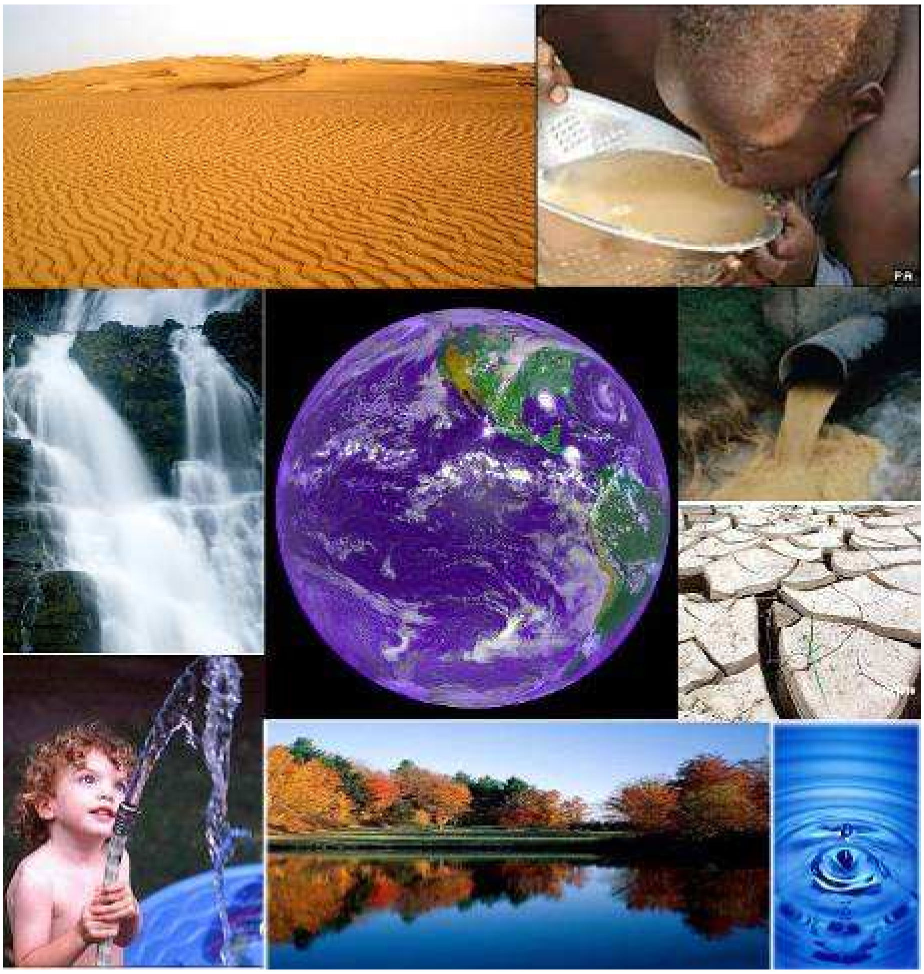
DECENTRALIZED WASTEWATER RECLAMATION IN BEIJING

An assessment of the performance of 4 systems and the drivers and barriers for implementation



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December, 2006

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Decentralized Wastewater Reclamation in Beijing

A Thesis Submitted

to Urban Environmental Management Group of

Wageningen University

in Partial Fulfillment of the Requirements

for the Degree of Master of Environmental Science

By

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December, 2006

Acknowledgement

I would like to thank all people who have given me their generous helps, commitment and enthusiasm, which have been the major driving force to complete the current paper.

Sincere my warmest thanks go to my supervisor Dr. Adriaan Mels, works in Urban Environment Group of Wageningen University, for his insightful guidance and earnest help all through the searching, analysis and paper-writing stages. Especially, his inspiring guidance and encouragement throughout my research were essential for this work. I also want to thank Dr. Okke Braadbraat for his reading of the manuscript and for helpful suggestions and other support. I also greatly appreciate the aid from Urban Environmental Management Group supporting me till the final stage of my research.

Finally, I would like to extend my heart-felt thanks to my family. My parents' support and blessing and, especially, my girlfriend's cooperation have made this work possible.

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Abstract

Nowadays, water scarcity becomes an increasingly severe problem all over the world. Wastewater reclamation as a solution has been widely used, also in China. The first regulation about wastewater reclamation in Beijing was enacted in 1987. During 19 years' development, the result is not satisfactory for the whole water demands of Beijing city. In order to find out the reason of limited development of decentralized wastewater reclamation systems in Beijing, the current performance was investigated in this research.

This paper starts with literature review of previous researchers' work about the wastewater reclamation systems. Though the arguments of wastewater reclamation theory the readers gain initial impression of the research. Within that the fours decentralized wastewater reclamation systems in the Beijing municipal area were selected as case study from Chapter 4 to Chapter 7. Water saving office as main stakeholder was interviewed in Chapter 8. The Key Performance Indicators (KPI), which include technical performance, operation and maintenance, social aspects, financial performance and health and safety, were summarized and compared for assessing current performance in Chapter 9. The results showed the decentralized systems were operated in the proper ways without any technical and management problems. Main drivers and barriers for implementation of the systems were found from the stakeholder analysis. The economic repayment, the strict policies, higher awareness and mature technical supporting are main drivers. The interviews from system owners and local water saving office presented the drivers such as the insufficient funds and construction troubles in the executing level, and chaotic management, unclear division of responsibilities, faint executing power and incompact monitoring in the governmental level. The recommendations in last chapter were given to different stakeholders to promote the development in future.

Key words: water scarcity, decentralized, wastewater reclamation, Beijing, current performance, drivers, barriers

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Chapter 1: Introduction

1.1 Background Information

This research focuses on the wastewater reclamation situation in Beijing. The general information of Beijing city is introduced firstly as background information. Beijing, a municipality directly under the Central Government is the capital of the People's Republic of China and the country's political, economic, and cultural and transportation centre as well as a famous historic city.

History

Beijing in Chinese means "capital in the north". Its establishment could be traced back to more than 3,000 years ago. From 1272 to 1911, Beijing was the capital of Yuan, Ming and Qing Dynasties. After the People's Republic of China was founded in 1949, Beijing is the capital of new China. (Second GEF Assembly, 2002)

Geography

Beijing is located in the northern part of the North China Plain and its terrain is high in the northwest and low in the southeast. Its total land area is 16,808 square kilometres, among which the mountain areas account for 52% and are distributed in its western, northern and north-eastern parts, and the plain accounts for 38% and is distributed in its southern and south-eastern parts.

Climate

Beijing is located in the temperate zone affected by continental monsoon. The spring and autumn in Beijing are shorter and dry while the summer and winter are relatively longer. The coldest month in Beijing is January with an average temperature of 4.7°C. The hottest month is July with an average of 26.1°C. Rapid temperature increases in the spring are often accompanied by sandstorms, but windless days in that season are wonderfully pleasant. The annual average temperature is 10-12°C, the annual mean rainfall from 1956 to 1998 is 595mm and the total annual amount of water resource is 4.33 billion m^3 (including the amount flowing from other regions).

Administration

Beijing is the political centre of China, and is one of the municipalities directly under the administration of the central government (the other three are Tianjin, Shanghai and Chongqing). Under its administration, there are 16 districts and 2 Counties.

Population

Beijing is a city with high population density. Its population is 11.5 million. 8 million people out of them are living in the city proper. In terms of nationality, most of Beijing citizens are Han Chinese but all the minority nationalities of China have citizens in Beijing. The language spoken is very close to the mandarin. (Second GEF Assembly, 2002)

1.2 Problem Description

Nowadays, water scarcity becomes an increasingly severe problem all over the world. 1.1 billion People have no access to a safe water supply and 2.6 billion have no access to basic sanitation, with the vast majority of these people living in developing countries. 1.6 million People die every year due to diseases related to poor sanitation and unsafe water supply. For the future, the situation will become more austere. Rapid economic growth and increasing urbanization will aggravate the uneven distribution of population, industries, and water in urban areas. With respect to these, water supplies and water pollution control are under unprecedented pressures. The major global challenges faced by then are the many people without sanitation, the health effects of poor water supply and sanitation, water shortage and water pollution and so on. (Chang Zhang, 2006)

China's water scarcity problems are more a result of uneven spatial and temporal distribution of water resources than of a lack of resources. For example, the North of China is very dry (per capita availability of water resources is only 750 cubic meters, and 80 percent of the rain falls during two summer months), but water is much more plentiful in the South (per capita availability of water resources in 3,400 m^3/capita). In comparison, per capita availability of water resources in Canada is 98,000 m^3/capita, in the United States availability is 9,400 m^3/capita, and the world average for per capita availability of water resources is 7,100 m^3/capita. This uneven temporal and spatial distribution of water has led to severe water shortages in the North and massive floods in the South. (The Woodrow Wilson International Center for Scholars, November of 1997)

With these constraints in mind, several suitable reclamation processes related to water reuse have been created in China, which are helpful to improve the situation of water scarcity. Beijing, located in North of China, already started to discuss the water reclamation from 20 years ago. The first regulation about wastewater reclamation in Beijing was published in 1987. Up to now, the emergence of wastewater reclamation, recycling and reuse is becoming a vital component of sustainable water resources management in urban and rural area in and around Beijing. However, the applications of decentralized wastewater reclamation are restricted. The current systems in a certain extent reduce the pressure on the water consumption, but the total development of water reclamation still cannot fulfil the gap between water demand and water supply. This research investigates the current performance of decentralized wastewater reclamation systems in Beijing and aims to analyze the drivers and barrier of system implementation. In order to realize this, a number of cases studies have been selected and evaluated based on technical, management, environmental, economical and social criteria and the comparison between different decentralized reclamation systems will be made.

1.3 Research Objective

To study why decentralized wastewater reclamation systems in Beijing only have relatively limited application while the regulation is from 1987 and Beijing has grown strongly since that time.

1.4 Research Questions

In order to realize the research objective, the research questions were designed to help to seek the answers.

- **Main research question 1:**

What is current performance of decentralized wastewater reclamation systems in Beijing?

Sub research questions:

- What is the processing capacity of the system?
- What is main technology of treatment of the system?
- How is the technical performance of the system?
  - Effluent quality
  - Processing efficiency
  - Sludge production
  - Chemical dosing
  - Energy consumption
- How is the operation and maintenance of the system?
  - Operation time
  - System failure time
  - Maintenance and recovery time
  - Labor input for operation and maintenance
- What are main social aspects from decentralized wastewater reclamation systems?
  - Awareness and knowledge of the users
  - Satisfaction of the users
  - Visible impacts from neighbors
  - Land occupation
  - Odor problem
  - Noise problem
- What is main financial performance from decentralized wastewater reclamation systems?
  - Initial investment
  - Operation cost
  - Maintenance cost
  - Estimated pay-back time
- What are main health and safety impacts from decentralized wastewater reclamation systems?
  - Accessibility of the system
  - Accidents records

- ◆ Illness records from employees
- ◆ Illness records from neighbors

- ■ **Main research question 2:**

What are the drivers and barriers of the implementation of the decentralized wastewater reclamation systems?

Sub research questions:

- ➢ Who are major stakeholders involved in the system?
- ➢ What are main functions of the stakeholders?
- ➢ What are the experiences from the stakeholders?
- ➢ What are main drivers of implementing the system?
- ➢ What are main barriers of implementing the system?

1.5 Scope and Limitations

This thesis research focuses on the investigation and assessment of decentralized wastewater reclamation systems. The final results by case study should be specific and realistic. The case selections are only considered within the boundary of Beijing area. The research works were divided into literature reviews, field work and data analysis. The field work was done in China and literature reviews & rest work was finished in the Netherlands.

Because the aim of the research is to generate the general assessments of decentralized wastewater reclamation systems, the results by investigating four cases in Beijing can reflect a part of truth of the whole situation. Moreover, the research period is around 24 weeks. The data collection in China is limited within three months. Therefore, the final conclusions could be restricted by time, cases capacities and cases quality.

1.6 Outline of the Report

The report is divided into ten chapters. The answers of research questions was summarized and integrated into different chapters. This introduction of this outline would like to guide the readers to primarily know the essentials and choose their reading emphases particularly.

Chapter 1: Introduction

This chapter gives the first impression to the readers. It provides the relevant information around the research. It includes the research background, research objective, research questions and scope and limitations. It guides the readers to be familiar with research process and helps them to start with this article.

Chapter 2: Research Methods

Here it describes the research design process in the primary preparation stage and in the investigation stage. This chapter focuses on how to do the research. It consists of the literature review, case study, interviews and questionnaires and data analysis methods. These studies enable readers to understand much clearly of the research keystones and information collection in the following chapters.

Chapter 3: Literature Review

This chapter reviews some Chinese and International literatures about wastewater reclamation theory and water scarcity in Beijing. By reviewing the wastewater reclamation development course and current situation of Beijing it describes why we need these studies and it makes the readers know the research aim well.

Chapter 4: Case 1- Beijing Rainbow Hotel

Hotel is one of main users in the wastewater reclamation field. Beijing Rainbow Hotel is a typical case to use the wastewater reclamation system in the early stage of this technology. This chapter is divided into three parts: general information, performance situation and the assessments. For the data comparison the same structure is used in next three chapters for other cases.

Chapter 5: Case 2 - BOBO Garden House Residential area

BOBO Garden House is a slap-up residential area in Beijing. As newly-built residential area, BOBO Garden House chose wastewater reclamation system to deal with its domestic sewage. This chapter introduces the performance situation of the residential area.

Chapter 6: Case 3- East district Student Dormitory of Tsinghua University

Bathhouse always discharges the relatively high quality wastewater than others. The balneal wastewater is much easier to be treated and recycled. The East district student bathhouse of Tsinghua University is one example of reclaiming the students' balneal wastewater in the university. This chapter shows the performance situation of the reclamation system.

Chapter 7: Case 4- DaShiQiao Student Dormitory of Tsinghua University

DaShiQiao student dormitory is the best dormitory in Beijing. The wastewater reclamation system is used as logo facility in this dormitory. Here the performance situation is investigated and demonstrated in this chapter.

Chapter 8: Water Saving Office of Beijing

After the investigation of four cases, it found that water saving office as external party is one of main stakeholders. The interview with them is a part of this research. Chapter 8 briefly introduces the opinions from water saving office. It is easier to help to analyze the main drivers and barriers from executing level.

Chapter 9: Data analysis and comparison

This chapter consists of data comparison and data analysis from four cases. According to the comparison of Key Performance Indicators, the current performance of decentralized wastewater reclamation cases is summarized. The stakeholder analysis also gives the drivers and barriers of main problems of limited development. It is the most important chapter in the report.

Chapter 10: Conclusions and Recommendations

As last chapter, it summaries mostly important points from above chapters and draws the conclusions. It assists the readers to fast recollect the whole research process and gain the main research results from this article. Some recommendations for further research are given as well.

Chapter 2: Research Methods

2.1 Framework of the research

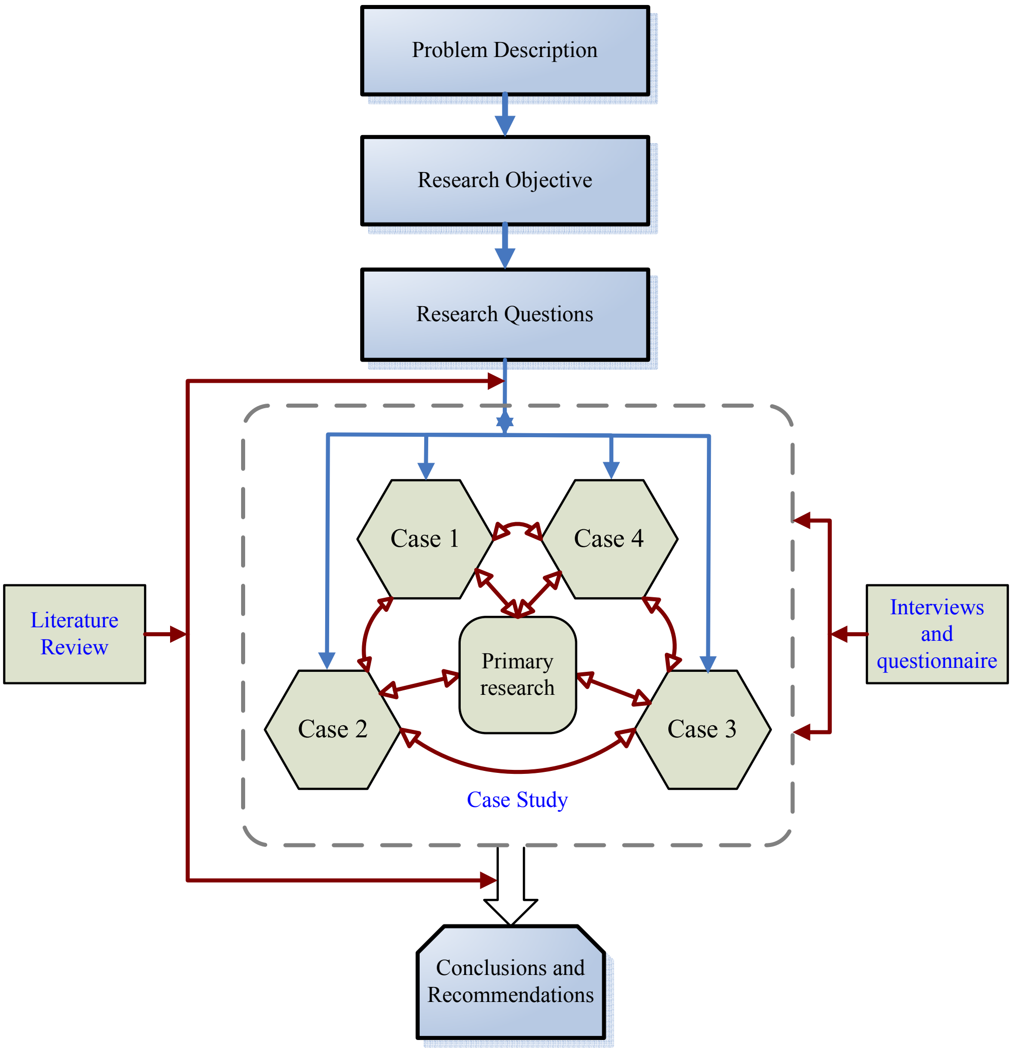


Figure 2.1: Framework of the research

The research started from problem description of water scarcity all over the world. The restricted water supply leads to the water scarcity problem. Wastewater reclamation system as one of high-efficient solutions was assessed in this research. The research objective and research questions were made around the assessment of decentralized wastewater reclamation system in Beijing. In order to make the assessment practical and feasible, the four cases in Beijing were chosen to be investigated and compared. Through studying the specific cases and interviewing the main stakeholders, the assessment of the system performance would be

summarized from the case study. The final conclusions were answered the research questions and the recommendations would be given to relevant stakeholders.

2.2 Literature Review

Some information should be collected at the beginning of the research, especially some background information. It can be found by reading literature and news from internet or library. The primary research on wastewater reclamation is the basic of this investigation. The literature review starts to search the relevant theory of water reclamation in the worldwide scope. From the general arguments the features of decentralized wastewater reclamation systems were discussed. Also the confirmed information and data can be collected from literature review to compare the current data. The related regulations and policies provide the clear development track for analyzing the current situation in Beijing.

2.3 Case Study

In order to obtain more in-depth knowledge about the current reclamation situation of Beijing, case study is regarded as a powerful strategy. Case selection seems to be a significant step of case study. It also closely related with the final research results. Because the research purpose focuses on the assessment of decentralized wastewater reclamation system in Beijing, the conditions of the cases would be limited within the research scopes.

Requirements of case selection:

1) Input water: the influent of the system should be wastewater or polluted water in definition. Such as balneal wastewater, domestic sewage, cooling water and so on.
2) Reclamation function: the system should be provided with wastewater recycling or wastewater reuse actions and the treated wastewater should be used in some purposes.
3) Style of the reclamation system: (Decentralized) the system is better to be on site. It means the treatment process and reclamation process should be near the wastewater sources and reclaimed water customers.
4) Scope of geography: the cases should be in the scope of Beijing municipal area.
5) Time boundary: the system should be formally built before 2004. It means the system was used at least more than one year. It means the operation of the system is in the normal and stable period. These experiences could be useful for this research.
6) Technical treatment: the wastewater should be treated by some technical methods. Direct reuse and recycling are not considered in this research.

7) Scale of the system: in order to ensure the data widely, the wastewater dischargers and wastewater customers should be a kind of community. The individual system like domestic swimming pool system could not be considered in this research.

2.4 Interview and questionnaires

- **Interview**

Interview is the most important and efficient way to get the information. Interview with people not only gains the main information, but also can get their opinions and suggestions. During the visiting in Beijing, the interviews were realized by face-to-face interview and telephone. Most of interviews were ranged with major stakeholders and people worked in key departments. Hereinto, the interviews with the system owners and environmental companies have already been planned in the proposal. The interview with water saving office was arranged during the research process. From the interview notes, the first-hand materials can be collected accurately.

- **Questionnaires & observation checklists**

Questionnaire is the secondary information source. Because the interview time is not available or the formal style of interview is not necessary, the questionnaire will help to save lots of time and get first-hand information in free style. It can be considered for users' level and employees' level. The questionnaires were used for residents in the residential areas, for guests and employees in the hotel, for the students in the university.

2.5 Data Analysis

- **Performance Analysis**

For analyzing the current performance, Key Performance Indicators (KPIs) were used and compared. Key Performance Indicators as quantifiable measurements help to define and measure the progress toward the goals. In this research, KPIs were defined from five aspects: technical, management, social, financial, and health and safety aspects. The results of current performance were from the comparisons of KPIs of four cases.

Table 2.1: Key Performance Indicators of current performance analysis

Key Performance Indicators	
KPI 1 Technical performance	Effluent quality
	Processing efficiency
	Sludge production
	Sludge disposals
	Chemical dosing
	Energy consumption
KPI 2 Operation and maintenance	Operation time
	System failure time
	Recovery time
	Labor input for operation and maintenance
KPI 3 Social aspects	Awareness of the users
	Satisfaction of the users
	Visible impact for neighbors
	Land occupation
	Odor problem
	Noise problem
KPI 4 Financial performance	Initial investment
	Operation cost
	Maintenance cost
	Estimated pay-back time
KPI 5 Health and safety	Accessibility of the system
	Accidents records
	Illness records related with system for neighbors
	Illness records related with system for employees

■ **Stakeholder Analysis**

Stakeholder analysis is the identification of a project's key stakeholders, an assessment of their interests, and the ways in which these interests affect project riskiness and viability. Key stakeholders who can significantly influence or are important to the success of the water reclamation development were participated in and asked by interviews. The interview results provided from stakeholders were summarized in this analysis process.

Chapter 3: Literature review

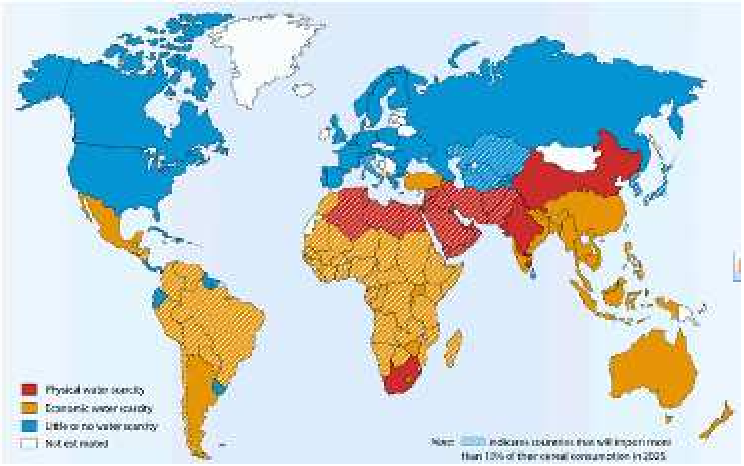
3.1 Water scarcity situation

3.1.1 Global water shortage

Water, as the lifeblood of Earth, is critical to sustainability. Unlike energy needs, where there are a variety of natural primary sources, such as wood, coal, oil, gas, wind, solar and many secondary supply routes such as electricity and heat. But there is no substitute for water. The only variations in type of water sources are those of physical form, ice, liquid, and vapor (as in clouds) and degree of purity, as in fresh, saline or otherwise unsuitable for drinking or agricultural purposes. (RWE Thames Water, N.D.)

