo/pages/yh_bz1.htm

million m³, and the deepest well in some places has reached a depth of as much as 1,400 meters. The Wanjiazhai Water Diversion Project (Fig.3) to introduce water from the mainstream of the Yellow River to the Fen River ("Yellow to Fen Water Introduction") was proposed and implemented as a drastic measure to overcome such a problem of the shortage of water resources. This project had already begun using water from the Yellow River in October 2003. Our survey revealed that the cost of introducing water from the Yellow River was extremely high, amounting to 8 - 10 Yuan/ ton, placing a heavy burden on both enterprises and households. Moreover, although the Provincial and Municipal Governments are now sharing a part of this cost, a policy has been settled to reduce this sharing gradually in future, which will supposedly increase the burden on households and enterprises further.

(4) Sewage treatment

Attaching enormous importance on the measures to treat sewage, Tai Yuan City constructed the Beijiao Sewage Treatment Plant in 1956. At present, in Taiyuan City, there are 4 municipal sewage treatment plants. They are Beijiao Sewage Treatment Plant (Beijiao), Yangjiabao Sewage Treatment Plant (Yangjiabao), Hexi Beizhongbu Sewage Treatment Corporation (Hexi Bei), and Yangjiabao Sewage Treatment Plant (Yangjiabao). There are 367 sewage pipes linked to these treatment plants with a total length of 340.94 km.

There are 2 industrial sewage treatment plants, namely Taigang Sewage Treatment Plant (Taigang) and the Nanyan Sewage Treatment Plant (Nanyan). (Table 1) (Fig. 1) In addition, there are 2 plants, namely the Chengnan Sewage Treatment Plant and the Jiancaoping Sewage Treatment Plant, are planned to be

Figure 4: Tour of a sewage treatment plant: Yangjiabao Sewage Treatment Plant (left) Hexi Eizhongbu Sewage Treatment Corporation (right)

constructed in the future. Their treatment capacities are 260,000 and 50,000 m^3/ day respectively. After put into operation, the ratio of sewage treatment in Taiyuan City is expected to reach 70%.

Table 1: State of sewage treatment plants

	Area for collection of sewage km^2	Designed capacity 10 thousand tons / day	Population benefited by the treatment 10 thousand persons	Volume of sewage treated 10 thousand tons / year	Cumulative investment 10 thousand Yuan	Operation cost Yuan / ton
Municipal sewage treatment plants						
Yangjiabao	58	16.64	56	5353	14253	0.35
Beijiao	18.09	8	16	363	7668.3	1.28
Yinjiabao	21	1	13	375	467	0.84
Hexi Bei	35	15	70	2182	12272	0.36
Industrial sewage treatmentplants						
Taigang	—	16.4	—	3650	17000	0.58
Nanyan	—	6	—	1460	5050	—

Placed in order on the basis of the Tai Yuan survey result

(5) Water saving

a) Policy

On the basis of the policy determined by the "Water Law" of the People's Republic of China and the "Water Resource Management Institute" of Shanxi Province, the Tai Yuan Municipal Government established the "Water Saving Regulation of Tai Yuan City." According to this regulation, the water saving standard is stricter than the national standard, in consideration of the condition of water resources in Tai Yuan City.

b) Measures

For enterprises:

- The regulatory system for the volume of water for use is to be adopted.
- Where water is used in excess, a water fee 2 ~ 5 times higher than the usual fee is to be charged.
- Industries requiring large water consumption will not be developed.
- In addition, a new enterprise is investigated in advance from the perspective of environmental management.

For households:

- To encourage water saving.
- To encourage the use of water-saving-type equipment in particular.

For agriculture:

- To establish model water-saving irrigation districts. (Fig. 5)
- To promote water-saving irrigation techniques further.
- To build up a system to purchase water for agriculture, using a cash card.
- To control the volume of agricultural water, taking into consideration the water resources conditions and type of agricultural products of each year.

Tai Yuan City has been developing water saving projects since 1980, and the water saving effect is improving, supported by the water pricing policy and administrative regulation. For this reason, it is nationally recognized as one of the water-saving cities.

Figure 5: Model water saving district (left); Cash card apparatus (upper right) Embedded type irrigation pipe (lower right).
Note) This is a system in which a farm household can purchase water, using a cash card under the control of the total volume effected by the government, taking into consideration the volume of water resources and condition of the cultivation of agricultural products of each year.

4. Conclusions

In the Yellow River basin, it is necessary to construct a sustainable society based on a thorough management of water resources. In our survey, we keenly felt that the depletion of water resources in the Fen River basin is a miniature version of the entire Yellow River basin where the same type of problems may arise in a much larger scale, and experiences in the Fen River basin provides valuable suggestions and

insights for formulating future policy measures against water shortage problems in regions placed under similar conditions. We are convinced that the study of the steps taken by Tai Yuan City and investigation of the causes of water resource depletion will lead to the sustainable management of water resources in the entire Yellow River basin.

Based on this survey, we plan to continue studies on the following questions:

- Quantification of the environmental capacity of the Fen River basin in terms of water resources availability and water pollution control
- Allocation schemes of water resources to different sectors
- User fees and cost recovery of water transfer projects such as Wanjiazhai Project
- Technological potential of water saving and reuse of treated waste water in industry, agriculture and household sectors