There is no current shortage of water on planet earth, only limitations to humanity's equitable and affordable access to freshwater. Liquid freshwater whether in springs, groundwater, rivers or lakes, represents less than 1% of the Earth's water resources but provides 99% of all water currently utilized by humanity. There is a relatively stable 'freshwater base' on the planet, but the quantity and quality of freshwater that is available to meet human needs at any given time or place is far from stable. (RWE Thames Water, N.D.)

On a global annual average basis, according to United Nations definitions, it is estimated that about 2,000 cubic meters of freshwater resources are required to sustain one human being with current agricultural, industrial and domestic practices. Taking today's global population of 6 billion, this would equate to roughly 30% of the total freshwater stocks on the planet (estimated at 35,000 cubic kilometers per annum). The situation appears satisfactory until one considers the dysfunctional relationship between the location of freshwater and the location of human need in the 21st Century. This imbalance means that only half of the water that should be consumed overall is actually consumed, and in grossly unequal shares within and between different countries. (RWE Thames Water, N.D.)



Currently, nearly 450 million people in 29 countries face water shortage problems, a figure that is projected to jump to nearly 2.5 billion people by the year 2050. (Serageldin, 2000) By 2025, 1.8 billion people will live in countries or regions with absolute water scarcity. Most countries in the Middle East and North Africa can be classified as having absolute water scarcity today. By 2025, these countries will be joined by Pakistan, South Africa, and large parts of India and China. This means that they will not have sufficient water resources to maintain their current level of per capita food production from irrigated agriculture—even at high levels of irrigation efficiency—and also to meet reasonable water needs for domestic, industrial, and environmental purposes. To sustain their needs, water will have to be transferred out of agriculture into other sectors, making these countries or regions increasingly dependent on imported food. (IWMI Global Water Scarcity Study, 2000)

3.1.2 Water scarcity in Beijing

Nowadays, China faces serious water scarcity which is becoming the main barrier to limit the whole development. The total water reserves of China are about 28,100 cubic meters, ranking sixth in the world. However, the water resource per capita is less than 240 cubic meters, only one-fourth of the world's per-capita water, equivalent to one-fifth of USA's and one of forty-eighth of Canada's, rankings No.110 in the world. China has already been classified one of 13 countries of per-capita water scarce in the world. (EPB of Wuzhou City, N.D.) The beginning of the 1990s, nearly 400 cities of total 668 cities in China have water shortage problems. By the end of 1993, 333 out of 570 medium and large cities in China were experiencing a shortage of water resources (Qian et al. 2001).

With rapid social and economic development, Beijing, the capital of China, must pay more attentions to the shortage of water. According to observation and analysis, the average

available and feasibly exploitable water resource in Beijing is 4.1 billion cubic meters per year, one third from surface water and two thirds from groundwater. Annual per capita water use in Beijing is less than 300 m^3, which are only one eighth of the average for China and one thirtieth of the world average. The total water consumption in Beijing for 1998 was 4 billion cubic meters (24% for domestic needs, 25% for industry, 49% for agriculture, and 2% for the urban water system). It is obvious that the water resource in Beijing is not in an advantageous position. The high population density as a result of the development of the city and the discordant economic structure development has placed demands beyond the limit of the carrying capacity of the current exploitation of the water resource. (Duan Wei, 2005)

The negative impact on the ecosystem because of the short supply of water has become more and more serious. Most of the rivers in Beijing are dry for a large part of the year. For example, the "mother" river of Beijing, Yongding River, has had no flow for decades. The groundwater has been over extracted by up to 6 billion cubic meters since 1960, which has resulted in the drying up of fountains, land surface subsidence, and degradation of water quality. In addition, more and more wastewater is discharged and has reached a level as high as 1.2 billion cubic meters per year (mixed with rainwater). Due to the lack of water, considerable eutrophication has been promoted in urban rivers and lakes, in turn causing the growth of a blossom of blue-green algae. (Duan Wei, 2005)

Over the past ten years, the average water consumption of Beijing urban area was increasing step by step and the total water consumption was up to 1.007 billion m^3 in 2000. In the capital's 21st century water resources planning, it is predicted that the gap between water requirement and natural water supply would be 1.2–3.0 billion m^3 in 2010. Meanwhile, the wastewater discharge of Beijing urban area is now approximately 0.9 billion m^3. With the advance of wastewater treatment technologies (such as microporous membranes), the reuse of sewage is now not only possible but has also been widely proved to be safe and reliable. (H. Jia et al, 2005)

3.2 Water reuse and reclamation theory

Some causes of water scarcity are natural, others are of human agency. The impact of natural processes can be aggravated by human responses. Human behavior can modify our physical environment in a way that makes useful water scarcer. The demand for water may be artificially stimulated, so that a given supply becomes "scarce". (J.T. Winpenny, N.D.) Planning for sustainable development and utilization of the limited water resources is, therefore, essential for worldwide sustainable socioeconomic development.

3.2.1 The definition of wastewater reclamation

The word "reclamation" has a long history in water resources management. In 1902, the U.S. Congress passed the first National Reclamation Act that created the Bureau of Reclamation and authorized it to construct irrigation projects in the western states and territories. Modern usage of the term "reclamation" refers to projects that reclaim usable water from wastewaters: that is, to take the waste component out of wastewater and reclaim the water for beneficial uses such as irrigating pasturelands and augmenting potable water supplies. The use of reclaimed water is most significant and cost-effective near urban areas where large volumes of wastewaters are generated. (Faye Anderson and William Arthur Atkins, 2006)

Reclamation views wastewater as a resource to be put to productive use, rather than as a waste to be disposed of. Water reclamation refers to the treatment of wastewater to produce reclaimed water (Faye Anderson and William Arthur Atkins, 2006). Developed nations commonly use water of potable quality to water lawns, flush human waste into sewers and so on. In fact, many water uses do not require such high quality water, and therefore important opportunities exist to put reclaimed water of lesser qualities to productive uses.

Water recycling refers to using water more than once by the same user, for example water is recycled in a home or factory. Water reuse refers to using water more than once after it is reclaimed and redistributed to a new use, such as from municipalities to farms. Water reuse often requires some level of treatment, but not necessarily to the highest standards for drinking water. The level of treatment required depends on the potential level of human contact or ingestion associated with the reuse activity. (Faye Anderson and William Arthur Atkins, 2006)

The primary definition of ‘reclaimed water’ was introduced from Japan in China. The official Chinese definition of ‘Reclaimed Water’ was announced in <Temporary Methods of Urban Reclaimed Water System 1995> by National Construction Ministry. It pointed that parts of high-quality domestic wastewater is treated to achieve <Domestic Wastewater Quality Standards>, and it can be reused within some scopes as non-potable water. In order to wide the application for other regions out of urban area, the ‘reclaimed water’ definition was modified and improved later on. (Goepe, N.D.) The quality of reclaimed water was regulated in the following conditions:

1) Meet sanitation requirements. Its main indicators are the number of coliforms, bacteria, chlorine, suspended solid, BOD_5 and others.
2) Meet human’s demand in a sense. It means that is not unpleasant feeling. Its main indicators are the turbidity, color, odor, etc.
3) Meet the requirements of construction and equipments. It means water quality should be less likely to corrode and scale the equipment and pipeline. Indicators are measured by pH value, hardness, evaporation residue, dissolved substances and so on.

3.2.2 Wastewater reuse trend

Wastewater reuse is in practice for agriculture, aquaculture, horticulture (e.g. flowers and forestry), natural flow allocation, groundwater recharge and industrial processes. The reuse of wastewater should adhere to standard values, such as to minimize public and environmental health impacts. Hence, wastewater should be treated to an appropriate level (e.g. standard or site specific criteria) for the reuse purpose (Zaini Ujang and Mogens Henze, 2006).

- **Agricultural reuse**

The idea of applying wastewater to cropland is not a new one. Today over 500,000 hectares (1,930 square miles) in fifteen countries are irrigated with municipal wastewaters. The practice of using treated wastewater to irrigate cropland originally fell out of favor due to concerns over health issues, especially those by bacteria, viruses, and parasitic worms. Current knowledge is enabling advancements in safe agricultural water reuse, and the World Health Organization has set standards for treating wastewater for irrigation of crops not eaten raw. (Faye Anderson and William Arthur Atkins, 2006)

While most wastewater constituents are viewed as pollutants, some elements are nutrients that belong on the land where they originated. Wastewaters contain lots of nitrogen, phosphorous, and potassium. Using water twice—once for municipal use and once for

irrigation use—converts would-be pollutants into valuable fertilizers while protecting rivers and lakes from contamination and providing a local source of water supply.

According to the survey data of 1997 in Beijing, the agricultural area irrigated by wastewater was about 10.96 million acres and the total wastewater consumption was about 0.22 billion m^3. Farmers pumped the reclaimed water from the discharge channels which had been treated by secondary treatment plants. In the future, with the adjustment of agricultural structure, the quantities of reclaimed water for agriculture in Beijing urban area may reduce. In the planning of wastewater reuse in Beijing central region, the agricultural irrigation was not considered. (H. Jia et al, 2005)

- **Municipal reuse**

Many cities have integrated reuse plans into their water management strategies. In addition to sending reclaimed waters to farms for irrigation purposes, cities themselves reuse wastewater to irrigate parks, playgrounds, greenbelts, cemeteries, and golf courses, and for other nonpotable uses such as toilet flushing, fire protection, street cleaning, and fountains. (Faye Anderson and William Arthur Atkins, 2006)

In general, converting wastewater into drinking-quality water makes less economic sense than converting it into irrigation water, due to the relatively high cost of treatment required to meet drinking-water standards. Moreover, the largest obstacle to reusing wastewater may be psychological; in other words, the public may struggle to accept this practice as good water management that safeguards their health and well-being.

Municipal reuse in Beijing began in the middle of 1980s, and the first wastewater reuse facility was built in a separate residential region. The main uses of reclaimed water are toilet flushing, street cleaning and grass irrigation. In 1987, “The management regulation on the building of reclaimed water facility in Beijing (trial)” was enacted by Beijing Municipal Government. According to the regulation, all the hotels which construction areas exceed 20,000m^2 and all the other public buildings which construction areas exceed 30,000m^2 must have its reclaimed water facility. Up to 2002, in Beijing central region, more than 154 small wastewater reuse facilities had been built and in which more than 120 small wastewater reuse facilities were in operation. These facilities were mainly built in hotels, universities, and office buildings. (H. Jia et al, 2005)

■ **Industrial reuse**

Water is used in many industrial processes, for cooling, washing, and incorporation into products. Industry accounts for almost a quarter of worldwide water use and this figure will increase as economic development advances. In the more advanced economies, industry accounts for between 50 and 80 percent of total water demand. Most of this water is used for activities that heat or pollute water, but that do not consume it the way irrigation does. Thus, much potential exists for recycling and reusing industrial water. (Faye Anderson and William Arthur Atkins, 2006)

Typical industrial uses of reclaimed water might include cooling, boiler feed, stack scrubbing, and process water. The quality of the reclaimed water needed for industrial purposes greatly depends on the specific industry and its product. For example, the use of reclaimed water in the paper and pulp industry is a function of the quality of the paper being produced. The higher the grade of paper, the greater its sensitivity to the quality of the water used to produce it.

Some factories in Beijing urban area had built their own wastewater treatment facilities to treat the internal industrial wastewater. According to the statistical data of 2000, 202 factories had built wastewater treatment facilities. Among these industries, 26 of them had reused treated wastewater and the total reuse quantity was 33,500m^3/d. Meanwhile, Beijing had built a large wastewater treatment plant, Gaobeidian Wastewater treat plant which had the capacity of 1 million m^3/d, from which the effluent had been sent to the neighboring power plant and used as cooling water after certain additional treatment. (H. Jia et al, 2005)

■ **Other reuses**

Several areas are using reclaimed water for environmental uses, such as stream augmentation, and for wetlands, marshes, and fisheries. The required level of treatment increases as the potential for human contact increases. Reclaimed water has also been used to recharge potable groundwater aquifers. (Faye Anderson and William Arthur Atkins, 2006)

Most rivers in urban area of Beijing run short of constant water supply and the main supply of some rivers were even wastewater. These urban rivers might be dried up after the cutting of wastewater. Using the reclaimed water to supply urban rivers would be a beneficial way to maintain the functions of urban rivers and keep the ecological balance. It should be mentioned that rivers for different functions need reclaimed water with different water quality. (H. Jia et al, 2005)

3.2.3 Feasible reclamation system

The feasible system of wastewater reclamation was illustrated from technical aspects. This sector gives the main processing technology and current species of reclamation systems. It includes the processing craft, main treatment technology and the selection of the processing craft.

3.2.3.1 Processing craft of wastewater reclamation system

In order to treat the wastewater to be reclaimed water, there are three basic treating phases:

1）Pre-treatment Phase: This phase mainly consists of grids and buffer tank. The primary role is to remove solid impurities and balance the water quality.

2）Main-treatment phase: This phase is the key to dealing with reclaimed water. The main effect is the removal of dissolved organic matters in wastewater.

3）Post-treatment phase: This phase in the main is for disinfection. It is the depth treatment for water quality. It guarantees the water effluent can achieve the standards.

3.2.3.2 Classification of main-treatment

Under the present method has been used can be broadly divided into three categories

A. Biological treatment: It uses the adsorption of microbes in water and oxidation and decomposition of the organic matters of the wastewater, including aerobic and anaerobic microbial treatment. Generally they are more aerobic treatments.
B. Physical chemistry treatment: The basic processing is to combine the coagulation and deposition method (flotation) with the carbon adsorption. Compared with the conventional secondary treatment, it enhances the effluent quality. But the operating costs are much higher.
C. Membrane treatment: It adopts Ultrafiltration (microfiltration) or Reverse Osmosis Membrane treatment. The advantage of this treatment is the high-efficient SS removal. Compared with the traditional secondary treatment, it reduces the occupied area. But there are still certain disputes in the practical application of this technology.

3.2.3.3 Selection of the processing craft

Many treatment systems in developing countries are not successful and unsustainable, because they were simply copied from Western treatment systems without considering the

appropriateness of the technology for the culture, land, and climate. Often local engineers educated in the Western development programs supported the choice for the inappropriate systems. Many of the implemented installations were abandoned due to the high cost of running the system and repairs (van Leir, 1998). Therefore, the proper processing technologies should be deliberate and selected for wastewater reclamation in Beijing.

A reasonable and reliable operation of the treatment process should be selected by considering following these conditions. (Goepe, N.D.)

- The input volume, water quality of raw water, and requests of reclaimed water must be taken into account when determining the craftwork.
- During the selection process, some issues should be considered, such as the occupied area of the system, the restrictions of surrounding environment, impact of smell and noise on the surrounding environment and so on.
- Organic matters in the raw water as main pollutant mostly could be considered to be treated by biological processing. In the process the sterilization and disinfection were essential craft. And disinfectant including chlorine is commonly used for disinfection.
- The main wastewater treatment process depends on quality of raw water and purpose of reclaimed water, which not only affects the choice, but also affects the cost. Therefore, the source of water is crucial choice. At present, in China sewage from residential districts mainly as raw water is treated to use for the water spray the flowers, toilet flushing, car washing and so on.

When the raw water is the effluent water from secondary treatment of a municipal sewage treatment plant, the Physical chemistry treatment with disinfection process could be adopted, as follows:

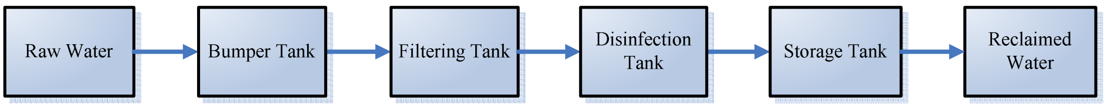


Figure 3.1: Flowchart for processing water from municipal WWTP

When the raw water is the sewage from residential areas, the biological chemistry treatment with disinfection process could be adopted as follows:

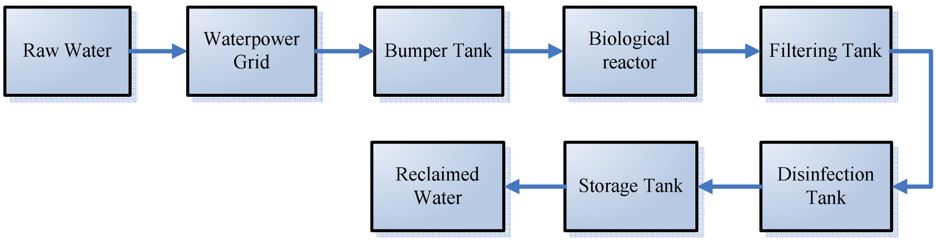


Figure 3.2: Flowchart for processing water from domestic sewer

3.2.3.4 The integrated wastewater reclamation facilities

The integrated wastewater reclamation facilities will concentrate a few reclamation treatment modules in facility. Its characteristics are compact structure, small size and high degree of automation. Normally the average handling capacity is less than 1,500m^3/day, and it applies mainly to the sewage treatment of a single construction with the general population less than 3,000 people. When the quality and quantity of sewage fluctuate greatly, the bumper tank is needed to adjust the raw water. But normally the bumper tank as individual construction is not considered in the wastewater reclamation facilities. The following equipment is used:

1) Assembly type of wastewater reclamation facilities

The process flow is designed into different monomers, such as the pre-processor, aerobic treatment unit, anaerobic treatment unit, flotation unit and so on. According to the different water quality and treating requests, the different monomers could be linked together into a complete process flow like building blocks. This equipment can be designed to be ground type or buried type depending on the local situation. Reinforced concrete could be used as materials, and plate (for anticorrosion) or steel materials may also be used.

2) MBR biological reactor

Membrane biological reactor is a kind of new system which combines Membrane separation technology with the biological treatment process. From overview of membrane bioreactor, the construction of the membrane bioreactor is composed of two parts: membrane modules and biological reactor. The membranes which applied in the bioreactor of wastewater treatment are micro-filtration membrane or ultra-filtration membrane. The configuration models are normally hollow-fiber-type or plate type.

3.3 Discussion of the centralized system and decentralized system

So far there are two kinds of urban wastewater reclamation systems: centralized and decentralized wastewater reclamation systems.

3.3.1 Centralized wastewater reclamation systems

Centralized wastewater reclamation system refers to the wastewater were collected in a relatively large areas and was concentrative treated, then reuse separately. Centralized wastewater treatment generally consists of a sewer system that collects wastewater from households, small enterprises, industrial plants and institutions, even storm water runoff, and transport this ever changing mixture to a wastewater treatment plant located outside or far away from the limits of the city or the village. In this context, the centralized wastewater reclamation system is mainly focused on municipal wastewater plants that have advanced treatment for water reclamation.

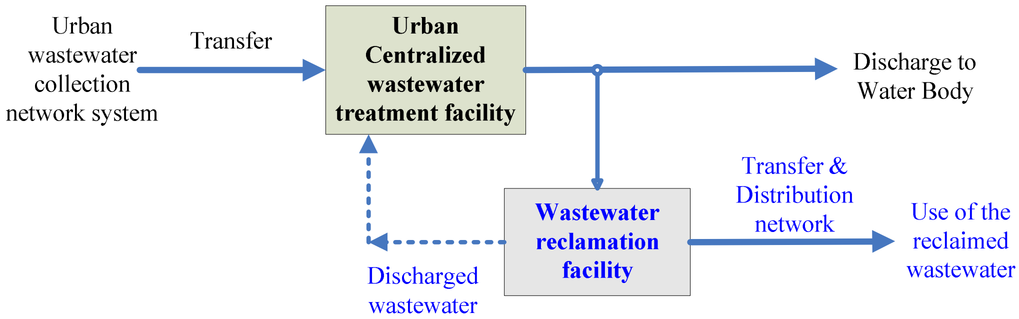


Figure 3.3: Scheme of the centralized wastewater reclamation system

In the past, the conventional wisdom has been that centralized systems are easier to plan and manage than decentralized systems. The centralized systems are always controlled by municipal governments. It means the treated process of the municipal wastewater treatment plant usually adopted the most reliable and mature techniques. And the skilled technicians were available for the centralized systems. Hence they are much easier to be accepted by the public. But the large substantial land use, the experience infrastructure investment and long distance transportation bring the resistances to implement in practice. The concept of large scale centralized systems is being questioned from the environmental sustainability point of view. Closing the water and nutrients cycles are difficult with large systems, requiring an extensive third reticulation system to bring the water and nutrients to where they can be reused (G. Ho, 2003).

3.3.2 Decentralized wastewater reclamation systems

Decentralized wastewater reclamation system refers to that the wastewater were collected from a few buildings and then treated and reused locally. The wastewater is treated from

decentralized systems rather close to the point of origin. Still, the wastewater has to be collected by means of a piping system, but the length of sewers is comparatively short. The collected wastewater flows to small on-site treatment plants, where wastewater and sludge treatment processes are executed. The treated water may be used for groundwater recharge, and polished by physical, chemical and biological processes during soil passage. Alternatively, the treated water may be sent to a nearby surface water body, or used for flushing toilets, washing clothes, for irrigation or fire fighting. The sludge is converted into compost that can be used, on site, as a soil conditioner and as a fertilizer source in gardening or landscaping (P.A.Wilderer and D.Schreff, 2000). In this context, decentralized wastewater reclamation systems refer to specialized reuse projects for individual residential areas, hotels, universities, official buildings, etc. The decentralized system generally includes the onsite system and the cluster system.

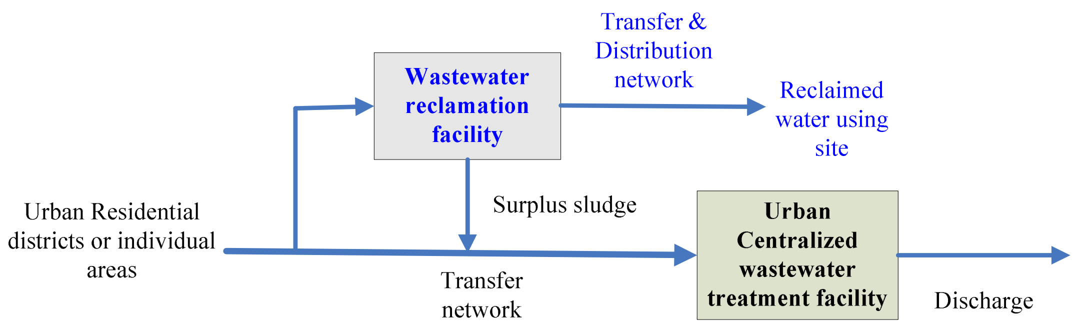


Figure 3.4: Scheme of the decentralized wastewater reclamation system

Decentralized and onsite wastewater treatment has gained importance across the world to treat wastewater from single sources and cluster scale housing. Onsite systems are systems contained within the household lot or within the close vicinity of the source of wastewater production. They typically have very little sewerage piping. The low cost and simplification of onsite systems has increased their applications in developing nations and when applied correctly they can provide substantial sanitation. The new high tech onsite systems can offer wastewater treated appropriately for reuse application (Randall, 2003). Small systems have implications beyond environmental sustainability. The lower cost of small systems, allows them to be designed for the available regional costs. The small scale reduces the capital cost involved in most small systems can ensure that operation and maintenance costs are within specified local budgets.

3.3.3 Arguments of two different reclamation systems

Centralized and decentralized systems have coexisted over the past years. The traditional approaches of centralized wastewater management provided in many developed nations have been inadequate for most developing nations. Although these approaches are often viewed as the most appropriate method for centralized management, they are associated with high development cost, especially infrastructure costs (e.g. deep sewerage costs), and high maintenance and operation costs (Ali, 2002). It is arguable that decentralized systems are more compatible with decentralized approaches to urban management than centralized systems. They are also compatible with the "unbundled" approach to service provision promoted by the World Bank. The Bank focuses on the financial aspects of unbundling, seeing it as a way of introducing private-sector investment and competition into service delivery and thus improving operational efficiency. However, the concept of unbundling can also cover the utilization of local resources through community-based and nongovernmental initiatives. (Parkinson J. and Tayler K., 2003)

- Decentralized decision-making and participatory planning

Decentralized planning and decision-making in wastewater management offers potential benefits relating to increased responsiveness to local demands and needs and, hence, increased willingness of communities to pay for improved services. Increased stakeholder involvement at the local level is often promoted by the non-governmental organizations (NGOs), which encourage a demand-responsive and participatory approach and often act as intermediaries to improve the flow of communication and broker agreements between communities and local government authorities (Parkinson J. and Tayler K., 2003). But another voice from Haniffa abdul Hamid and Zaini Ujang (2006) is that the decentralized systems are difficult to plan and upgrade. It is a common situation in developing countries that small sewerage facilities are used for many years without improvement or upgrading by individual owners. In many cases it will be difficult for authorities to plan and invest to refurbish the facilities.

- Financial advantages of decentralized management

The capital investment for decentralized wastewater systems is generally less than for centralized systems in peri-urban areas, and they are also likely to be cheaper to construct and operate (Parkinson J. and Tayler K., 2003). In small communities with low population densities, the most cost-effective option is often a decentralized and small system. This system will reduce capital cost of wastewater collection and treatment by retaining water and solids near the point of waste generation, especially when a reuse scheme is available. This is

more obvious in developing countries. But the financial advantage of decentralized systems is not obvious by calculating the wastewater processing capacity. The analysis from Jia shows that the average construction cost in large reuse systems is far less than that of small reuse systems. Meanwhile, the operational cost of large systems was also much lower than that of investigated small systems.

- Operation and management

The use of decentralized systems in development situations is often more flexible than centralized approaches, allowing the design to fit into a number of development locations and scenarios (Wilderer and Schreff, 2000; Randall, 2003). Properly managed decentralized and small wastewater systems can provide the appropriate treatment necessary to protect public health and comply with the water quality standards. Decentralized systems can be sited, designed, installed and operated to meet various required effluent standards. But treatment technologies are usually inadequate to meet the effluent standards (Odegaard, 2001). Due to lack of manpower and financial resources among owners or local Authorities, many plants are poorly operated and maintained. These systems are also difficult to be supervised by authorities due to the fact that most of the on-site facilities and sewage plant are owned by individual or private business entities. And the volume is too numerous to be properly supervised and controlled by authorities.

- Compatibility with local demands for wastewater reuse

Decentralized wastewater systems are likely to be compatible with local demands for wastewater reuse in peri-urban areas where water and the nutrient content in the wastewater increase agricultural productivity and contribute to the livelihoods of peri-urban communities. Wastewater may also be re-used for aquaculture, in which aquatic plant biomass is used either directly or as an ingredient in a feed-mix to raise fish or livestock for human consumption. Wastewater reuse can promote incentives for local people to operate and maintain local systems, and thus help to ensure long-term operation and financial sustainability. The reuse of waste can increase local agricultural productivity, resulting in increased revenue for local producers. Whilst this argument is not absolute insofar as financial benefits can be obtained equally well from the reuse of effluent from centralized facilities, it implies that decentralized management systems may achieve a better distribution of benefits and thus have the potential to be more pro-poor than centralized management. (Parkinson J. and Tayler K., 2003)

- Nutrients recycling

Small systems can be applied in urban and peri-urban areas as a method to increase sustainability, because they are more cost-effective at recycling water and nutrients than traditional centralized wastewater system (Fane et al., 2002; Ho, 2003; Mulder, 2003). The use of small wastewater systems has been put forth as one of the best means to recycle nutrients within the anthropogenic nutrient loop (UNEP, 2002). Small systems can be located near the source of nutrient and water use (e.g. agriculture), allowing the nutrients and water to be reused back at the source of application, after adequate treatment (Jonsson, 2002; Maurer et al., 2003). This cycle process allows the recycling of nutrients within the natural biogeochemistry protecting aquatic water bodies, whilst also ensuring that primary industries such as agriculture have available nutrients and water for production (Ho, 2003). In addition, the added advantage of recycling non-renewable nutrients such as phosphorus, in a cost-effective manner (e.g. close to the source of application), can enhance long-term sustainability of resources (Jonsson, 2002).

3.3.4 Drivers of the decentralized systems

The use of decentralized systems in development situations is often more flexible than centralized approaches, allowing the design to fit into a number of development locations and scenarios (Wilderer and Schreff, 2000; Randall, 2003)

Recently, the changes in public perception from scarcity of water resources have increased the focus on wastewater reuse, and the reuse of wastewater to supplement water supplies has been introduced in counties where it has been publicly accepted. In addition, the reuse of wastewater in some urban centers has taken into account a water cycle approach, where wastewater is used to ensure the hydrological cycle approach, where wastewater is used to ensure the hydrological cycle is maintain, by supplementing water sources (e.g. irrigation water) with appropriately treated wastewater (Robert Hughes, Goen Ho and Kuruvilla Matthew, 2006).

In developing nations there is a particular focus on cheap small scale systems that can provide beneficial resources, rather than large scale systems such as dual reticulation, which require considerable costs and can provide significant health threats (e.g. cross contamination of water supplies) where they are not maintained appropriately e.g. appropriate plumber certification programs.

In term of sustainability, decentralized systems offer the major advantage of reuse potential, because they do not concentrate wastewater in one location and can be placed to divert a particular stream of wastewater to an area where reuse potential is high.

3.3.5 Barriers of decentralized systems

- Lack of management expertise

Even where policy makers accept the validity of the decentralized approach, a lack of capacity to plan, design, implement and operate decentralized systems is likely to be a severe constraint on efforts to ensure its wide adoption. Even in the United States, the Environmental Protection Agency concluded that lack of management was a major barrier to implementing decentralized systems.

The management arrangements and responsibilities for operation and maintenance must be considered in relation to the capabilities of the individual householders, community groups or government departments. Therefore, where a system requires that ongoing operation and maintenance tasks are devolved to individual householders or community groups, it is essential that responsibilities are clearly explained at the outset. (Parkinson J. and Tayler K. 2003)

The sustainable operation of decentralized wastewater management systems must be compatible with the knowledge and skills available at the local level. Although even the simplest technologies often fail in practice due to a lack of attention to operational and maintenance requirements (Yhdego, M, 1989), decentralized management may provide opportunities for these tasks to be carried out correctly by local stakeholders, who have a greater incentive to ensure that facilities continue to perform as intended.

- Institutional constraints

In the majority of countries, there is a lack of suitable institutional arrangements for managing decentralized systems and a lack of a suitable policy framework that encourages a decentralized approach. There is a danger that decentralization will lead to fragmentation and a failure to address overall problems adequately. Without technical assistance and other capacity- building measures, problems of institutional capacity that existed under a

centralized operation are simply passed on to the new structures. (Campbell, T, G Peterson and J Brakarz, 1991)

Decentralization requires greater coordination between government, the private sector and civil society, and there is a need to look at the most appropriate institutional arrangements for managing decentralized wastewater systems and for monitoring and regulating those organizations that are responsible for their monitoring. One of the consequences of decentralization may be a lack of attention to pollution control,(35) and it is therefore necessary to consider the regulation of wastewater discharges, which may prove difficult where there are many smaller decentralized systems (Parkinson J. and Tayler K., 2003).

- Economic constraints

Decentralized systems may reduce the cost of investment required for wastewater management, but the majority of local government agencies and departments lack the resources to invest in new infrastructure and rely on grants from higher levels of government to finance improvements in service provision. Many poor communities lack the financial resources to invest in improved infrastructure. Lack of access to credit may also be a critical factor, inhibiting communities' ability to invest in improved services.

Those with a lack of secure tenancy also lack the incentive to invest in infrastructure to improve wastewater management practices. The acquisition of land for the more extensive forms of treatment that are effective in removing pathogens may prove difficult for those with limited financial resources. Wastewater re-use is widely practiced in the informal sector but is limited to a few official schemes, and benefits are not widely recognized in the wider macroeconomy.

- Social constraints

This brings us to perhaps the key constraint, the fact that there is currently no real demand for implementing effective systems for wastewater and faecal sludge management and, partly as a result of this; there is generally little willingness to pay for services, particularly for wastewater treatment (Linares, C and F Rosensweig, 1999). This may relate to a lack of concern or awareness of environmental pollution and of the health implications relating to wastewater disposal and re-use.

3.4 Wastewater reclamation development in China

Although the water resources in Beijing have guaranteed the prosperity and development of the city, the ecological environment has been significantly degraded. Groundwater has been overpumped, causing a rapid drop in the level of the groundwater table. The city's water resource now presents a great challenge, as the groundwater and environment have already been affected. The Beijing municipal government has recognized that the only way to overcome the problem is to insist on sustainable water resources exploitation and water reuse. (Duan Wei, 2005)

Both centralized and decentralized wastewater reclamation systems have been used in Beijing regions, and they are very different in many aspects. In general, the decentralized systems were often used to treat wastewater produced by small or medium industries and scattering housing and the centralized systems were often used to treat urban domestic wastewater produced by large centralizing housing and community (H. Jia et al, 2005). Now the domestic wastewater of Beijing urban area has been the primary problem since the polluting industries of this region migrate to the suburb of Beijing. Therefore, the dominating problem would be the treatment, reuse and recycling of domestic wastewater. According to the situation of Beijing, the centralized systems were adopted in the wastewater reuse planning of Beijing central region, and the decentralized systems were recommended to be used in the suburb of Beijing. (Duan Wei, 2005)

3.4.1 Chinese policy and regulations for water reclamation

From the perspective of policy making, the wastewater control and reclamation is considered as an important solution for the water quantity problems of semi-arid Beijing. Therefore, more and more national and local policies and standards start to focus on water reuse. "To prevent water pollution and to economize on water resources" has been declared as a national policy by the Chinese government. (Chang Zhang, 2006)

In China, the definition of 'Reclaimed Water' was announced in <Temporary Methods of Urban Reclaimed Water System 1995> by National Construction Ministry. It pointed that parts of high-quality domestic wastewater is treated to achieve <Domestic Wastewater Quality Standards>, and it can be reused within some scopes as non-drinking water. Because the water scarcity is not only in the urban area but also in the countryside and towns, the definition of 'Reclaimed Water' should be provided with the universality and forecasting.

Therefore, 'Reclaimed Water' was described that the wastewater from household and production is treated to achieve <Domestic Wastewater Quality Standards> or <Industry Water Using Standards>, and it can be reused in some scopes as non-drinking water. The relevant policies and regulations about wastewater reclamation in Beijing are introduced as follows:

In 1987, Beijing Municipal government promulgated <The Management Regulation on The Construction of Wastewater Reclamation Facility in Beijing (Trial)>. This is the first regional regulation about reclaimed water. (City Water Conservancy, 2005) According to the regulations, the following new projects within administrative area of Beijing should require necessarily to construct the wastewater reclamation facilities.

1) Hotels, restaurants and apartments whose construction area is more than 20,000 square meters
2) Organs, scientific research institutions, universities and large cultural and sports buildings and others whose construction area is more than 30,000 square meters
3) Residential areas and concentrated construction zones which are planned to build wastewater reclamation facilities.

In 1991, National Construction Ministry consigned China Engineering Construction Standard Association to constitute <Design Standard for Architectural Reclaimed Water System> (CECS30-91). It declared the basic standards of raw-water of reclaimed water, reclaimed water quality, wastewater reclamation system, technology and facilities, location of main process train equipments, and security and monitoring.

In 1995, Beijing's government had drawn up < Reuse master plan of reclaimed water from Beijing urban sewage treatment plant>. There are some explicit requirements for the urban construction. For example, when the plan is made for reclaimed water pipeline under the new roads, the pipelines installation must be started simultaneously along with the construction of new roads. (City Water Conservancy, 2005)

In 1996, National Construction Ministry enacted <The tentative management method of Urban Reclaimed water facilities>. The water reclamation facilities should be built by regulations of the construction area and reclaimed water volume. The detailed methods can be made by local government which must be higher than county level. But it should be accorded with following requirements:

1) Hotels, restaurants, shops, apartments, integrated services buildings and high-rise housing with construction area more than 20,000 square meters

2) Organs, scientific research institutions, universities and large cultural and sports buildings with construction area more than 30,000 square meters
3) Residential area with planning population above 30,000 (or reclaimed water volume more than 750 cubic meters per days)

In 1998, <Regulation of City Water Saving> was issued by the Chinese government. It was said that every organization that was using water must have a water meter. Additionally, every organization should try its best to make use of water recycling technologies for the sake of water saving. At the same time, the country encouraged the public, households, organizations, and industries to plan their water use. The uses of advanced water saving technologies were also proposed by the new regulation. (Li Xiangbin, 2006)

In 1999, Standard Ration Department of National Construction Ministry started the preparations for the edit of <Design Standard for Architectural Reclaimed Water System>. (Sun Yulin, N.D.) In the same year, Beijing started on a bigger wastewater reclamation project: Reuse Project of Reclaimed Water from Gaobeidian Sewage Treatment Plant. (City Water Conservancy, 2005)

In 2000, National Construction Ministry carried out the relevant indications from central government and entirely edited <Design Standard for Architectural Reclaimed Water System> and <Design Standards for Wastewater treatment and reuse> in order to upgrade to be national standards. In the same year in July, Beijing drainage group set up. It started to be responsible for construction and development and management of Beijing municipal wastewater reuse facilities. (City Water Conservancy, 2005)
In 2001, < Design Criterion of building reclaimed water system> (GBJXX-2001) was examined by National Construction Ministry and advanced to be National standards. (Sun Yulin, N.D.)

In 2002, General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China published < Urban Reuse of recycling water- Water quality standard for urban miscellaneous water consumption>. The reclaimed water quality was regulated in the following table:

Table 3.2: Reclaimed water quality standards in 2002

No.	Items	Toilet flushing	Road cleaning	Urban afforestation	Car washing	Construction
			Fire-fighting			

1	Color ≤	30				
2	pH	6-9				
3	Odor	No unpleasant smell				
3	Turbidity(NTU) ≤	5	10	10	5	20
4	Dissolved Solids (mg/l) ≤	1500	1500	1000	1000	---
5	BOD_5 (mg/l) ≤	10	15	20	10	15
6	Ammonia nitrogen (mg/l) ≤	10	10	20	10	20
7	Anion surfactants (mg/l) ≤	1.0	1.0	1.0	0.5	1.0
8	Fe (mg/l) ≤	0.3	---	---	0.3	---
9	Mn (mg/l) ≤	0.1	---	---	0.1	---
10	Dissolved Oxygen (mg/l)>	1				
11	Free residual chloride (mg/l)	>=1.0 after 30 minutes contact >=0.2 at the end of pipes				
12	Coliform Number/L ≤	3				

In April of 2006, National Construction Ministry and National Technology Ministry associated together and promoted <Urban Wastewater Reclamation Technology Policy> in order to encourage the water cycling and water reuse in the urban area. In this policy, the main processing technologies are mentioned for guiding and regulating the wastewater reclamation industry.

In addition, other relevant laws and regulations as follows also influence the wastewater reclamation in Beijing:

- Water Law of the People’s Republic of China
- Urban Planning law of the People’s Republic of China
- Sanitary Standard for Drinking Water (GB 5749-1985)
- Discharge Standard for Municipal Wastewater (CJ 3082-1999)
- Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant (GB 18918-2002)
- City Wastewater Treatment and Pollution Protection Policy (Construction 2000 No.124)
- Urban Wastewater Reclamation Technology Policy (Construction 2006 No.100)
- Urban Water saving regulation etc.

3.4.2 Water reclamation development in Beijing

In the U.S., water reuse has been widely used in western states where the amount of rainfall is insufficient to meet demands. However, scarcity of water resources is forcing implementation of water reuse in eastern regions of the country as well. New Jersey and Georgia have recently published guidelines for water reuse (State of New Jersey, 2000, State of Georgia, 2002). However, regulations in the East are not yet as comprehensive as regulations or standards in California, Florida, and Washington. Onsite wastewater treatment is currently employed to treat wastewater for approximately 25% of the US population (Dawes and Goonetilleke, 2003). One out of every four American households currently treat and release wastewater on their own property. Although most people assume that on-site systems are confined to rural areas, in fact half are in suburbs and a few even remain within the confines of large cities. In recent years, the proportion of new homes not connected to sewer lines has actually risen. Nationally 37 percent of new homes are now approved with on-site sewage treatment and in Minnesota; the percentage has risen even higher, to 45 percent of new homes. The message is clear: decentralized wastewater systems are here to stay. (Feinbaum, R., 2001)

Wastewater reclamation in China started relatively late. The first wastewater reclamation project was built in 1985 by the Beijing Municipal Environmental Protection Sciences. In the later few years, the water reclamation projects increased rapidly. But for various reasons, the facility did not have the good operation efficiency at the beginning. For example, only 60 units could be maintained to keep the operation within total 120 sets of water reclamation facilities. With the continuous improvement of technology and management, wastewater reclamation has been significant progress.

In 2003, the reclamation efficiency of the wastewater is 20% in Beijing. Information provided by Beijing Water Authority, in 2005 Beijing has about 1.3 billion cubic meters of sewage discharge, 800 million cubic meters from urban areas. Nine urban wastewater treatment plants can deal with 2.48 million cubic meters sewage per day with 70% processing efficiency. In 2005, 260 million cubic meters reclaimed water was used in Beijing, which 110 million cubic meters for industrial cooling, 120 million cubic meters for agricultural irrigation, 22 million cubic meters for town miscellaneous and 8 million cubic meters for urban water consumption for environment. While in 2005 the reclamation efficiency of the wastewater in the urban area raises up to be 30%. By the end of 2005, four wastewater treatment plants for reclamation were built with total handling capacity of 255,000 cubic meters per day. (Fang Shuai, 2006)

Currently, Beijing has built a total of more than 300 sets of wastewater reclamation systems in residential areas and other constructions. Daily handling capacity is designed totally to be 50,000 cubic meters. New systems in the constructing process were more than 100 sets, which concentrated mainly in hotels, offices, some institutions and other residential areas. Beijing plans that in the coming three years, the recycling rate for reclaimed water is 30%, 40%, 50%. (Fang Shuai, 2006) In addition, the regulations for the residential areas advised, if the residential areas in the areas of the pipe network systems, they should use the reclaimed water transported by the pipe networks. If there are no pipe systems around the residential areas, the construction company should build the treatment and recycling facilities at residential level.

For the decentralized wastewater reclamation systems, the influent water can be grey water and black water. The grey water refers to the wastewater collected from bathroom and washbowl, and the black water refers to the wastewater which includes the wastewater from toilets. For different wastewater, various treatment techniques can be adopted. In Beijing, according to the investigation in 2002, the 21 small reuse systems which use grey water as supply mainly adopted the technique of contact oxidation plus physical and chemical treatment. And the 12 small reuse systems which use black water as supply adopted several kinds of techniques, including contact oxidation plus physical and chemical treatment, MBR plus physical and chemical treatment and other treatments. (H. Jia et al, 2005)

3.4.3 Future targets and plans

By 2010, the water shortage in many developing countries is recognized as one of the most serious political and social issues of the time. Lack of water is stopping development and in many countries the rural poor suffer as their water and other needs take second place to those of swelling cities and industry. Local government worldwide is increasingly distrusted over water allocation, and historical divides between rich and poor are exacerbated by water shortages. However, by 2025 a worldwide hydro economy is developing, led by China. Vast new investments are made in recycling water and the cost of desalination is greatly reduced. Innovative small-scale water treatment processes become the norm. (John Vidal, 2006)

Water saving is listed as the top priority in the sustainable water resources management action plan. Although Beijing has made great progress in water saving, there is still some room for improvement. Saving water is also the best way to protect the water environment because reduced water consumption means less pollution and less wastewater requiring treatment. Water conservation is the pre-stage in wastewater management and is the most economic measure.

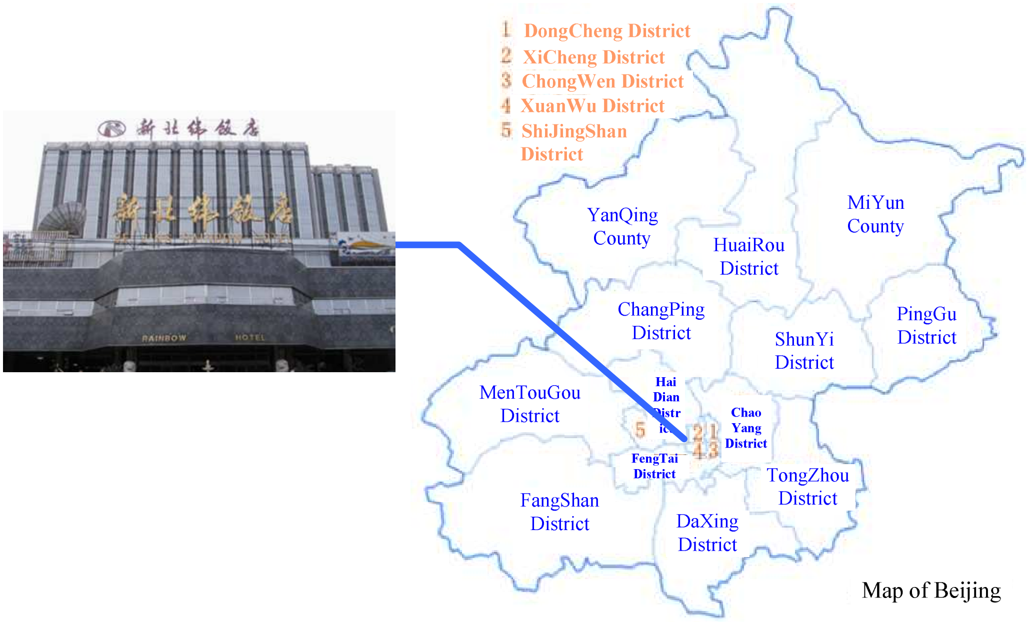
According to the promise for 2008 Olympic Games in Beijing, 16 municipal wastewater treatment plants would be in operation from wastewater treatment planning in Beijing, and 90% wastewater in urban areas would be treated in 2008. (H. Jia et al, 2005) Before 2008 ten centralized wastewater reclamation systems will be finished in urban regions of Beijing with processing capacity 590,000 m^3/day. Meanwhile, the reclamation efficiency of the wastewater expects to be 50% in 2008. In addition, the infrastructures of the reclaimed water will be improved. Main stem of pipeline was planned to be constructed 80 km in 2006. In 2008, the reclaimed water pipe expects to be 400 km. (Fang Shuai, 2006)

The objective for the year 2010 is for Beijing to become a water-saving city at the same level as that of cities in developed countries. The supply and demand balances should be reached in a hydrologically normal year, and water quality in the city should meet national standards. A savings of 410 million cubic meters of fresh water are planned for 2010. (Wei Duan, 2005)

It is easy to establish objectives but not so easy to meet them. In solving the water resources problem, Beijing requires new ideas and methods, including the broadening of its water resources, reducing water consumption, and protecting and managing the water environment effectively and in a sustainable way.

Chapter 4: Case 1- Beijing Rainbow Hotel

4.1 Introduction



Map of Beijing

Beijing Rainbow Hotel is also called Beijing Xin Bei Wei Hotel. It was founded in 1990 and rebuilt in 2000. Beijing Rainbow Hotel is a modern international joint venture. The hotel situated in a long street full of Beijing features, it is entirely integrated into ancient culture of the capital. The hotel is located in Xuanwu district and is next to Tiantan Park (Temple of Heaven) and TaoRanTing Park. There are 13 floors of main hotel building with 585 rooms. The hotel is equipped with each kind of dining room, as well as leisure fitness facilities, sauna, bowling, ping-pong, KTV. The hotel also has big assembly halls which may hold 200 people.

Table 4.1: Background of Beijing Rainbow Hotel

Background of Case One <Beijing Rainbow Hotel>	
Items	**Remarks**

Year of foundation	1991	used formally in 2002
Occupied Area	100 m^2	there are two workshops
Total investment cost	600,000 RMB	≈ 58,651 Euro
Maximum design capacity	120m^3/day	
Beneficial customers	300~400 people	guests living in the hotel
Source of influent	balneal wastewater (Only grey water)	from the hotel bathroom
Purpose of effluent	Toilet flushing	100% used for toilet flushing

The wastewater reclamation system of Beijing Rainbow Hotel was founded in 1991. In 2002, the technology was changed and the system was used formally. The occupied area of the process train equipment is 100 m^2. There are two workshops, and the average area of workshop is around 40 m^2. The maximum design capacity of system is 120m^3 wastewater per day. The influent wastewater is the balneal wastewater without the black water from the bathroom. The reclaimed water is used for toilet flushing and supplied for 300~400 guests living in the hotel per day. The total investment costs for the reclamation system is 600,000 RMB (≈ 58,651 Euro, calculated by 1 Euro≈ 10.23 RMB, August 2006). The system works in whole year except necessary maintenance and emergency.

4.2 Current situation of the system

4.2.1 Main processing technology

Biological Contact Oxidation technology

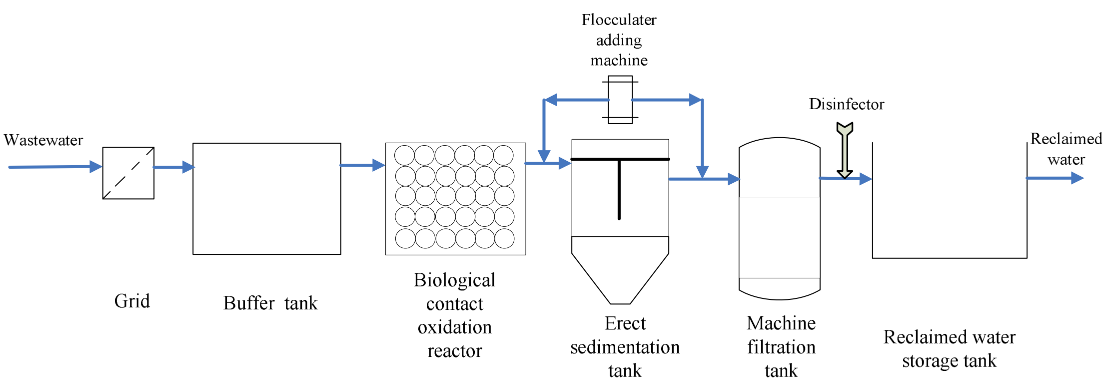


Figure 4.1: Flowchart of Biological Contact Oxidation technology

The main technology procedures: the padding is filled in biological reactor. The wastewater with oxygen immerges to the padding fully and flows through them with certain speed. The bio-film is generated between the padding. The completed contact between wastewater and bio-film takes place in the reactor. During this process, according to microbe metabolic effect in the biomembrane, the organic pollutants of wastewater are wiped off and purified.

4.2.2 Operation situation of the system

From the interview with system managers, in fact the average capacity of the system is $80m^3$/day. From the point of view of technical aspect, the wastewater reclamation system can process $29,200m^3$ wastewater per year.

Water Reclamation Capacity:

Original wastewater:	$80m^3$/day
Working time:	365 day/year
Reclaimed wastewater:	$80m^3$/day * 365 day/year
	$29,200m^3$/year

The quality of influent flow is very stable from the hotel bathroom such as COD150 mg/l, BOD100 mg/l, because balneal wastewater is grey water without heavy pollution and the water quality is balanced thought the buffer tanks. But the big change of room occupancy ratio and checking in periods in hotel leads to the unstable quantity of raw water. So the reclaimed water supply network connected with fresh water source for ensuring the waster supply when the water is not enough. The treated wastewater as reclaimed water is used for toilet flushing back to the hotel room. From the interview with the manager, the reclaimed water quality is judged only by COD, BOD and other physical characters. 30 mg/l COD and 10 mg/l BOD as main treated targets can achieve the water standards. Because the raw water quality of reclaimed water is better than industrial wastewater with heavy pollution, BOD is the main parameter in the standard for testing the reclaimed water quality. Therefore, BOD removal efficiency could be considered as main processing efficiency from technical aspect.

Processing efficiency:

Input COD:	150 mg/l
Output COD:	30 mg/l
COD removal efficiency:	(150-30)/ 150 = 80%
Input BOD_5:	100 mg/l
Output BOD_5:	10 mg/l
BOD removal efficiency:	(100-10)/ 100 = 90%

The additional chemicals are filled into the process for flocculating and disinfection. The whole reclamation process uses 1460 kg flocculants per year and some Sodium Hypochlorite for the treatment. The byproduct of the system is the sludge from the reactors. Because of using of biological contact oxidation technology, the total amount of sludge production per year is very little. But there is no written record for sludge amount. The energy consumption is 43,800 Kwh per year.

4.2.3 Management situation of the system

The owner and private environmental engineering company managed the wastewater reclamation system together. The operator is hired by Beijing Rainbow Hotel as employee and is responsible for this system. Normally the operator from the hotel who is trained by environmental engineering company checks the system every day. System monitoring and operation is his part-time job in the hotel. He puts 5 hours per day for checking the equipments and basic operation, such as pH value, surplus chlorine, smell and so on. The system runs in the whole year without intermission for maintenance. There is no record about system failure. In order to avoid the water shortage when accident happens or insufficient input, the system is prepared with the spare equipments and anti-emergency capacity, such as fresh water supply system. The backup equipments also provide the convenience for checking and maintaining them in daily operation. Meanwhile, the hotel has the electricity generator to continue the working of the pumps for temporary power cut. If the accidents or some technical problems are very serious and intractable, the operator will contact with Environmental Company to handle that and maintain the system. The fluctuation of the influent flow was considered in the design stage, so there is no testing for influent quality so far. The simple monitoring of the reclaimed water was taken for basic data and equipment operation by operator. The official testing of reclaimed water for COD, BOD and other items were applied by Environmental Protection Bureau once a year.

4.3 Assessment of Social Effect

In order to assess the social effects of the system, one questionnaire of reclaimed water knowledge and awareness was used in the hotel. Because the guests as main customers only live in the hotel in a short time, the answers from them may be not convincing. From the interview with system manager, there is no any complaint from the guests for toilet water yet. In order to know real using situation, the internal employees as a part of users were asked for knowledge and awareness. Therefore, the questionnaire was only asked for employees of the

hotel. The general questions consist of the knowledge of reclaimed water and the function of reclaimed water as follows:

> Question 1: Do you know the reclaimed water?
> Question 2: Do you know the reason for wastewater reclamation?
> Question 3: Do you know which water is reclaimed water in the hotel?
> Question 4: Are you satisfied with the quality of the toilet flushing water?
> Question 5: Do you have some suggestions for wastewater reclamation?

Because the interview was allowed in the working time, it has to be short and simple. The questionnaires started from ten employees of the hotel. It consists of three desk clerks, one chef, four housekeepers and 2 managers.

Table 4.2: The interview results from Beijing Rainbow Hotel

	Desk clerk 1	**Desk clerk 2**	**Desk clerk 3**	**House -keeper 1**	**House -keeper 2**	**House -keeper 3**	**House -keeper 4**	**Chef**	**Manager 1**	**Manager 2**
Q1	N	N	N	Y	Y	N	Y	N	Y	Y
Q2	N	Y	N	Y	Y	Y	Y	Y	Y	Y
Q3	N	N	N	Y	Y	N	Y	N	Y	N
Q4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Q5	N	Y	N	N	N	N	Y	N	Y	N

Note: Y= the answers are positive; N= the answers are negative.

4.3.1 Knowledge and Awareness

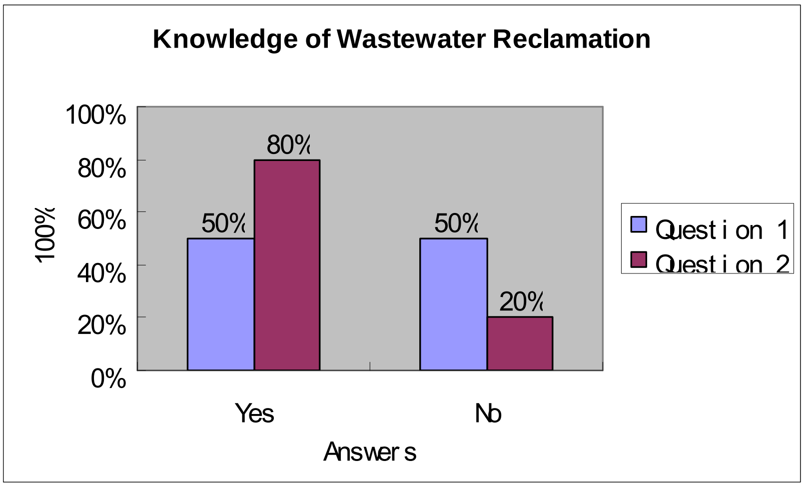


Figure 4.2: Investigation results of the knowledge of Beijing Rainbow Hotel

50% internal employees heard about reclaimed water before and 80% of them know the reasons for recycling the wastewater. Therefore, 65% internal employees have the basic knowledge for wastewater reclamation.

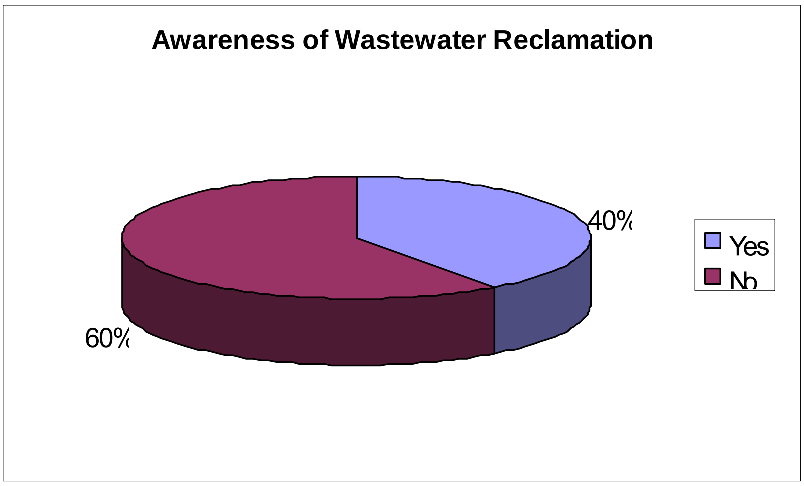


Figure 4.3: Investigation results of the awareness of Beijing Rainbow Hotel

40% of them are aware the reclaimed water as toilet flushing water in the hotel. Although most of them have the knowledge of wastewater reclamation, it is pity that 60% of them did not know the real application in their lives. They are not so interesting in the reclaimed water, and only few of them expect to gain more information in future.

4.3.2 Satisfaction of reclaimed water

Because the quality and transparency of reclaimed water is close to the fresh water and the reclamation information is not delivered, the users did not feel any uncomfortable. The answers of question3 are positive. They are satisfied with water quality of toilet flushing. From the system managers, the guests did not have any complaint. Reclaimed water as toilet flushing water is accepted by most of users.

4.3.3 Land occupation and visible impact

The total system occupied 100 m^2 lands for equipments and tanks. From the land selection and construction it is not so difficult for the existing hotel. Main workshops are in the basement and main equipments are installed in the workshops. The buffer tank and storage tank are in the basement too. There is no visual averseness for the neighbors.

4.3.4 Smell and noise impact

There is no obvious smell in the workshops and out of the room, because raw water is balneal wastewater without pungent odor. Normally, the noise comes from the pump and oxidation machine. All of equipments are installed in the basement, so the noise from them is very light. There is no complaint yet for the noise from the system.

4.4 Assessment of Economic Effect

The total investment costs for the reclamation system is 600,000 RMB. The cost includes the basin construction and pipe rebuilding. Because the rebuild of existing buildings is rather difficult, the hotel applied some subsidy from the government. So 30% of the total cost was paid by government.

Primary investment cost:

Subsidy from the government:	180,000 RMB, 17,595 Euro
Self-payment:	420,000 RMB, 41,056 Euro
Total one-off investment:	600,000 RMB, 58,651 Euro

The operation cost of the system is 31,250 RMB per year. The annual operation cost consists of processing cost and labor cost. Hereinto, the processing cost includes the chemicals cost, equipments expending, energy consumption and so on.

Reclaimed water processing cost:

Average cost:	0.68 RMB/m^3 (Data from operator)
Average volume:	80m^3/day
Running time:	365 day/year
Total annual cost:	0.68 RMB/m^3 * 80 m^3/day * 365 day/year
	20,000 RMB/year, 1,955 Euro/year

Labor cost:

Average salary:	1500 RMB/month/person (8 hours/day)
Workload:	12 month/year (5 hours/day for the system)
Total annual cost:	1500 RMB/month * (5 / 8) * 12 months
	11,250 RMB/year, 1,100 Euro/year
Average cost:	0.385 RMB/m^3

The economic repayment comes from the price difference between the operation cost and tap water price. In China, the tap water price is not same for different customers. The specific price depends on the purpose of water consumption. The tap water charging standards is in the following table.

Table 4.3: Tap water price standards in Beijing

Tap Water Charging Standards in Beijing		
Classification	**Water prices**	**Scopes**
1. Living for residents	3.7 RMB/m^3	1) Domestic using 2) Municipal consumption 3) Plunge bath 4) Students' bathroom and school canteen
2. Service departments	5.4 RMB/m^3	1) Administration departments 2) Army 3) School, Kindergarten and hospital
3. Industry and commerce	5.6 RMB/m^3	1) Industry 2) Commerce
4. Hotel, restaurant and catering industry	6.1 RMB/m^3	1) Hotel, restaurant and hostel 2) Catering industry 3) Entertainment 4) Business office 5) Temporary construction
5. Special industry	41.5 RMB/m^3	Purity water production enterprises
	41.5 RMB/m^3	Car washing company
	61.5 RMB/m^3	Bath center of hotel and other for-profit organizations
6. Compensatory price for agriculture	0.6 RMB/m^3	The water collection influence the water level for agriculture
Others	5.6 RMB/m^3	Other purposes are not included in above six classes

The current water price for hotel is 6.1 RMB/m^3 in Beijing (August, 2004). Because the reclaimed water is used for internal water consumption of the hotel, the water price is not obvious. The cost of reclaimed water is 1.07 RMB/m^3. Reclaimed water instead of tap water can save almost 5 RMB/m^3 for the residents.

Annual cost saving:

Tap water price: 6.1 RMB/m^3

Reclaimed water cost: 1.07 RMB/m^3

Volume of reclaimed water: 80m^3/day

Running time: 365 day/year

Total annual cost saving: 5.03 RMB/ m^3 * 80 m^3/day * 365 days/year

146,876 RMB/year, 14,357 Euro/year

Table 4.4: Economic assessment of Beijing Rainbow Hotel

Economic Assessment of Case One <Beijing Rainbow Hotel>				
Items		RMB	Euro	Remarks
Primary investment cost	Financial supporting	180,000	17,595	30% of total cost came from government
	Self-payment	420,000	41,056	Rest of the cost was paid by owner of system
	Total	600,000	58,651	It includes basin construction and pipe rebuilding
Annual operation cost	Processing cost	20,000	1,955	
	Labor cost	11,250	1,100	Calculated by average salary 1500 RMB/month/person
	Total	31,250	3,055	
Annual cost saving		146,876	14,357	Every cubic meter reclaimed water saves 5.03 RMB

Note: All exchange rate in the calculation by 1 Euro≈ 10.23 RMB, August 2006

Pay-back time is related with the decision making for investment. So the pay-back time for the system is calculated by investment and economic repayment. The initial investment is 600,000 RMB. The annual economic repayment is 146,876 RMB/year.

The pay-back time:

Initial investment: 600,000 RMB

Economic repayment: 146,876 RMB/year

Pay-back time: 600,000 RMB / 146,876 RMB/year

≈ 4 years

The initial investment is huge for the system owner. But the economic repayment is visible. The system owner can recover the cost in four years after implementing the system.

4.5 Assessment of safety and health

From the safety management of the system, only internal employees are allowed to come into basement of the hotel. The door of workshops is always closed during the working time, so nobody can come in except operator. People cannot touch the system without appointment. The wastewater goes into the buffer tanks and directly comes to be treated. There is no chance to contact the untreated wastewater.

The operator is responsible to monitor the system with simple testing. There is no record from guests and employees of the hotel and residents in the neighborhood experienced an illness related to the reclamation system. The reclaimed water sample was sent to Environmental Protection Bureau once a year. The results showed it can achieve the standards to be safe as non-drinking water.

4.6 Interviews with system owner

The ownership of the wastewater reclamation system belongs to Beijing Rainbow Hotel. The management team of the hotel is the decision maker of relevant issues of system. They decided to choose the technology, invest the equipments, hire the employees and implement the system. The interview was made with system manager for asking their experience and feeling. The main interview questions are listed as follows:

1) Why did the hotel want to invest to wastewater reclamation system?
2) Which departments asked for wastewater reclamation? What are their functions?
3) How did the hotel make the decision to invest?
4) At the beginning of the project, what were main problems for the owner?
5) What do you think the most difficult trouble for the owners?
6) What were the new problems when the system was implemented? How to solve them?
7) What are the main advantages and disadvantages of this system?
8) What effects did the system bring to the hotel?
9) Did the system owner have any expectations for other stakeholders?

Hotel as main stakeholder is a private for-profit organization, so they pay more attentions to the business and profits. The heavy operation cost of the hotel already restricts the development. Reducing the operation cost is main motivation for hotel managers to keep the business going. Comparing with the high tap water price, the reclaimed water cost is much cheaper. Wastewater from the hotel can be treated well and used in the hotel instead of tap water. The economical repayment is obvious as main driver for system owner. Meanwhile, the wastewater problem can be solved very well for conforming the policies and regulations. But the initial investment is huge, because the pipeline rebuilding in the existing hotel and new equipments purchase and installation are experience. The free space in the hotel for the system is limited as construction problem. The hotel started to contact with private Environmental Technology and Engineering Company for consultation. Moreover, the subsidy applications were sent to relevant administrative departments. The leadership of the hotel is significant in the decision making process. The repayment always needs a pay-back period for economic profit. The temporary manager is difficult to make the long-term plan. So the system was left unused when leadership was not stable. The technical supporting from Environmental Company is also important. When the technology were designed and guaranteed by Environmental Company and a part of investment was paid by Government, the hotel made the decision to implement the system. At the beginning of the system implementation, the system was not operated in a proper way. The machines did not work normally and the operator could not control it. Though the adaptive period, the system was getting to be the working order. The good communication and cooperation with Environmental Company helps the system manager to solve the problems. Now the wastewater problem is solved as well as economic profits for hotel is coming with wastewater reclamation.

Chapter 5: Case 2 - BOBO Garden House Residential Area

5.1 Introduction

Map of Beijing

Beijing BOBO Garden House is located in the east side of Olympic Sports Center Park of Tongzhou District. It is next to Green Belt of Beijing-Hangzhou Canal. The transportation is convenient and the scenery is beautiful. The total area of BOBO Garden House Residential Area is 186,000 m^2. Public afforested area and forestation rate could reach 40%. The north and south garden area has 4500 square meter central gardens respectively, central is green ecology main roads. The BOBO Garden House as high quality integrated residential area is self-contained: Fitness office, Chinese and the West dining room, community supermarket, upscale beauty shop, Harvard International Bilingual Infants' home. So BOBO Garden House is receiving people's widespread favor more and more.

Table 5.1: Background of BOBO Garden House Residential Area

Background of Case Two <BOBO Garden House Residential Area>		
Items		**Remarks**
Year of foundation	2003	used formally in 2004
Occupied Area	300 m^2	underground workshops
Total investment cost	3,000,000 RMB	≈ 293,255 Euro

Maximum design capacity	1200 m^3/day	
Beneficial customers	9600 people	residents living in the area
Source of influent	Household wastewater (Black water)	from the septic tank of the residential area
Purpose of effluent	Toilet flushing, irrigation and road cleaning	80% used for toilet flushing, 15% for irrigation and 5% for road cleaning

The wastewater reclamation system of BOBO Garden House was founded as originally installed at the beginning of 2003 as same as the construction of residential area. In 2004, the system was used formally. The occupied area of the process train equipment is 300 m^2. The workshops are underground. The maximum treatment capacity of system is 1200m^3 wastewater per day. All wastewater is treated to be discharging standards. 30% of the total treated wastewater will be reclaimed by special reclamation process as toilet flushing water and rest will be discharged into urban sewer system. The raw wastewater is the domestic sewage which is the black water from the septic tank of the residential area. The reclaimed water is used for toilet flushing (80%) and irrigation (15%) and road cleaning (5%). The reclaimed water is supplied for 9600 residents living in the area per day. The total investment costs for the reclamation system is 3,000,000 RMB (≈ 293,255 Euro, calculated by 1 Euro≈ 10.23 RMB, August 2006). The system works in whole year except necessary maintenance and emergency.

5.2 Current situation of the system

5.2.1 Main processing technology

Biological Contact Oxidation + Activated sludge

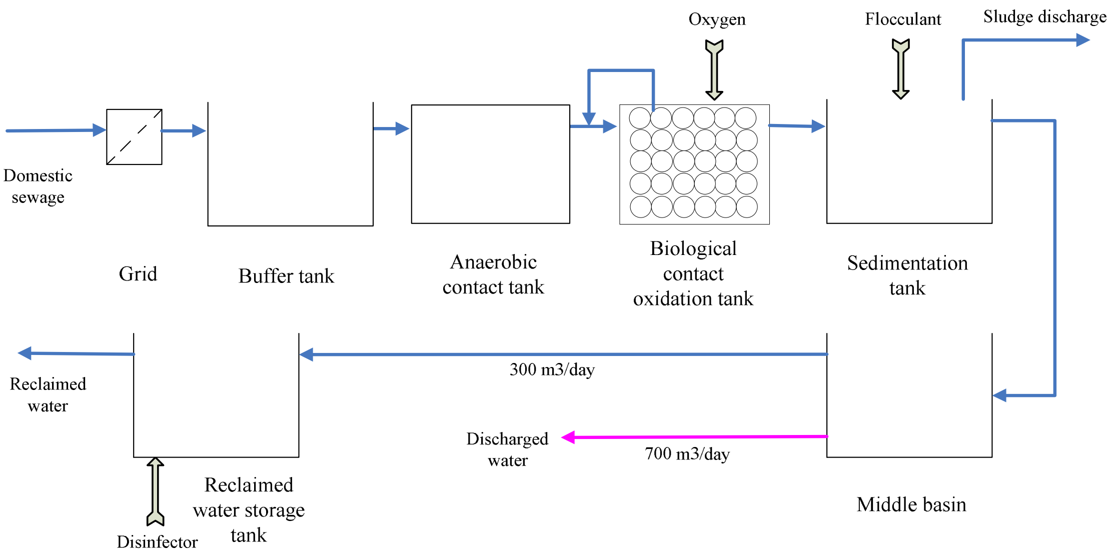


Figure 5.1: Flowchart of Biological Contact Oxidation plus Activated sludge

The domestic sewage is treated for wastewater discharging standards and wastewater reclamation standards. The mixed wastewater with black and grey water contains high organic matters. Single biological contact oxidation technology cannot process the wastewater to be the high quality reclaimed water. Therefore, the activated sludge method was used firstly for primary treatment. The treated wastewater with sludge got the better growing environment in the biological contact oxidation tank. Because the reclaimed water demand is lower than water production, a part of treated wastewater after the middle basin was discharged into urban sewer system. The rest was disinfected as reclaimed water into the toilet water supply system. This combination improves the processing efficiency and safety factors of the system.

5.2.2 Operation situation of the system

In fact, the average treatment capacity of the system is 1000m^3/day. 300m^3/day wastewater is treated as reclaimed water and 700m^3/day treated wastewater is discharged into urban sewer system.

<u>Water Reclamation Capacity</u>:

Original wastewater:	300m^3/day
Working time:	365 day/year
Reclaimed wastewater:	300 m^3/day * 365 day/year
	109,500m^3/year

The quality of influent flow is very stable such as COD300 mg/l, BOD200 mg/l, because domestic wastewater is from the septic tank in the center of residential area. The reclaimed water supply network connected with tap water network for ensuring the waster supply when the reclamation system fails. The treated wastewater as reclaimed water used for toilet flushing (80%) and irrigation (15%) and road cleaning (5%). Reclaimed water achieves the reclaimed water standards: COD: 30 mg/l, BOD: 10 mg/l.

Processing efficiency:

Input COD: 300 mg/l

Output COD: 30 mg/l

COD removal efficiency: (300-30)/ 300 = 90%

Input BOD_5: 200 mg/l

Output BOD_5: 10 mg/l

BOD removal efficiency: (200-10)/ 200 = 95%

The additional chemicals are filled into the process for flocculating and disinfection. The reclamation system uses 18,250 kg flocculants per year and some Sodium Hypochlorite for the disinfection. The byproduct of the system is the excess sludge from the reactors. The sludge goes into the septic tank to be disposed with excrements. There is no written record for sludge amount. The energy consumption is 131,400 Kwh per year.

5.2.3 Management situation of the system

The Property Company and Environmental Engineering Company managed the wastewater reclamation system together. The operator is the employee of Property Company and is responsible for operating this system. Normally the system works automatically. One operator only monitors the system 2~3 hours per day for checking the equipments and pH value, surplus chlorine, smell and other issues. The system runs in the whole year without intermission for maintenance. At present there is no record about system failure. The system prepares the spare equipments for anti-emergency, such as fresh water supply system in order to avoid the water shortage when accident happens. If the accidents or some technical problems are very serious and intractable, the operator will contact with Environmental Company to make the correction action together and deal with the problem. The cesspool as buffer system always provides the raw water with stable quality, so the influent was not monitored. The reclaimed water sample was asked Environmental Protection Bureau to be checked once a year.

5.3 Assessment of Social Effect

In order to assess the social effects of the system, the same questionnaire of reclaimed water knowledge and awareness was used in the residential area. The questionnaire was asked to the residents living in the BOBO Garden House area. The questions include the definition of reclaimed water, knowledge of wastewater reclamation, their awareness about using reclaimed water as toilet flushing water, the quality of their toilet flushing water and their opinions. The general questions are as follows:

Question 1: Do you know the reclaimed water?
Question 2: Do you know the reason for wastewater reclamation?
Question 3: Do you know which water is reclaimed water in this residential area?
Question 4: Are you satisfied with the quality of the toilet flushing water?
Question 5: Do you have some suggestions for wastewater reclamation?

The interview was taken in the residential area. The ten residents accept the questionnaires. Because the system was installed originally in the area, every house has two water meters for measuring the water consumption. The tap water fee and reclaimed water fee are charged separately for residents. According to the processing cost, the system owner regulates the reclaimed water price as 1 RMB/m^3. The property company is in charge of collecting the water fees.

Table 5.2: The interview results of BOBO Garden House residential area

	Resident 1	**Resident 2**	**Resident 3**	**Resident 4**	**Resident 5**	**Resident 6**	**Resident 7**	**Resident 8**	**Resident 9**	**Resident 10**
Q1	Y	Y	Y	Y	Y	N	Y	Y	N	Y
Q2	Y	Y	N	Y	Y	N	Y	Y	N	Y
Q3	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Q4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Q5	N	Y	N	N	Y	N	Y	N	N	N

Note: Y= the answers are positive; N= the answers are negative.

5.3.1 Knowledge and Awareness

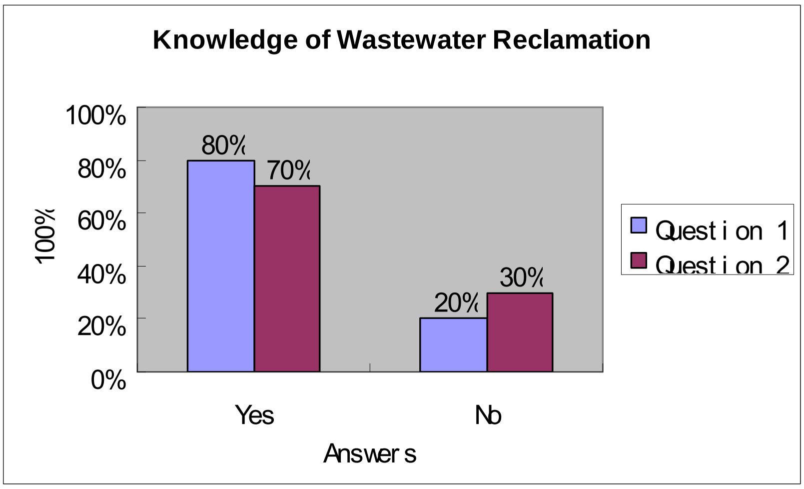


Figure 5.2: The investigation results of the knowledge of BOBO Garden House

80% residents know the definition of the reclaimed water and 70% of them accept the wastewater reclamation theory. Because the system was built as same as the main construction of residential area, the information was transmitted to the residents at the beginning of their inhabitation. According to the results, 75% of the residents have the basic knowledge of wastewater reclamation.

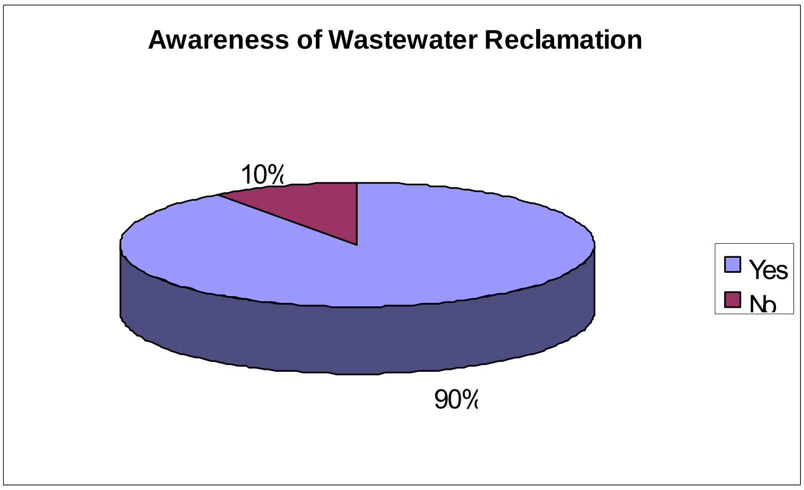


Figure 5.3: The investigation results of the awareness of BOBO Garden House

The results are optimistic. 90% residents know they are using reclaimed water now, because the cost of reclaimed water is closely linked with the residents' expending. From this point of view, the residents would like to gain certain knowledge subjectively. Therefore, the residents have high awareness and participation.

5.3.2 Satisfaction of reclaimed water

Due to high awareness and cooperation, the residents recognize the significance of wastewater reclamation. From the observation, the transparency and color of reclaimed water is not different with the tap water, the residents did not have any quality complaints. Reclaimed water as toilet flushing water is accepted by most of residents. They are also satisfied about the reclaimed water price.

5.3.3 Land occupation and visible impact

The system is located in the center of the residential area with 300 m^2 land occupation. Main workshops are underground near the underground cesspool and main equipments are installed in the workshops. The buffer tank and storage tank are in the underground too. The overground area of the workshops is covered by lawn. The system is not abhorrent from visual aspect.

5.3.4 Smell and noise impact

The source of the noise comes from the fans. They are all in the underground room, so noise from them is around 50~60 db in the room. Noise is reduced by deadening wall for surrounding residents. There is some obvious smell in the workshops. The smell is acceptable unlike strong smell from wastewater. There is no obvious smell around the system. There is no any record from the residents about smell and noise.

5.4 Assessment of Economic Effect

The total investment costs for the reclamation system is 3,000,000 RMB. The cost includes the basin construction and pipe installation. All cost was paid one-off by residential area developer Beijing YongTaiHongJi Real Estate Development Company. According to the environmental regulations and water administrative policy, the new residential area should prepare the wastewater treatment facility and wastewater reclamation (Residential population > 30,000 or daily reclaimed water volume > 750 m^3). So the system with 1000 m^3/day processing capacity had to be constructed from the plan stage. In fact, the cost of wastewater reclamation only took up three tenth of the total investment cost.

Initial investment cost:

Total one-off investment: 3,000,000 RMB, 293,255 Euro

Wastewater treatment investment: 2,100,000 RMB, 205,279 Euro

Wastewater reclamation investment: 900,000 RMB, 87,976 Euro

The operation cost for wastewater reclamation is 96,600 RMB per year. The operation fee consists of reclaimed water processing cost and labor cost. Hereinto, 700 m^3/day wastewater treatment fees were not calculated and the reclamation cost includes the chemicals cost, equipments expending, energy consumption and so on.

Discharged wastewater processing cost:

Average cost:	0.3 RMB/m^3 (Data from operator)
Average volume:	700m^3/day
Running time:	365 day/year
Total annual cost:	0.3 RMB/m^3 * 700 m^3/day * 365 day/year
	76,650 RMB/year, 7,493 Euro/year

Reclaimed water processing cost:

Average cost:	0.8 RMB/m^3 (Data from operator)
Average volume:	300m^3/day
Running time:	365 day/year
Total annual cost:	0.8 RMB/m^3 * 300 m^3/day * 365 day/year
	87,600 RMB/year, 8,563 Euro/year

Labor cost:

Average salary:	2000 RMB/month/person (8 hours/day)
Workload:	12 month/year (3 hours/day for the system)
Total annual cost:	2000 RMB/month * (3 / 8) *12 months
	9,000 RMB/year, 880 Euro/year
Average cost:	0.025 RMB/m^3

The residents pay the reclaimed water fee to the owner of the system. The reclaimed water cost is 0.825 RMB/m^3. The current water price for residents is 3.7 RMB/m^3 in Beijing. Reclaimed water instead of tap water can save 2.875 RMB/m^3 for the residents.

Annual cost saving:

Tap water price:	3.7 RMB/m^3
Reclaimed water price:	0.825 RMB/m^3
Volume of reclaimed water:	300m^3/day
Running time:	365 day/year
Total annual cost saving:	2.875 RMB/ m^3 * 300 m^3/day * 365 days/year
	314,813 RMB/year, 30,774 Euro/year

Table 5.3: Economic Assessment of Beijing Garden House Residential Area

Economic Assessment of Case Two <Beijing Garden House Residential Area>				
Items		RMB	Euro	Remarks
Primary investment cost	Financial supporting	________	________	No financial supporting from outside
	Total self-payment	3,000,000	293,255	
	Wastewater treatment	2,100,000	205,279	7/10 of total investment
	Wastewater reclamation investment	900,000	87,976	It includes basin construction and pipe installation
Annual operation cost	Reclamation cost	87,600	8,563	It includes wastewater treatment cost and wastewater reclamation fee
	Labor cost	9,000	880	Calculated by average salary 2000 RMB/month/person
	Total	96,600	9,443	
Annual cost saving		314,813	30,774	Every cubic meter reclaimed water can save 2.7 RMB

Note: All exchange rate in the calculation by 1 Euro≈ 10.23 RMB, August 2006

Pay-back time in this case is only considered about wastewater reclamation part. The initial investment is 900,000 RMB. The annual economic repayment is 314,813 RMB/year.

The pay-back time:

Initial investment: 900,000 RMB

Economic repayment: 314,813 RMB/year

Pay-back time: 900,000 RMB / 295,650 RMB/year

≈ 3 years

From the wastewater reclamation, the initial investment can be paid back in three years. Meanwhile, the wastewater can be discharged legally into urban sewer system. The reclamation system has the double function for the residential area.

5.5 Assessment of safety and health

Only the operator can come into underground workshop of the system in the residential area. The visitors should make the appointment with operator or Property Company firstly. The main chemicals are stored in the room and the tanks are buried underground. The residents cannot contact with untreated wastewater.

The operator is responsible for daily monitoring. The official examination of reclaimed water was asked by sampling testing in local Environmental Protection Bureau every year. There is no record from operator of Property Company and residents in the neighborhood experienced an illness related to the reclamation system.

5.6 Interviews with system owner

The ownership of the wastewater reclamation system belongs to Beijing YongTaiHongJi Company. Beijing YongTaiHongJi Company is also the developer of BOBO Garden House Residential Area. This company mainly involved in real estate development, operation of office building and hotel, property management and etc. Company has focused on Beijing's real estate market and developed some residential areas. The opinions of system owner were asked in following questions:

1) Why did the developer want to invest to wastewater reclamation system?
2) Which departments asked the residential area for wastewater reclamation? What are their functions?
3) At the beginning of the project, what were main problems for the owner?
4) What do you think the most difficult trouble for the owners?
5) What were the new problems when the system was implemented? How to solve them?
6) Which reflections did the system bring to the system owner?

Selling the houses is main purpose of the developer of residential area. Because the purchasers would like to seek the high quality of residential conditions, the wastewater reclamation systems as main environmental friendly symbol were installed originally and propagandized during the building selling process in the real estate industry. Meanwhile, the separated charging of cheap reclaimed water can save some money for tap water consumption of the customers. Therefore, in order to improve the competitive power, the developer expects to attract more purchasers by install wastewater reclamation system. In

addition, the wastewater treatment facility and wastewater reclamation system were mentioned clearly for new residential area in the policy and regulations. So the wastewater treatment system is required for residential area. The residents were informed with wastewater reclamation information at the beginning of their purchase. They have high participation and cooperation with reclaimed water. Some residents had the doubts about water quality and water safety in the early stage of system implementation. But the cheaper price comparing with tap water is the main driver to encourage them to use the reclaimed water. After using the reclaimed water and increasing the knowledge, they started to accept this reclaimed water. The treated water was used for toilet flushing and other water consumption in the area, such as road cleaning, plant irrigation and so on. It also saves lots of money for the developer instead of tap water consumption. But the huge initial investment shared a big part of budget. At the beginning, the technical problems were solved by Environmental Company. The reclaimed water was made a price as 1 RMB/m^3 by processing cost. Although most of the residents friendly cooperated for charging the reclaimed water fees, sometimes the cost could not be collected on time. This influences the operation of the system. The system owner expects the relevant departments shall make the reclaimed water price standards to push the wastewater reclamation development in realistic execution.

Chapter 6: Case 3 East-district Dormitory of Tsinghua University

6.1 Introduction

Map of Beijing

Tsinghua University is one of the most famous universities in China. Located in the northwestern suburbs of Beijing, Tsinghua University was built on the site of "Tsinghua Yuan"--a former royal garden of Qing Dynasty. When the University was established in 1911, it had the name of "Tsinghua School". In 1928, the School became the National Tsinghua University. From then on, it has developed into a comprehensive, research-intensive university, covering sciences, engineering, humanities, law, medicine, economics, management and art. Tsinghua University is not only a teaching center, but also a scientific research base of national importance. At present, Tsinghua University has 47 research institutes, 29 research centers (including 5 national engineering research centers), 13 national laboratories accounting for one tenth of the total number of national laboratories in China, and 27 post-doctoral research stations. The east-district is one of dormitory area of Tsinghua University.

Table 6.1: Background of East-district Dormitory of Tsinghua University

Background of Case Three <East-district Dormitory of Tsinghua University>		
Items		**Remarks**
Year of foundation	2003	used formally in 2003
Occupied Area	100 m^2	overground workshops
Total investment cost	2,000,000 RMB	≈195,503 Euro
Maximum design capacity	200m^3/day	
Beneficial customers	400 people	students living in the dormitory
Source of influent	balneal wastewater (Only grey water)	from the students' bathhouse
Purpose of effluent	Toilet flushing	90% used for toilet flushing and 10% irrigation

The wastewater reclamation system of East-district Bathhouse was founded in 2003 and the system was used formally in the same year. The occupied area of the process train equipment is 100m^2. The basins and equipments are installed in the overground workshops. The maximum design capacity of system is 200m^3 wastewater per day. The influent wastewater is the balneal wastewater without the toilet water from the students' bathhouse. The reclaimed water is used for toilet flushing (90%) and Virescence irrigation (10%). It is supplied for 400 students living in the student dormitory per day. The total investment costs for the reclamation system is 2,000,000 RMB (≈ 195,503 Euro, calculated by 1 Euro≈ 10.23 RMB, August 2006). The system works in whole year except necessary maintenance and emergency.

6.2 Current situation of the system

6.2.1 Main processing technology

Micro-Filter membrane method

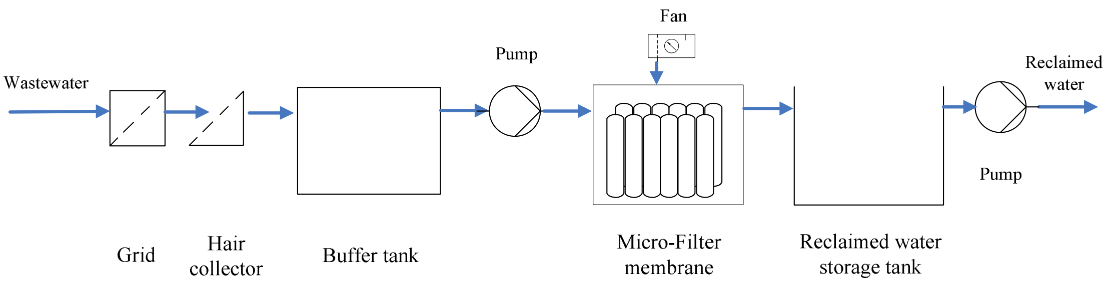


Figure 6.1: Flowchart of Micro-Filter membrane technology

Micro-filtration is the main technology of advanced treatment of sewage and water reclamation. It is also the membrane separation proprietary technology in the solid-liquid separation of biochemical reactions. According to use the world-class quality of the membrane material, the solid-liquid separation process of activated sludge will be completed in the membrane reactor tanks. Through a single sewage treatment equipment (the integration of membrane filtration and biological reaction), sewage can be used to produce clear, stable and transparent water. Effluent quality is far better than that of other sewage treatment processed. The quality of reclaimed water is extremely stable and free of bacteria, so it can be discharged or reuses without disinfection. And it can also be used as a pretreatment effluent of osmosis desalination.

6.2.2 Operation situation of the system

In the real life, the average treatment capacity of the system is 150m^3/day. The system runs 16~20 hours per day and non-stop in the whole year. From the point of view of environmental protection, the wastewater reclamation system can retrench 54,750m^3 tap water consumption per year.

<u>Water Reclamation Capacity</u>:

Original wastewater:	150m^3/day
Working time:	365 day/year
Reclaimed wastewater:	150 m^3/day * 365 day/year
	54,750m^3/year

The quality of influent flow is stable and even good for reclamation system such as COD150 mg/l, BOD100 mg/l, because the balneal wastewater does not contain too much organic matters. But the water quantity is changeful by influence of balneal time and number of the students. So the reclaimed water supply network connected with tap water for ensuring the waster supply when the water is not enough. The water level in the reclaimed water storage

basin will balance the water supply and discharge automatically. The treated wastewater as reclaimed water used for toilet flushing in the student dormitory. The quality of the reclaimed water is in the below table and it can achieve the reclaimed water standards.

Table 6.2: The testing results from Environmental Protection Bureau in December 19th, 2004

Items	The quality of reclaimed water
Turbidity	< 1
Dissolved solid, mg/L	874
Color	< 5
Odor	Third level
pH value	8.71
BOD_5 , mg/L	3.0
Free residual chloride, mg/L	2.22
Ammonia nitrogen, mg/L	< 0.05
Anion synthetic detergent, mg/L	0.04
Fe, mg/L	< 0.05
Mn, mg/L	< 0.05
Coliform No, number/L	< 3

Processing efficiency:

Input BOD_5: 100 mg/l

Output BOD_5: 3 mg/l

BOD removal efficiency: (100-3)/ 100 = 97%

The additional chemicals are filled into the process for flocculating and disinfection. The byproduct of the system is little sludge from the system. There is no any record about the Chemicals, sludge and energy consumption.

6.2.4 Management situation of the system

Tsinghua University and Beijing Novel Environmental Protection Company managed the wastewater reclamation system together. Only one operator takes care of the system and is

hired by Tsinghua University. He already accepted the technical training from the environmental company and always contacts with them regularly. All equipments and all water meters are connected with central computer system. The digital measurement is more exact and fast for the daily operation. So the operator only works one hour per day for checking the digital results. The system is operated in the whole year without intermission for maintenance. The system prepares the spare equipments and anti-emergency capacity, such as tap water supply system in order to avoid the water shortage when accident happens or insufficient input. The fluctuation of the raw water was considered in the design stage, so there is no testing for influent quality. The normal operation was monitored by computer. The reclaimed water sample was tested by Environmental Protection Bureau once a year.

6.3 Assessment of Social Effect

In order to assess knowledge and awareness of reclaimed water, a short question list was used in the dormitory. The questions include the definition of reclaimed water, knowledge of wastewater reclamation, their awareness about using reclaimed water as toilet flushing water, the quality of their toilet flushing water and their opinions. The general questions are as follows:

Question 1: Do you know the reclaimed water?
Question 2: Do you know the reason for wastewater reclamation?
Question 3: Do you know which water is reclaimed water in your dormitory?
Question 4: Are you satisfied with the quality of the toilet flushing water?
Question 5: Do you have some suggestions for wastewater reclamation?

The interview was taken in the visiting of Tsinghua University. The ten students accept the questionnaires. All of them have the shower experience in this student bathroom. They also live in the student dormitory in the east-district of Tsinghua University. The answers of the questionnaires showed in the table.

Table 6.3: The interview results of East-district dormitory of Tsinghua University

	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9	Student 10
Q1	Y	Y	Y	Y	Y	N	Y	Y	N	Y
Q2	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Q3	Y	Y	Y	Y	Y	N	Y	Y	N	N
Q4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Q5	N	Y	N	N	Y	N	N	N	N	N

Note: Y= the answers are positive; N= the answers are negative.

6.3.1 Knowledge and Awareness

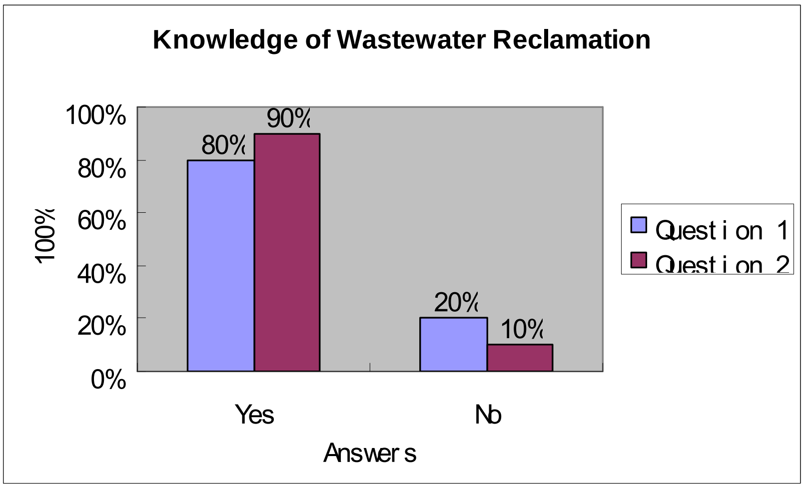


Figure 6.2: The investigation results of the knowledge of East-district dormitory

80% students understand the definition of reclaimed water and 90% can tell the theory of wastewater reclamation. The results show the students in the university have lots of knowledge about reclaimed water and wastewater reuse. During the interview, they can provide some information of wastewater reclamation; even some students can set out the technical theory. The knowledge from them is mainly from the internet/intranet or their specialty courses. Therefore, 85% interviewed students have the wastewater reclamation knowledge.

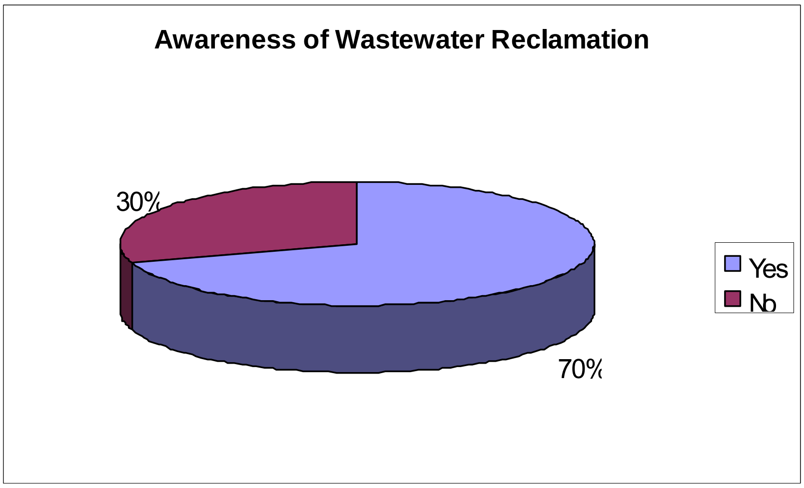


Figure 6.3: The investigation results of the awareness East-district dormitory

70% of the interviewed students are aware the wastewater reclamation in their dormitory. In addition, the new students will receive the introduction about their dormitory when they live in. They got the information from the university.

6.3.2 Satisfaction of reclaimed water

The interviewed students have no complaints about water quality. Because they have high knowledge background, all of them are satisfied with the water quality and safety. They are pleased to use the reclaimed water too. Reclaimed water as toilet flushing water is accepted.

6.3.3 Land occupation and visible impact

The total system occupied 100 m^2 lands for equipments and tanks. The workshops are next to the bathhouse and main equipments are installed in the workshops. The buffer tank and storage tank are buried underground. There is no visual averseness of the system.

6.3.4 Smell and noise impact

The system is not close to the student dormitory. The noise from the system is weakened by deadening wall. Noise is not a problem. Because the wastewater is balneal water, the smell is not strong at all. There is no obvious smell around the system.

6.4 Assessment of Economic Effect

The total investment costs for the reclamation system is 2,000,000 RMB. All cost was paid one-off by owner Tsinghua University. The cost includes the basin construction, pipe installation, pipe rebuilding and cost of measurable equipments and computer system. This project is a pilot model of the wastewater reclamation system by membrane technology in Tsinghua University at that moment. The investment was emphasized particularly on technical aspect. So the price of investment is much higher than current practical price.

Primary investment cost:

Subsidy from the government: ----
Self-payment: 2,000,000 RMB, 195,503 Euro
Total one-off investment: 2,000,000 RMB, 195,503 Euro

The operation cost is 30,375 RMB per year. The operation fee consists of processing cost and labor cost. Hereinto, the processing cost includes the chemicals cost, equipments expending, energy consumption and so on.

Reclaimed water processing cost:

Average cost: 0.5 RMB/m^3 (Data from operator)
Average volume: 150m^3/day
Running time: 365 day/year
Total annual cost: 0.5 RMB/m^3 * 150 m^3/day * 365 day/year
27,375 RMB/year, 2,676 Euro/year

Labor cost:

Average salary: 2000 RMB/month/person (8 hours/day)
Workload: 12 month/year (1 hours/day for the system)
Total annual cost: 2000 RMB/month * (1 / 8) * 12 months
3,000 RMB/year, 293 Euro/year
Average cost: 0.054 RMB/m^3

At present, the reclaimed water cost is 0.55 RMB/m^3. The current water price for school bathroom is 3.7 RMB/m^3 in Beijing. Reclaimed water instead of tap water can save 3.15 RMB/m^3 for the residents.

Annual cost saving:

Tap water price: 3.7 RMB/m^3
Reclaimed water price: 0.55 RMB/m^3
Volume of reclaimed water: 150m^3/day
Running time: 365 day/year
Total annual cost saving: 3.15 RMB/ m^3 * 150 m^3/day * 365 days/year
172,463 RMB/year, 16,859 Euro/year

Table 6.4: Economic Assessment of East-district Bathhouse of Tsinghua University

Economic Assessment of Case Three < East-district Bathhouse of Tsinghua University >				
Items		RMB	Euro	Remarks
Primary investment	Financial supporting	________	________	No financial supporting from outside

cost	Self-payment	2,000,000	195,503	
	Total	2,000,000	195,503	It includes basin construction and pipe installation and pipe rebuilding
Annual operation cost	Processing cost	27,375	2,676	It includes wastewater treatment cost and wastewater reclamation fee
	Labor cost	3,000	293	Calculated by average salary 2000 RMB/month/person
	Total	30,375	2,969	
Annual cost saving		172,463	16,859	Every cubic meter reclaimed water can save 3.15 RMB

Note: All exchange rate in the calculation by 1 Euro≈ 10.23 RMB, August 2006

The pay-back time for the system is calculated by investment and economic repayment. The initial investment is 2,000,000 RMB. The annual economic repayment is 172,463 RMB/year. The pay-back time:

Initial investment: 2,000,000 RMB

Economic repayment: 172,463 RMB/year

Pay-back time: 2,000,000 RMB / 172,463 RMB/year

≈ 11.5 years

The initial investment is huge from the budget part. But the economic repayment is remote. The system owner can recover the total investment cost in eleven and half years after implementing the system. It is a long-term investment for the system owner.

6.5 Assessment of safety and health

The overground system is managed by operator. The system is very close to the students' bathroom, so the wastewater is transferred to the buried basins directly. Main machines and tanks are installed in the room, so it is not easy to contact them. People who want to visit the system need to make the appointment with operator.

The system mostly is monitored by computer system. The operator checks the records of key steps and gives the reaction. The water quality was tested by Environmental Protection Bureau once a year. There is no record from operator and students experienced an illness related to the reclamation system.

6.6 Interviews with system owner

The ownership of the wastewater reclamation system of East-district Bathhouse belongs to Tsinghua University. The university is also the investor and technology provider. It is a pity that the interview with system manager was failed with contact problem. But the same questions were asked from the system operator. The answers can reflected some experiences from the system implementation. The interview questions are listed as follows:

1) Why did the university want to invest to wastewater reclamation system?
2) Which departments asked the residential area for wastewater reclamation? What are their functions?
3) At the beginning of the project, what were main problems for the owner?
4) What do you think the most difficult trouble for the owners?
5) What were the new problems when the system was implemented? How to solve them?
6) Which effects did the system bring to the system owner?

Tsinghua University is one of the most famous universities in China. Tsinghua University attaches great importance to academic research and real practices. The wastewater reclamation system as key project has already become a pilot model in the research of Tsinghua University. The environmental friendly awareness and facilities as logo also improves the school's reputation. These are main motivations to invest the wastewater reclamation system. As the technical pilot, the system was paid more attention to the technology improvement and system automation. The initial investment is huge than normal decentralized wastewater reclamation systems. The equipments mostly are imported and accurate. So the system was operated well so far. The students in the university who have good educational background can give more cooperation with reclaimed water. But the processing technology might be limited due to its high investment cost comparing with other practical technologies. The long pay-back time is the biggest problem for system owner to make the final decision.

Chapter 7: Case 4 DaShiQiao Student Dormitory of Tsinghua University

7.1 Introduction

Map of Beijing

DaShiQiao student dormitory of Tsinghua University is located in DongSheng village of HaiDian district. It is the largest student apartments of China. The dormitory occupies 28.4 hectares land. The total construction area of 350,000 square meters of college dormitories can accommodate 22,400 students. This project is the biggest construction project of Tsinghua University since 1990. The designed single room is allowed to live with four undergraduates or two master's degree students or one doctoral student. Public facilities are complete in the district, including student restaurant and student sport center and student service center and so on. Apartment own hot shower facilities, telephone, and television and internet connection. Therefore, this dormitory not only meets the basic requirement of living for students but also can satisfy their each kind of requirements such as learning, entertainment, communication, exercise and information gain.

Table 7.1: Background of DaShiQiao Student Dormitory of Tsinghua University

Background of Case Four <DaShiQiao Student Dormitory of Tsinghua University>		
Items		**Remarks**
Year of foundation	2003	used formally in 2003
Occupied Area	200 m^2	Semi-underground workshops
Total investment cost	2,000,000 RMB	≈195,503 Euro
Maximum design capacity	1800m^3/day	
Beneficial customers	15,000 people	students living in the dormitory
Source of influent	Household wastewater (Black water)	from the septic tank
Purpose of effluent	Toilet flushing and Virescence irrigation and road cleaning	70% used for toilet flushing and 20% for irrigation and 10% for road cleaning

The wastewater reclamation system of DaShiQiao Student dormitory was founded in 2003 and the system was used formally in the same year. The occupied area of the process train equipment is 200 m^2. The basins and equipments are installed in the Semi-underground room workshops. The maximum design capacity of system is 1800m^3 wastewater per day. The influent wastewater is the domestic wastewater which is the black water from the students' dormitory. The reclaimed water is used for toilet flushing (70%) and Virescence irrigation (20%) and road cleaning (10%). It is supplied for 15,000 students living in the student dormitory per day. The total investment costs for the reclamation system is 2,000,000 RMB (≈ 195,503 Euro, calculated by 1 Euro≈ 10.23 RMB, August 2006). The system works in whole year except necessary maintenance and emergency.

7.2 Current situation of the system

7.2.1 Main processing technology

Biological Aerated Ceramicite Filter

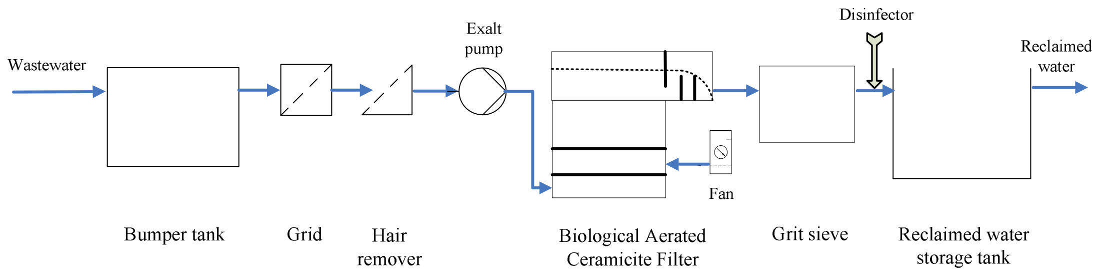


Figure 7.1: Flowchart of Biological Aerated Ceramicite Filter

Aerated Biological Ceramicite Filter provides a highly efficient and simple purification technology, including highly efficient mass transfer, biochemical, biological flocculation and filtration technology. Through the huge surface area of porous carrier, it increases the biomass of the unit volume. And it also greatly improves the capacity utilization and the effect of the reactors. The effluent water from the system is clear and clean. It applies to purification and reclamation of domestic sewage, municipal sewage and low concentration industrial wastewater.

7.2.2 Operation situation of the system

At present, the average treatment capacity of the system is 1800m^3/day. The system runs 20 hours per day and non-stop in the whole year. From the point of view of technical aspect, the wastewater reclamation system can process 657,000m^3 domestic wastewater per year.

Water Reclamation Capacity:

Original wastewater:	1800 m^3/day
Working time:	365 day/year
Reclaimed wastewater:	1800 m^3/day * 365 day/year
	657,000m^3/year

The quality with 400 mg/l COD, 250 mg/l BOD and 180 mg/l SS and the quantity of influent flow are stable for reclamation system, because the domestic wastewater gets the buffer effect in the cesspool. The reclaimed water supply network connected with tap water for ensuring the waster supply when the water is not enough. The water level in the reclaimed water storage basin will balance the water supply and discharge automatically. The treated wastewater as reclaimed water used for toilet flushing in the student dormitory and plant irrigation and road cleaning in the university. The quality of the reclaimed water is in the below table and it can achieve the reclaimed water standards.

Table 7.2: The testing results from Environmental Protection Bureau in January 18th, 2005

Items	The quality of reclaimed water
Turbidity	3
Dissolved solid, mg/L	772
Color	5
Odor	No smell
pH value	6.82
BOD_5, mg/L	< 2
COD, mg/l	< 10
SS, mg/l	4.96
Dissolved Oxygen, mg/l	7.9
Free residual Chloride, mg/L	6
Ammonia Nitrogen, mg/L	0.202
Anion synthetic detergent, mg/L	0.093
Fe, mg/L	0.074
Mn, mg/L	0.036
Coliform No, number/L	< 3

Processing efficiency:

Input COD: 400 mg/l
Output COD: 10 mg/l
COD removal efficiency: (400-10)/ 400 = 97.5%
Input BOD_5: 250 mg/l
Output BOD_5: 2 mg/l
BOD removal efficiency: (250-2)/ 250 = 99.2%
Input SS: 180 mg/l
Output SS: 4.96 mg/l
SS removal efficiency: (180-4.96)/ 180 = 97.2%

The Sodium Hypochlorite as chemicals was filled into the process for disinfection. The byproduct of the system is the excess sludge to the cesspool. The sludge was cleaned with manure half a year. There is no record about sludge production and energy consumption.

7.2.3 Management situation of the system

Tsinghua University and Beijing Novel Environmental Protection Company managed the wastewater reclamation system together. Only one operator takes care of the system and is hired by Tsinghua University. Because the system is automatic by computer, he works six hours per day for checking the electronic flowchart from the computer and basic data every day. The operator already accepted the technical training from the Environmental Company. The emergency correction plans and handbooks in the workshops will normally help the operator to solve the familiar problems. For the accidents or serious technical problems he contacts with the environmental company. The system runs in the whole year with simple maintenance regularly. Because the system does not work at full time of the day, the rest time is always used for simple maintenance and cleaning and chemical addition. The system also owns the spare equipments and anti-emergency capacity, such as tap water supply system in order to avoid the water shortage when accident happens or insufficient input. The change of the influent flow is very few, so there is no testing for influent quality so far. The official test of reclaimed water was made by Environmental Protection Bureau once a year.

7.3 Assessment of Social Effect

The same questionnaire for east-district dormitory was used in DaShiQiao students' dormitory. In order to present the exact the results, the interview targets were enlarged to be 20 students. The answers from them are showed as follows:

Table 7.3: The interviews results of DaoShiQiao students' dormitory

	Student 1	**Student 2**	**Student 3**	**Student 4**	**Student 5**	**Student 6**	**Student 7**	**Student 8**	**Student 9**	**Student 10**
Q1	Y	Y	Y	Y	Y	N	Y	Y	N	Y
Q2	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Q3	Y	Y	Y	N	Y	N	Y	Y	N	N
Q4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Q5	N	Y	N	N	Y	N	N	N	N	Y

	Student 11	Student 12	Student 13	Student 14	Student 15	Student 16	Student 17	Student 18	Student 19	Student 20
Q1	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Q2	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Q3	N	Y	N	N	N	N	Y	N	Y	Y
Q4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Q5	N	N	N	N	Y	N	N	N	N	N

Note: Y= the answers are positive; N= the answers are negative.

7.3.1 Knowledge and Awareness

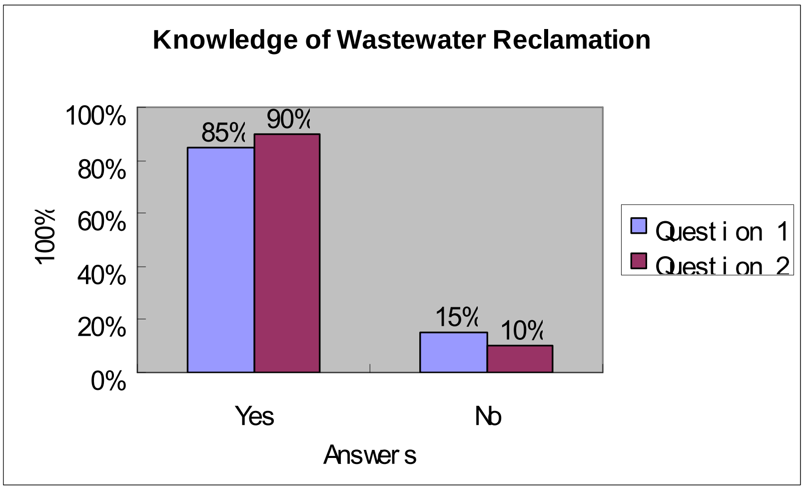


Figure 7.2: The investigation results of the knowledge of DaShiQiao dormitory

85% students understand the definition of reclaimed water and 90% can tell the theory of wastewater reclamation. The results show 87.5% of them heard about reclaimed water and wastewater reclamation system and have certain knowledge of that topic.

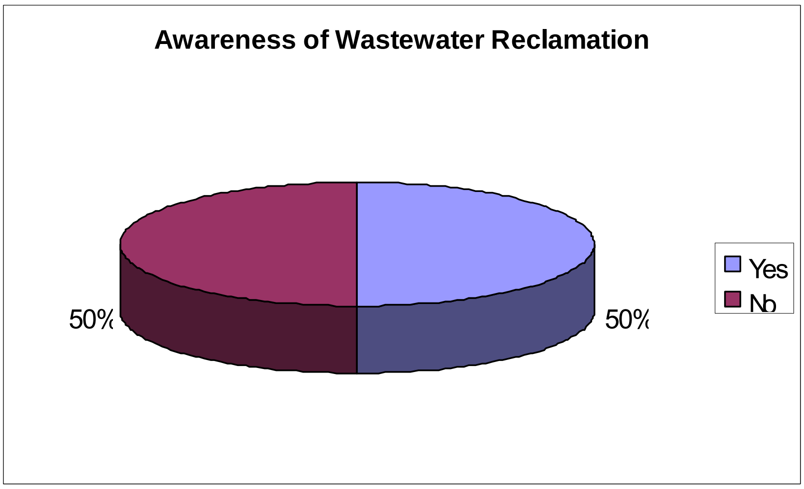


Figure 7.3: The investigation results of the awareness of DaShiQiao dormitory

Half interviewed students are aware the wastewater reclamation in their dormitory. The other half did not recognize the reclaimed water in their dormitories. This random questionnaire is limited by time and capacity of interviewees. It may contain errors for the results. But it reflects there are still some blank parts of the introduction of the university for the students.

7.3.2 Satisfaction of reclaimed water

The students who accepted the interviews are satisfied with reclaimed water quality and also are pleased to use the reclaimed water in their dormitory. The administration departments of university did not receive the complaints for reclaimed water.

7.3.3 Land occupation and visible impact

The total system occupied 200 m^2 lands for equipments and tanks. The workshops are located in the center of the dormitory area and main equipments and basins are installed in the workshops. The workshop looks like the normal storeroom in the university. There is no visual averseness of the system.

7.3.4 Smell and noise impact

The Noise is only from the fans and is very light out of the workshops. Noise does not bother the students. Because the wastewater is from cesspool, there is the certain smell in the workshops. But there is no obvious smell around the system.

7.4 Assessment of Economic Effect

The total investment costs for the reclamation system is 2,000,000 RMB. All investment was paid one-off by owner Tsinghua University. The cost includes the basin construction, equipments installation, pipe installation and pipe rebuilding. In addition, the central computer system is expensive and measurable equipments are imported. This project is

attached importance as a pilot model of the wastewater reclamation system in Tsinghua University then.

Primary investment cost:

Subsidy from the government:	----
Self-payment:	2,000,000 RMB, 195,503 Euro
Total one-off investment:	2,000,000 RMB, 195,503 Euro

The operation cost is 441,765 RMB per year. The operation fee consists of processing cost and labor cost. Hereinto, the processing cost includes the chemicals cost, energy consumption and so on.

Reclaimed water processing cost:

Average cost:	0.645 RMB/m^3 (Data from operator)
Average volume:	1800m^3/day
Running time:	365 day/year
Total annual cost:	0.645 RMB/m^3 * 1800 m^3/day * 365 day/year
	423,765 RMB/year, 41,424 Euro/year

Labor cost:

Average salary:	2000 RMB/month/person (8 hours/day)
Workload:	12 month/year (6 hours/day for the system)
Total annual cost:	2000 RMB/month * (6 / 8) * 12 months
	18,000 RMB/year, 1,760 Euro/year
Average cost:	0.027 RMB/m^3

At present, the reclaimed water cost is 0.672 RMB/m^3. The current water price for school is 3.7 RMB/m^3 in Beijing. Reclaimed water instead of tap water can save 3.028 RMB/m^3 for the residents.

Annual cost saving:

Tap water price:	3.7 RMB/m^3
Reclaimed water price:	0.672 RMB/m^3
Volume of reclaimed water:	1800m^3/day
Running time:	365 day/year
Total annual cost saving:	3.028 RMB/ m^3 * 1800 m^3/day * 365 days/year
	1,989,396 RMB/year, 194,467 Euro/year

Table 7.4: Economic Assessment of DaShiQia Student Dormitory of Tsinghua University

Economic Assessment of Case Four < DaShiQiao Student Dormitory of Tsinghua University >				
Items		RMB	Euro	Remarks
Primary investment cost	Financial supporting	________	________	No financial supporting from outside
	Self-payment	2,000,000	195,503	
	Total	2,000,000	195,503	It includes basin construction and pipe installation and pipe rebuilding
Annual operation cost	Processing cost	423,765	41,424	It includes wastewater treatment cost and wastewater reclamation fee
	Labor cost	18,000	1,760	Calculated by average salary 2000 RMB/month/person
	Total	441,765	43,184	
Annual cost saving		1,989,396	194,467	Every cubic meter reclaimed water can save 3.028 RMB

Note: All exchange rate in the calculation by 1 Euro≈ 10.23 RMB, August 2006

The pay-back time for the system is calculated by investment and economic repayment. The initial investment is 2,000,000 RMB. The annual economic repayment is 1,989,396 RMB/year.

The pay-back time:

Initial investment: 2,000,000 RMB

Economic repayment: 1,989,396 RMB/year

Pay-back time: 2,000,000 RMB / 1,989,396 RMB/year

≈ 1 years

The initial investment is huge for the system owner. But the economic repayment is visible. The system owner can recover the cost in one year after implementing the system.

7.5 Assessment of safety and health

The whole system is managed by operator. Because main machines and tanks are in the room, so it is not easy to contact them. People who want to visit the system need to make an appointment with operator.

The main parameteres of reclaimed water are measured by computer and monitored by operator. From the technical point of view, it is safety for toilet flushing. The quality of reclaimed water is also applied the testing to Environmental Protection Bureau every year. The results can achieve the standards to be safe as non drinking water. There is no record from operator and students experienced an illness related to the reclamation system.

7.6 Interviews with system owner

The case three and case four both belong to Tsinghua University. So Tsinghua University is also the system owner of this case. The interview results from case three are reflected in this case. The high participation of the students and the enough budgets are main drivers to implement the wastewater reclamation system. The system can protect the environment and improve the reputation of the university. The huge economic repayment and short pay-back time also encourage the owner to install the system.

Chapter 8 Water Saving Office of Beijing

8.1 Purpose of interview with Urban Water Saving Office of Beijing

After visiting the case managers and the customers, it becomes clear that water saving office as one of the stakeholder plays a main management role for wastewater reclamation systems in Beijing, especially in the policy making and policy execution process. The water saving office also holds many statistics and information. Therefore, one interview with water saving office was planned at the end of Chinese field research.

The interview is related with the function and responsibility of water saving office. Though the interviews, the main drivers and barriers from the system owners can be summarized and combined with the current problems from the water saving office. The main questions are listed as follows:

1) What is the main function of water saving office?
2) Which department does the water saving office belong to?
3) Which roles the water saving office plays in the application process of wastewater reclamation systems?
4) What is the current situation of wastewater reclamation from the statistics?
5) What are the main barriers for water saving office in the executing process?

8.2 Function of Water Saving Office

Water Saving Office used to be a subordinate of the National Construction Ministry. After organizational reform, Water Saving Office becomes a subordinate of Beijing Water Authority. Urban Water Saving Office of Beijing is responsible for the city's water conservation work. Their Management scopes are categorized as follows:

- Organize to draw out the water saving policy
- Prepare the water saving plan, organization and implementation
- Formulate and supervise the implementation of water standards
- Charge the water resource fees
- Participate in major water-saving projects in the engineering design review and acceptance

In other words, Beijing’s water saving office is in charge of implementing the various national and Beijing’s policies and regulations related with the water conservation. It

organizes the implementation of water saving tasks and propagandized the water saving knowledge and experience. Hereinto, it also provides the wastewater reclamation knowledge and information to polluters. For new/changed/expanded projects, Water Saving office has the examination authority and approval authority of the project establishment and water management. It executes 'Three-Simultaneity' principles for any new constructing projects, namely the wastewater treatment and reclamation facilities should be designed as same as the design of principal part of the new project; the wastewater treatment and reclamation facilities should be constructed as same as the main constructions; the wastewater treatment and reclamation facilities should be checked and accepted as same as the main products. After getting the approval from the water saving office, the system can be used officially for the wastewater reclamation. Therefore, the water saving office of Beijing is a major manager of wastewater reclamation in Beijing.

8.3 Implementation Procedure of Wastewater Reclamation System

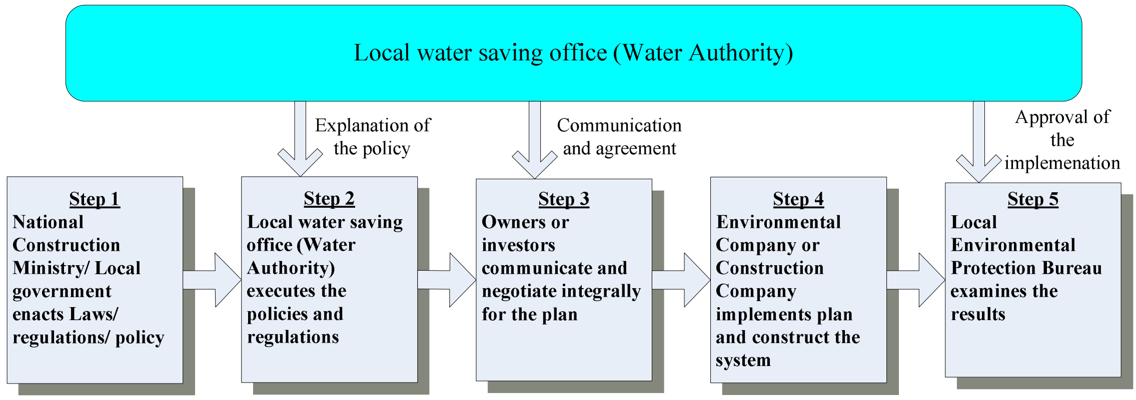


Figure 8.1: The implementation procedure of wastewater reclamation system

Water saving office is responsible to whole water reservation in Beijing. The wastewater reclamation is also managed by the water saving office. There are five steps in the implementation process of wastewater reclamation system. Water saving office plays the different roles in this process.

Step one: Law ordination and policy making

The relevant laws and policies of wastewater reclamation and recycling are basic for establishment of the system. Normally the laws are made by national level of Chinese government. Because of special requirements of technical and management background, the regulations and statutes of wastewater reclamation are made by National Construction

Ministry. The detailed regulations and policies could also be constituted by local government. As the first stage, the policy and regulation are the gist of the implementation. Therefore, the clear and felicitous policy and regulations are main products from the first stage.

Step two: Policy and regulation execution

The enacted laws and regulations need to be connected with real life. Water saving office plays its role between the laws and present practices. One function of water saving office is to explain the policy and provide water saving knowledge. In the second step the projects with wastewater problem will be given with the wastewater reclamation information and the explanation of relevant policies. Parts of the projects with serious water problems have to be administered and installed wastewater treatment or wastewater reclamation system forcibly. Some projects without serious problems will be also given some recommendations and suggestions for sustainable development. In this step, the awareness of polluters could be improved to intend to reclaim the wastewater.

Step three: Communication and negotiation

When the project superintendents and investors received the information from water saving offices, they should give the reflection and find the solutions for their water problems. They can ask the consultation from the water saving office. And they can also look for the technical supporting and plan design from private Environmental Consulting Company or Environmental Engineering Company. According to the specific requirements, the Environmental Company will do the investigations of location and wastewater quality and deign the project. The project plan needs to put on records as materials to water saving office for primary approval of the project. Meanwhile, depending on the budgets of the project, the project owners can seek the financial subsidy from water saving office or other relevant departments. This will bring a series of communications and negotiations between water saving office and the system owner, the system owner and Environmental Company, and system owner and its potential customers. In third step, after getting the project plan from Environmental Company, the agreement with potential customers and primary approval from water saving office, the decision for wastewater reclamation should made by investors,.

Step four: Implementation and construction

This step is responsible by Environmental Company or Construction Company. According to the approval plan, Environmental Engineering Company will start to choose and purchase the facilities according as the technical blueprints. Environmental Company or other construction company install the equipment and build the basins. A tough part of the implementation is

pipe construction or pipe rebuilding. It can be assisted by Urban Planning departments and local residents' committee. The wastewater reclamation system will be finished in this step.

Step five: Checking and approval
The wastewater reclamation system should be checked by water saving office or construction departments. The construction products will be checked and compared with recorded project plan. Normally the water saving office will ask the Environmental Protection departments to test the reclaimed water quality comparing with the water standards. These procedures will ensure the wastewater reclamation system can be operated in a proper way. When everything is fit with the standards, the wastewater reclamation system is approbated and allowed to use officially. This is the last step to start to implement the wastewater reclamation system and use the reclaimed water in the real life.

8.4 Analysis of current situation

One officer of water saving office described the current situation of wastewater reclamation systems in Beijing. He thought the impact of wastewater reclamation is notable and positive. In 1987, Beijing Municipal government promulgated <The Management Regulation on The Construction of Wastewater Reclamation Facility in Beijing (Trial)>. In the last 19 years, the facilities construction and management of wastewater reclamation made certain achievements. In June 2001, *Beijing Municipal Planning Commission*, *Beijing Construction Commission* and *Beijing's Services Regulatory Commission* jointly issued 'Announcement about strengthening management of the reclaimed water facilities,' identified the centralized construction areas and residential areas with more than 50,000 square meters construction area or recyclable water capacity more than 150 cubic meters per day must focus on the construction of wastewater reclamation facilities. Currently, the city's reclaimed water facilities have been put into operation with 100 sets of SMEs, 70% of the normal operation; while more than 100 construction projects are in the process, mostly in hotels. These numbers are increasing till now. From the policy making aspect, Chinese government is going to extend the wastewater reclamation concept and provide more assistants from management and executing level. More efforts are expected to increase the public knowledge and awareness of water saving.

However, some reclamation systems already stop the use or leave unused for a long time. In some cases the reclaimed water occur the serious quality and safety hidden troubles. The

emergence of these issues has caused water saving office to ponder. Three major factors are summarized to restrict the effective use of the reclaimed water:

- ✓ Factor one: Infrastructure of wastewater reclamation hardly meets the demand.

Some residential areas in Beijing planed to use the reclaimed water at the beginning of construction stage. But the reclaimed water supply network cannot connect with them, because the cost of construction for pipeline is very high. Even without taking into account the over bridge and demolition and other factors, the cost is still near three million Yuan per km. Meanwhile, the lack of sufficient economic incentives, investors and owners are not enthusiastic about the result. Therefore, wastewater reclamation facilities and main projects could not be designed and constructed with main project construction at the same time.

- ✓ Factor two: Monitoring in the operation of the system is absent.

There are some complaints about the quality of reclaimed water from some residential areas. The reclaimed water is getting green or yellow with kinds of smell. This was mainly due to the crude wastewater reclamation technology from some Environmental Companies. Firstly, there are so many Environmental Technology Companies and the Engineering Companies in Beijing, but the technology levels are absolutely different. Many Companies only focus on their profits, but the follow-up services and technical quality cannot keep up. Secondly, the wastewater reclamation systems in the residential areas are small-scale with low management level. In order to gain the maximize profits, some developers artificially reduce the operation cost and management costs of the system. Therefore, the quality of reclaimed water in some cases is declining. The official monitoring from the relevant departments is absent. The monitoring of wastewater reclamation system is unrestricted, even some systems were used for some years without any water quality monitoring sites or facilities or professional personnel. Therefore, the monitoring of the system as a weak link could be a barrier to influence the system implementation.

- ✓ Factor three: The leverage of prices is not obvious enough.

The advantage of reclaimed water price can play a direct role in determining whether a user enthusiasm has been mobilized. Currently, Beijing has been increased the tap water price to be 3.7 RMB per cubic meter for residents, and reclaimed water price is still 1 RMB per cubic meter. The difference between the prices of water is to promote wastewater reclamation development. But comparing with huge primary investments, the price difference can lead to the long pay-back time. This is not enough to attract in investors’ interesting.

8.5 Barriers of Water Saving Office

Water saving office as executor faces many actual problems. During the communication with other stakeholders, some problems which the water saving office is difficult to solve were presented as follows:

- Water saving office originally attached to the Ministry of Construction, which was transferred to the Water Authority after mechanism reform. However, many water policies, which were promulgated by National Construction Ministry before, cannot be implemented reasonably by water saving office. Therefore, water saving office is facing an awkward position.
- Water saving office has major management authority of wastewater reclamation system. During the working process, the division of responsibility is not clear because it involved the participation of many other sectors, even the overlapping responsibility could lead to confusion. Therefore, it needs more clear requirements for division and cooperation between different sectors.
- According to the requirements in the regulations, the wastewater reclamation systems should be installed forcibly for applicable units. But the execution power is not enough. It could need more assistance and cooperation from local government and other departments.
- Water saving office is a small department. At present, material resources and manpower are not enough for more works. It is necessary to continually enhance the quality of employees and the hardware.
- Now a lot of enterprises and organizations which are required to install wastewater reclamation system already have the high awareness and good cooperation. However, the basic preconditions for the projects cannot be provided. For example, there is no chance to rebuild the pipeline, or there is no space for equipment installation. These kinds of actual problems trouble project owners and water saving office.
- At present, many organizations and individuals have already qualified for environmental awareness and knowledge of water conservation. But they still hardly make the decision for investment, because the initial investment is too large. It leads to flinch of a considerable sector in the enterprises.
- Water saving office has the foundation for supporting the organizations to build the wastewater reclamation system. But it cannot meet the current requirements for so many projects. Also there is no good judgment standard to help the water saving office to distribute the capitals. This is also difficult when the project owner asked for financial supporting.

Chapter 9: Data comparison and analysis

9.1 Current performance analysis

In order to conclude the current performance of the systems, Key Performance Indicators were compared for current situation analysis. In this research, KPIs consist of technical performance, management performance, financial effect, social effect and health and safety effect. The relevant information was colleted around these five KPIs.

KPI 1: Technical performance

Technical performance includes main information related with processing technology and operation situation. This indicator focuses on the technical operation of the system. In order to extend the research scopes and educe the logical conclusions, the extra four cases of the decentralized systems in Beijing were introduced and compared with this research. Hereinto, there are two decentralized systems, named 'Beiluchun Residential Area' and 'Beijing Jiaotong University' from Chang Zhang in thesis research of 2006. Other two systems were called 'Beijing Normal University' and 'Xiedao' from the research of Xiangbin Li in 2006. Their researches are referred in the bibliography.

Table 9.1: Comparisons of technical performance of the decentralized systems

Cases of the decentralized system	Processing capacity (m^3/day)	Input BOD (mg/l)	Output BOD (mg/l)	Standards (mg/l)	BOD removal efficiency (%)
Beijing Rainbow hotel	80	100	10	10	90
East bathroom of Tsinghua	150	100	3	10	97
Beijing Jiaotong University	150	140	3.5	10	97.5
BOBO Garden house	300	200	10	10	95
Beijing Normal University	400	80	10	10	87.5
Beiluchun residential area	600	180	6.3	10	96.5
Dashiqiao dormitory	1800	250	2	10	99.2
Xiedao	2000	100	15	15	85

The decentralized systems are normally independent close to the raw-water sources and reclaimed water users. Comparing with the centralized wastewater reclamation plant with 3,650,000m^3/year reclamation capacity in Gaobeidian of Beijing (Chang Zhang, 2006), the wastewater processing scale of decentralized systems is very small. The effluent quality of reclaimed water is main object to test the practicability of the processing technology. Generally, COD and BOD of reclaimed water are more sensitive which need to be checked as main values. Other parameters like SS, Chloride, Ammonia Nitrogen and Coliform number could be checked based on different reclamation purposes. In this research, BOD output and BOD removal efficiency was calculated and elaborated to analyze the processing efficiency of current technical performance. It is another reason to select BOD that the existing information of BOD_5 in these systems is sufficient.

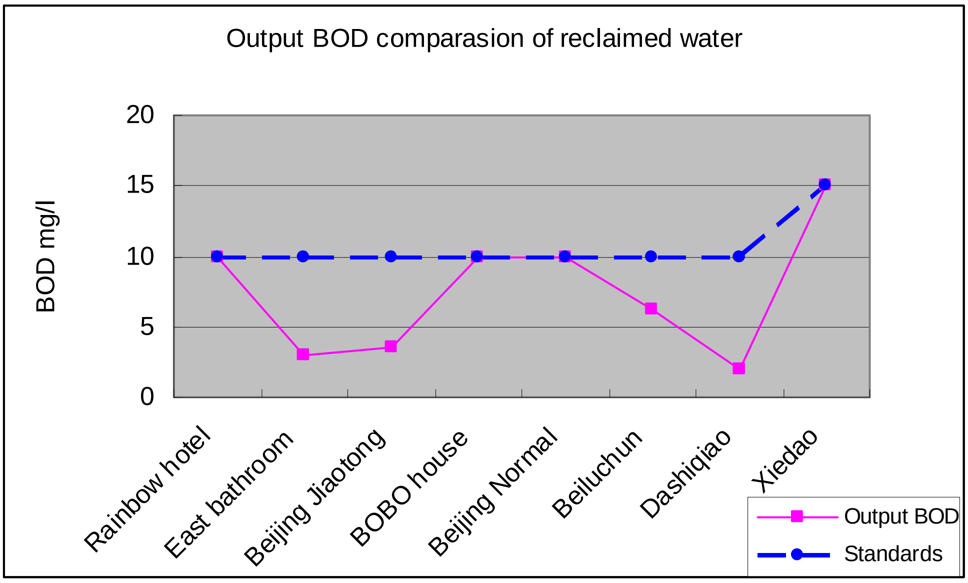


Figure 9.1: BOD comparison of the reclaimed water from the decentralized systems

In the standards, BOD of the reclaimed water should be lower than 10 mg/l for toilet flushing or 15 mg/l for road cleaning and fire-fighting. From the above figure, the results showed that achieving the standards is major target for the systems implementation and is realized by all kinds of different technology. From a technical point of view, the wastewater reclamation technology for decentralized systems is already mature. These systems fully meet the needs of reclamation.

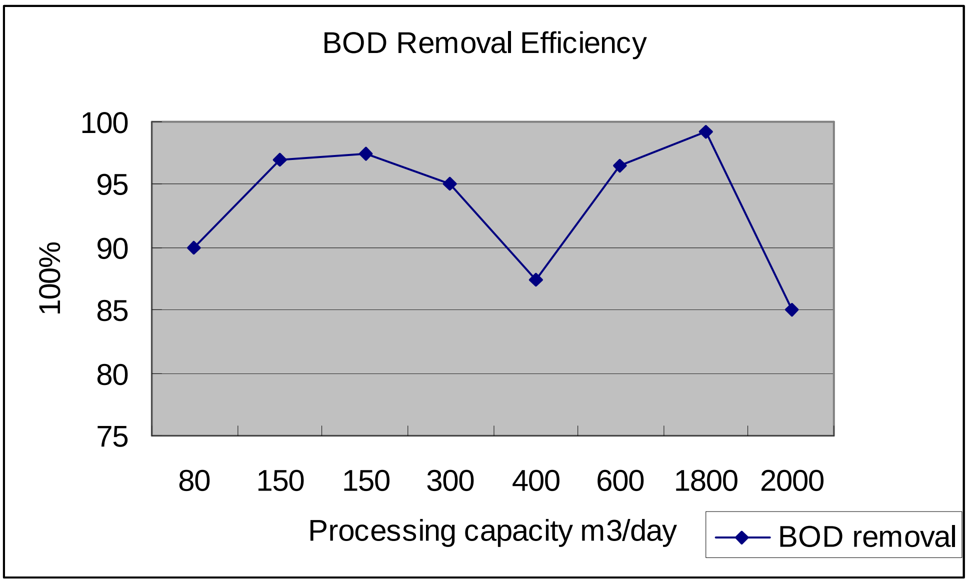


Figure 9.2: BOD removal comparison of the reclaimed water from four systems

BOD removal efficiency is an important indicator of processing efficiency. Because of single raw-water source, the decentralized system presents the stable processing results. In these systems, BOD removal efficiencies are more than 85%. Moreover, from figures 9.2 the data wave fluctuates in a small scale. It presents the whole stable processing situation in BOD removal. Comparing with the general BOD removal efficiency of the wastewater treatment plant, the decentralized systems for wastewater reclamation were operated in the proper way.

Table 9.2: Comparisons of other technical performance of four systems

	Case One	Case Two	Case Three	Case Four
Sludge quantity	No record	No record	No record	No record
Sludge disposals	Cleaned by workers once half a year	Cleaned with the cesspool once a year	Cleaned with membrane	Cleaned with the cesspool
Chemical dosing	1460 kg/year 0.049 kg/m^3	18,250 kg/year 0.17 kg/m^3	---	---
Energy consumption	43,800 Kwh/year 1.46 Kwh/m^3	131,400 Kwh/year 1.2 Kwh/m^3	---	---

The main byproduct is the sludge from the system. No quality requirement for sludge at present is the main reason of the loose management and monitoring. In these four systems, the sludge issues were not recorded in the treating process. However, from the interview results of the operators, all sludge was disposed simply in different ways from environmental protection aspect. In addition, a spot of sludge won't become a problem for the decentralized wastewater reclamation systems. Because of the insufficient data, the data comparisons with other systems in sludge production, chemical dosing and energy consumption were skipped.

KPI 2: Operation and maintenance

The management performance consists of the system operation and labor management. This indicator focuses on the management records. The characters of different systems are diverse, and most of them are recorded as documentation. Therefore, the operation and maintenance of the systems were not compared with primary researches.

Table 9.3: Comparisons of management performance of four systems

	Case One	Case Two	Case Three	Case Four
Daily working time of the system	24 hours	24 hours	16~20 hours	20 hours
System failure time per year	0	0	0	0
Recovery time when it fails	0	0	0	0
Operator number	1	1	1	1
Labor input for maintenance	5 hours/day	3 hours/day	1 hours/day	6 hours/day

From the operation records, these systems work normally without serious problems. From the operation experience, the possible failure mostly causes by power cut for the equipments or unstable and insufficient raw-water or inappropriate operation of the workers. Power cut is the main reason of the system intermission in Beijing. It could happen for some hours due to the maintenance or the special reasons with the aforehand announcements. The unexpected power cut takes place by accidents singularly. However, because of the function of spare machines and the reasonable capacity of the storage tank, the power cut won't give the reclamation problem. For example, the hotel has the electricity generator for the temporary

power cut. Other three systems have the enough capacity to store the water for the reclamation demands, although the power cut can influence the system by some hours. The insufficient raw water problem could be solved by automatic water supply system. The tap water connections will cooperate with water meters to control the water supply. The operators who were trained by environmental company can handle the general problems. Furthermore, the automatic operation with the advanced equipments enormously reduced the works for the operators. The wrong operation could be considered in the emergency. From the voice of the operators, the systems without failure records are durable and stable. From the table 9.4, each system only needs one operator. The operators work less than 8 hours per day. Therefore, the systems are normally automatic without full monitoring. Therefore, the operation of the decentralized systems is very simple and convenient. It is worth to ponder over that all conclusions depend on the interviews with the operators. The system failure records may be not exact by influence of the subjective emotion and inclination of the system owners or operators. This part of the assessment provides the data for reflecting the certain situation of the implementation and it could be reinvestigated and combined with other research in future.

KPI 3: Social aspects of the system

Social effects of the system are assessed from the evaluation of the users and neighbors. Their evaluations also reflect the implementation situation of decentralized system in the real life. In this sector, the questionnaires results from four systems were summarized into the table. The social acceptance is reflected by knowledge, awareness, visual feeling and environmental impacts.

Table 9.4: Comparisons of social effects of four systems

	Case One	Case Two	Case Three	Case Four
Knowledge of the users	65%	75%	85%	87.5%
Awareness of the users	40%	90%	70%	50%
Satisfaction of the reclaimed water	Yes	Yes	Yes	Yes
Visual impact for neighbors	No	No	No	No
Occupied area of the process train equipment, m^2	100 m^2	300 m^2	100 m^2	200 m^2

Location of process equipments	In the basement	Underground	Overground	Semi-underground
Odor complaints from the neighbors	No complaints filed	No complaints filed	No complaints filed	No complaints filed
Noise complaints from the neighbors	No complaints filed	No complaints filed	No complaints filed	No complaints filed

The users of the reclaimed water have the basic knowledge in wastewater reclamation field. This knowledge is indicated by the understanding of the concepts and the function of the wastewater reclamation. The average data shows that more than 78% users have the basic knowledge of the wastewater reclamation. The reasons, which causes the knowledge shortage of rest 22% of the users, includes the educational background, information obtaining approach, income level and so on. The users from the hotel and the residential area have the complicated background, so the knowledge from case one and case two presents the uneven character and relative poor knowledge level. The students in the university are in the higher educational level with similar background, so the knowledge of wastewater reclamation is higher in case three and case four. But the high knowledge group also could be with low awareness. It shows other elements also could influence the social acceptance of the system, such as water price, income level, and participation and so on. From the existing data, the reclaimed water was satisfied from most of the users.

The occupied area of the decentralized system is small for each individual case. Mostly the equipments and tanks are buried without surface occupation, so the location selection of the system is easy. The surface space with underground equipments can be harvested as car parking zone, lawn or other purposes. From the visual observation, the system is not repulsive.

There is no any complaint from the neighbors about noise and odor. So the system has no obvious environmental damages and environmental displeased impacts. Four systems are environmental friendly for the surroundings.

KPI 4: Financial performance

Economic effect is evaluated by the investment, operation cost and pay-back time. The financial part is vital for the decision making and implementation of the systems. The economic repayment is the main motive for the investors. The total investments and the pay-back time were closely related to the prophase budgets and final decision making. The operation cost is also paid the attention to avoid high financial burdens to restrict the future development. Therefore, the financial performance is significant KPI.

Table 9.5: Comparisons of economic effects from the decentralized systems

Cases of the decentralized system	Actual daily capacity (m^3/day)	Investment costs (RMB/m^3 per day)	Total initial investment (RMB)	Operation costs (RMB/m^3)	Pay-back time for two kinds of tap water price (Year)	
					3.7 RMB/m^3	6.1 RMB/m^3
Beijing Rainbow hotel	80	7,500	600,000	1.07	8	4
East bathroom of Tsinghua	150	13,333	2,000,000	0.55	12	7
Beijing Jiaotong University	150	2,000	300,000	0.75	2	1
BOBO Garden house	300	3,000	900,000	0.83	3	2
Beijing Normal University	400	8,500	3,400,000	1.5	11	5
Beiluchun residential area	600	2,333	1,400,000	1.08	2	1
Dashiqiao dormitory	1,800	1,111	2,000,000	0.67	1	1
Xiedao	2,000	2,800	5,600,000	2.09	5	2

The initial investment is always one-off payment in the budget. The different investments depend on the main processing technology, the construction fees and pipeline building cost, the financial sources and other reasons. The initial investment could be a burden for the system owner, but it is not too experience to be implemented in the budget of the decentralized systems.

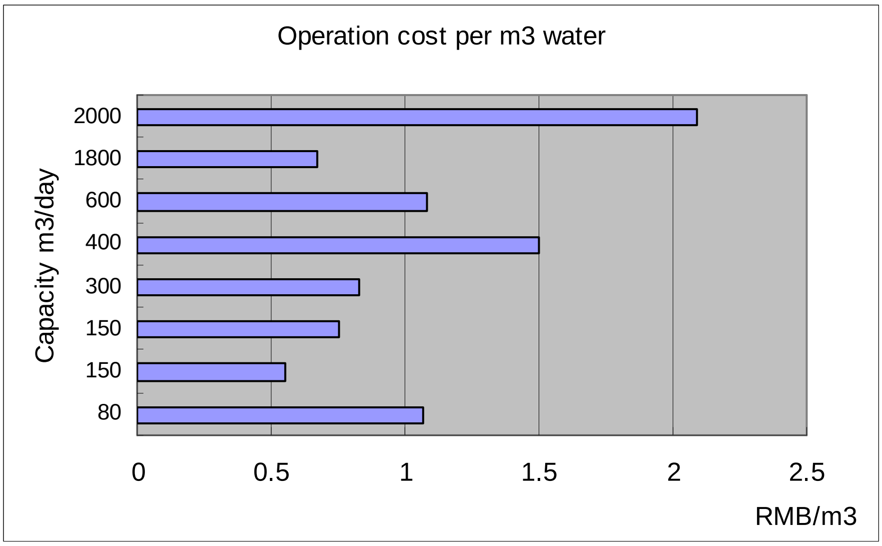


Figure 9.3: Operation costs analysis from the decentralized systems

The annual operation cost is calculated by the processing cost and the labor cost. From figure 9.3, most operation costs of the decentralized systems are between 0.5 RMB/m^3 to 1.5 RMB/m^3. The average price also adapts to the temporary reclaimed water price by Water Authority. Comparing with the current tap water price with 3.7 RMB/m^3, the reclaimed water processing is profitable. On the face of it, the operation costs are protean. The actual cost could be influenced by technology, operation, management and other artificial reasons. It is hard to estimate the relations between the processing capacity and the operation costs.

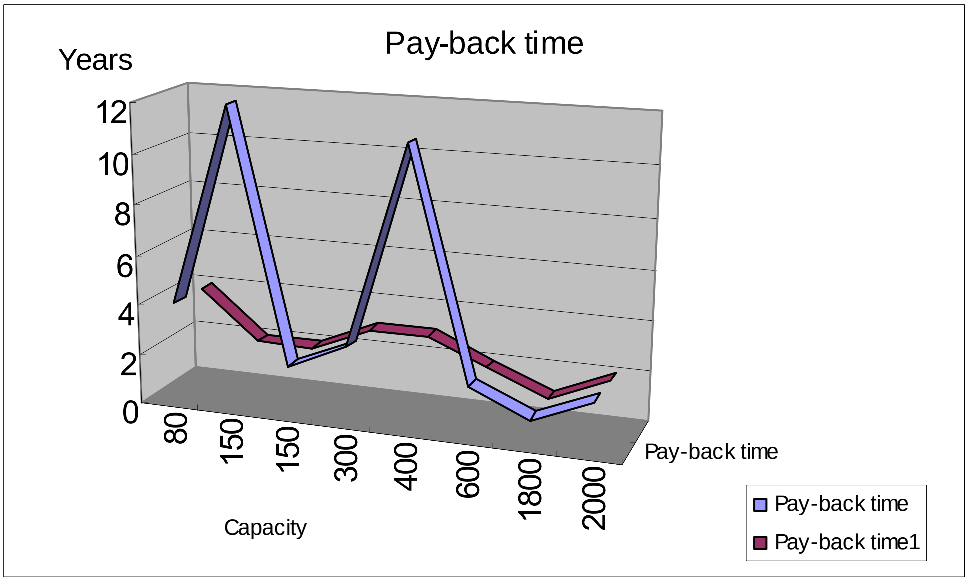


Figure 9.4: Pay-back time analysis from the decentralized systems

The pay-back time is calculated by comparing the tap water price and operation costs. The initial investment is considered as financial gap to be covered by the price differences. The time calculation based on the actual processing capacity of the different systems. From the figure 9.4, the grey pay-back time curve describes the actual calculations. There are two peak values about 12 years and 11 years pay-back time. They are very outstanding from other decentralized systems. Hereinto, the East-district bathhouse is the pilot project for the micro-filter membrane technology in Tsinghua University. The investment is superabundant comparing with market price, because it could be considered for in-depth research. Therefore, the pay-back time of this case is especial without considering the budget in the decision making process. The system of Beijing Normal University processes the low volume wastewater with huge initial investments. It is not worth from the investment and the profits aspects. If those two systems are ignored as special examples, the curve of the pay-back time could be showed as pay-back time1 in the figure. This curve is smooth and thin undulatory in small scale. Therefore, generally, the decentralized systems have the short pay-back time within five years. The existing systems and successful examples also showed that the shorter pay-back time is much acceptable for implementing the system.

KPI 5: Health and safety

The health and safety is assessed by the relevant records of health problem and illness history. It is an important element to judge the processing efficiency and management situation. It is also deeply concerned by the users of the reclaimed water. Therefore, health and safety as last key-performance indicator is evaluated.

Table 9.6: Comparisons of health and safety of four cases

	Case One	Case Two	Case Three	Case Four
Accessible for unauthorized personnel	No	No	No	No
Direct contact with untreated waste water for inhabitants	No	No	No	No
Illness records related with system for neighbors	No record	No record	No record	No record

Illness records related with system for employees	No record	No record	No record	No record

The system is managed and controlled by operator or system managers. Any visitors need to make the appointment with them. The main storage basins and pipe are buried underground, so there is no chance for neighbors to touch the system directly. Therefore, the systems could be safe from the construction and management aspect. The visiting experience also proved this standpoint. From information provided by operators, there is no illness records from the employees and the neighbors related with the system. And there is no complaint for reclaimed water quality. Therefore, the reclaimed water from the systems is healthy for the user in a manner. The records of the testing results from Environmental Protection Bureau once a year can improve the certain reliability. However, the information provided by operators could be questionable. It is worth to refine that the records were made by operators and the testing was made once a year. The realistic fact still needs to be found from more research in future.

9.2 Stakeholder analysis

In the implementation procedure, there are two stakeholders are very important for the whole process: the system owners and the water saving office. System owners as principal part should have high awareness and can participate in the implementation forwardly. The analysis was made from their feeling and experience after they implemented the systems. From the executing level, the main drivers and barriers could be summarized from these interviews. On the other hand, the water saving office as major executor should have better control with all steps in the procedure. The main problems from governmental level are from interview results with water saving office. Therefore, the analysis aims at these two main stakeholders.

9.2.1 Analysis of system owner

Table 9.7: Analysis of the system owner of four systems

Stakeholders	Drivers	Barriers
Case 1 **System owner** Beijing Rainbow Hotel	1) Operation fees for hotel with high tap water price is the big pressure for system owner 2) The external financial supporting from government encourages the system owner 3) Reclaimed water can give the economic repayment	1) Space for system is limited, so the processing capacity is limited. 2) High initial investment and long pay-back time are main problems for decision makers. 3) The change of the leadership is the barrier for implementation. 4) At the beginning, the technical and equipments problems bother the system owners.
Case 2 **System owner** Developer of BOBO Garden House residential area	1) System should be required from the policy statement for new residential area 2) High participation and cooperation from the residents 3) System as green logo is used for competition with other residential area	1) The official charging standards of reclaimed water is absent. The pay-back cannot be guaranteed by policy or standards. 2) High initial investment is the financial burden for developer.
Case 3 and Case 4 **System owner** Tsinghua University	1) High awareness and good cooperation from students 2) The systems as pilot project have enough budget 3) The system can protect the environment and improve the reputation of the university	1) Pipeline network building is the most experience part of the investment, also is very difficult to be constructed. 2) The technology (Micro-filter membrane and Aerated Biological Ceramicite Filter) is much experience comparing with other reclamation treatment

Results from system owners:

- The systems were installed forwardly, because the processing cost is much cheaper than tap water price.

From the practical experience, the system owner gained the economic repayment from the wastewater reclamation. The processing cost was calculated in the planning stage, so the investors were pleased to implement the systems. This is the main driver for system owners.

- The huge initial investment is financial burden for system owner.
  The wastewater reclamation system has the huge initial investment, and the return is not obvious in the short term. The one-off investment is a tough decision as financial burden for the investors. This is main reason that the project plan was gave up in the budget planning stage. The long pay-back time is also a barrier for decision maker to invest for the system; especially the budget is not enough for the initial investment.

- The pipe construction and rebuilding is the most expensive and difficult part of the plan.
  The pipeline rebuilding and construction are the most expensive part in the budget. The unplanned existing infrastructure always increases the construction cost. For changed and expanded projects, the residual space is restricted for the system construction. This is a realistic problem from system owners.

- Sometimes, the operation cost cannot be collected on time because of lack of charging standards.
  For internal wastewater reclamation, the reclaimed price is not clear reflected. But the reclaimed water as product for external users needs to charge the fees. Because of lacking of charging standards, the economic returning cannot be guaranteed.

- The stable and forward-looking leadership can guarantee the implementation of the system.
  The four cases shows the leaders or decision makers of the system are forward-looking. They have high awareness and long views. Meanwhile, the stable leadership insures the implementation go on wheels.

9.2.2 Analysis of water saving office

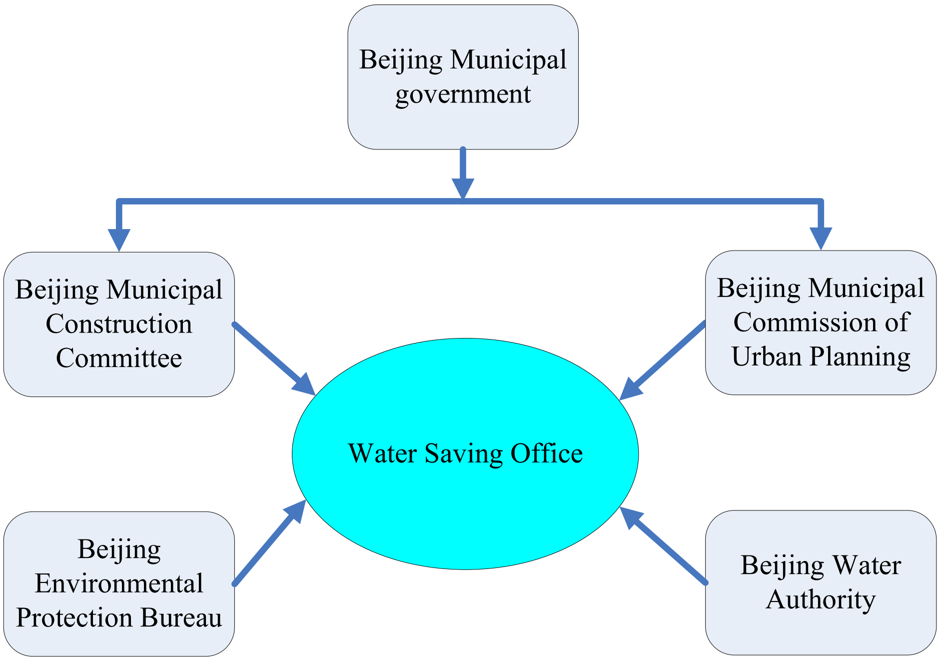


Figure 9.5: Stakeholder analysis of water saving office

Water Saving office is a section of Beijing Water Authority. Before the institutional reform, the water saving office was a department of Urban Construction Bureau. From the implementation process, four main actors as governmental level are involved.

Government has the integrated management and control authority to all kinds of main events in the city area. Government organizes all kinds of bureaus and departments in the city level. Beijing Municipal Construction Committee and Beijing Municipal Commission of Urban Planning both belong to Beijing Municipal government. They are responsible for approval and planning of main constructions work or pipeline network building in the city.

Water Authority is mainly in charge of water resource management, water supply and water conservation. The wastewater reclamation as main water saving method is also in the control of Water Authority. Water Saving Office as major executor focuses on the wastewater reclamation work. But the wastewater treatment and management also belong to Environmental Protection Bureau. The wastewater quality is always tested and monitored by Environmental Protection Bureau.

Therefore, the main problems are listed as follows:

1) The department function for wastewater reclamation could be overlapped.

From the construction aspects, Construction Committee and Urban Planning Commission both can manage and judge the project. For wastewater, it could be controlled by Water Authority and Environmental protection Bureau. The distribution of the tasks is very blurry for different departments.

2) The Major leading authority is weak.
   Actually Water Saving Office is main organizer officially with main authority for wastewater reclamation. But this authority is not mentioned clearly in any policies. This will influence the cooperation with other departments. Meanwhile, it will influence the executing power of the policy and regulations.

3) The implementation procedure is chaotic.
   This always confuses the investors and system owners. They do not know how many tasks they should finish, which department is necessary, when they should make it. There is no clear layout in their mind. It brings some troubles for project application and system approval.

4) There is no monitoring for the systems.
   The wastewater was tested only by Environmental Protection Bureau at the beginning of the operation for system approval. The monitoring is not executed by Water Saving Office or Environmental Protection Bureau. Therefore, after approval the system is operated without official monitoring from relevant administrative departments.

5) Small department needs to be enhanced for more works.
   Water saving office is a small department in Urban Water Authority. More functions and works are limited by current competence. Therefore, the department should be enhanced by increasing the manpower and improve the hardware.

6) More practical problems need to be solved by water saving office.
   During the execution of the policies and regulations, the water saving office encountered the practical problems for the project implementation. The system owners with high awareness expect to implement wastewater reclamation system, but they did not have enough capitals for initial investment. For some other cases, the system constructions and pipeline network installation and rebuilding in the existing infrastructure were impossible. The system owners who were bothered by intractable problems asked the help from the water saving office. But they cannot get the satisfactory answers for these problems from the water saving office.

7) The subsidy system needs to be improved.

Water saving office has the certain funds for supporting the wastewater reclamation development. But the foundations are skimpy for so many new projects in Beijing. The subsidy only can be distributed in some projects. The complaints will come from other uptight projects. The subsidy standards become to be created for improving the system implementation.

Chapter 10: Conclusions and Recommendations

10.1 Main conclusions

10.1.1 Current performance situation

Current performance results of the decentralized wastewater reclamation systems in this research are positive. From the data comparisons, the four decentralized systems work well and basically meet the water demands for reclamation. The reclamation technologies are mature and diversiform. The main technology includes biological processing methods and the physical processing methods. In this research, the processing technologies involve the biological contact oxidation technology, micro-filter membrane method and Biological Aerated Ceramicite filter technology. The systems are operated in full time without intermission. The reclaimed water quality from the system can achieve the water standards. The high organic matter removal efficiency ensures the technical requirements for wastewater reclamation. Four systems are managed without any system failure records. They are monitored by operators in the daily checking. The knowledge and awareness of the users presents the uneven character. In the existing investigations, more than 50% interviewees have the basic wastewater reclamation knowledge and are aware the reclaimed water application in their lives. The decentralized system always occupies small area, so it is better for system owner to select the location and construct the system. The buried tanks and the underground workshops are not disagreeable for the neighbors and the users. The other way round, the overground space of the buried system could be harvested as green belt or car park. The odor and noise from the systems are controlled availably for surroundings. The initial cost is one-off investment in the budget. Comparing with other business investment, the wastewater reclamation systems with expensive construction cost always need the stated pay-back time. But the economic repayment is obvious to stimulate to continual development according to the current tap water price. The reclaimed water of the four systems is monitored by operators and is tested by Environmental Protection Bureau once a year. The reclaimed water is healthy and safe, because there is no any complaint from the users and there is no illness record from the employees and neighbors related with the systems. Therefore, the performances of the decentralized wastewater reclamation in this research present the positive situation.

10.1.2 Main Drivers of system implementation

1. The price difference between processing cost and water price as economic stimulation is major driver.
   From the interviews with system owners, the processing price is around 1 RMB/m^3. This cost is rather cheaper than tap water price. The economic repayment is the major driver to stimulate the polluters to invest for the wastewater reclamation system.

2. The continual adopted policies give the encouragement and support and limitation.
   During the last 19 years, more policies and regulations were enacted for wastewater reclamation. Some parts give the encouragement and supports to water conservation and wastewater reclamation, and some parts give the limitation and punishment of water pollution. It is a kind of pressure for water user to push them to improve the wastewater reclamation awareness.

3. The improved awareness and knowledge changes people's behaviors.
   The knowledge of environmental protection and water conservation were increased comparing than 20 years ago. People started to put the insight to their environmental problems and waste disposals. The pubic health awareness became a part of this driver once the world population and subsequent wastewater discharge increased, leading to an increased chance of contact between the public and the discharged wastewater and/or subsequent degraded and contaminated environment. The green logo as one of the competitive mean also present the awareness improvement of environmental health and environmental benefits.

4. The feasible technology is innovated and mature experience can be provided.
   The technology for wastewater treatment and reclamation has a big progress and development in last several years. The existing experience and technology are not the barriers anymore for the implementation. Meanwhile, good technology and positive results as green logo are already a kind of competition tool for same industry. Therefore, this is also driver to implement the wastewater reclamation system.

5. The inadequacy of the centralized systems stimulates the development of the decentralized system.
   The centralized wastewater reclamation systems require more specific terms. The infrastructure and pipeline construction and other reasons limit the implementation of the centralized systems. However, the decentralized systems can fulfill the demands of

wastewater reclamation in small scale without above troubles. Therefore, when the centralized system cannot serve on wastewater reclamation, the decentralized systems become the major approach to achieve the standards.

10.1.3 Main barriers of system implementation

■ Main barriers at governmental level

1. Lack of executing power for regulations and policies

   The existing policies and regulations cannot be put in practice, because the water saving office as executor does not have enough executing power. At present, this executing power was not mentioned and recorded in certain policies and regulations. Local government and other relevant departments cannot give the correct assistance for executing either. This is caused by unfavorable execution of policies and regulations.

2. Chaotic management and duplication of responsibilities

   There are some different departments participate in the application procedure from plan to implementation. It includes the local government, water saving office, Environmental protection bureau and so on. But the management is chaotic without clear division of responsibilities. The communication and cooperation between different departments are still blank; even some departments have the repetitive function with another. This makes the confusion for the investors and brings the extra trouble for project implementation from governmental level.

3. Lack of monitoring and communication with the systems

   In these four cases there is no health and safety problem of reclaimed water. The reclaimed water sample was sent to local Environmental Protection Bureau for checking the quality. This behavior is only subjective without relevant regulations for system owners. But this procedure exposes the monitoring and auditing problems. Because of lack of monitoring system, the existing decentralized wastewater reclamation systems could be failed due to the poor and unhealthy quality of reclaimed water. At the governmental level, the absent monitoring system also could be the driver for system implementation and favoring operation.

- Main barriers at executing level

1. Financial problems:
   - High capital costs

     The high initial budget is normally a financial burden for the investors or system owners. In the plan stage, it is always a tough decision for investors because of one-off payment. The financial investment also makes the project failure for the investors without enough capitals.
   - Lack of ongoing operation costs

     For existing systems it also could be failed because of lack of enough operation costs. Nowadays, there is no charge standard of reclaimed water. There is obvious problem for internal reclamation system. But when reclaimed water is used as product for external customers, the payment of reclaimed water could be important for operation costs. So the charging standard should be needed to ensure the enough funds for operation.
2. Actual constructing problems:
   - Infrastructure rebuilding

     The existing infrastructure is very difficult to be rebuilt and modified. The new plan with equipments installation cannot be implemented and matched with old infrastructures. There is no chance for construction of wastewater reclamation systems.
   - Pipeline network construction

     The pipeline network cannot be built in existing urban plan. Namely there is no more space for wastewater collection pipes and reclaimed water distribution pipes. Or it is too complicated for pipeline network construction in the real life. This is also the reason that the plan is delayed and stopped in the constructing stage.

10.2 Recommendations

Because some departments participate in the implementation procedure, the main recommendations were given to different stakeholders from top to down.

- Improvement of policy and regulations (Policy makers)

  More policies and regulations proved the water scarcity got the enough attentions from governmental level. For policy makers, the adopted policy and regulations should be more feasible and efficient. The policy makers should not only pay attention to the policy making process, but also should focus on the reflection and feedback from

implementation. Therefore, the policies and regulations should be continually improved for policy makers. At the other hand, the relevant policies and regulations should be transferred officially to Water Authority. It is better for executors to implement the policies and regulations.

- Unification of the management and definitude of the responsibility (Local government)
  The local government needs to point the main management department for wastewater reclamation and define the clear responsibility for other departments. The local government should also enhance the executing power to direct executors. It will be major role for local government in future to guide a concordant conversation and create a close communication between different departments.

- Integrated urban planning (Urban planners)
  For the urban planners, the integrated urban planning is needed with long-term development. The existing infrastructures should be improved by proper methods. The new infrastructure and pipelines network will be endued with the definition of sustainable development in the urban planning. This will provide more convenient conditions for construction of decentralized wastewater reclamation systems.

- Generalization of the knowledge (Water saving office)
  The main function of the water saving office is to generalize the water conservation knowledge and water reclamation knowledge. The awareness expects to be improved by proper educations from water saving office. At the other hand, the explanations of the policy and regulations could be efficient for executing them.

- Regular communication and monitoring (WSO)
  The communication with system owners will be also helpful to solve the practical problems and execute the policy and regulation. The extent to which water reclamation is accepted depends on several factors, including perceptions on the safety of reclaimed water, the uses it will be put towards, and how closely those uses appear to affect users. For these reasons, testing and monitoring often are integral aspects of reclamation programs. The monitoring system needs to be created with cooperation from other departments. The regular monitoring and testing can insure the good performance of the systems.

- Long-term development insight and water saving awareness

  For the polluters they should increase the environmental knowledge and improve the water consumption awareness. This will lead to more environmental friendly plans and sustainable development designs from the polluters.

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Function of water saving office in Beijing

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