

Development of Sewage Treatment System in Beijing, China

Preface

The People's Republic of China has developed modern sewerage systems in more than 50 cities including from mega-cities such as Beijing, Tianjin and Chongqing to small/medium frontier cities in the frontier of Xinjiang, utilizing the proceeds of Japan's ODA loans amounting to 200 billion yen in total. The Beijing Sewage Treatment Plant Construction Project was the first sewerage project under Japan's ODA loan program to China

Water Pollution in Capital City

In 1950, the amount of sewage discharged from Beijing was 65,000m³. In 1960, this jumped up to 630,000m³, and in 1980s reached 2,000,000m³. Fifty percent of this was



Fig-1 Tong Hui River

domestic waste water and the rest was industrial waste water. At the time, the majority of the urban population lived in apartment houses. The houses were connected to sewers, but mostly not connected to a treatment plant. At the end of 1988, 92% of sewage was discharged to the nearby rivers and lakes without treatment, except a mere 8% of sewage

which received primary treatment. The number of the industries that discharged wastewater directly to the river was 1,200. This polluted the river water. Among them, the worst polluted was the Tong Hui River, where BOD values of up to 80 mg/l were recorded and which had an unpleasant odor. Fig 1 shows the outlook of the river in the late 1980s.

The importance of having sewage treatment plants had been well understood by the government. A master plan of the Beijing sewerage was completed well before this time. However, construction of a new sewage plant was not implemented, mainly due to financial

reasons. Japan's ODA loan for the Beijing Sewage Treatment Plant Construction Project, amounting to 2.64 billion yen with an interest rate of 2.5% and repayment period of 30 years including a 10-year grace period, was extended to the People's Republic of China in 1988. The loan was on-lent to Beijing Municipality Government on the same terms.

Capacity Development of Beijing Sewerage Administration

Beijing Municipal Design and Research Institute was assigned to be responsible for all the aspects of the design. It had started experimental research with a pilot plant to select the process of sewage treatment. Basic planning for the entire process was completed in 1973. Although a long period of time was taken for preparation, the institute began to feel its lack of experience in carrying out the working design. At this time, they did not have any experience



Fig-2 Gaobei Dian WWTP

of designing such a large sewage plant as capacity of 1,000,000m³ a day. They sought the advice of Tokyo Metropolitan Sewerage Bureau, Tokyo being a sister city of Beijing.

Finally, the process design of the whole new sewage plant was fixed. "The anoxic-oxic biological reactor" was the main compartment

of the process. This would help with good solid-liquid separation at the final clarifier. An anaerobic digestion process was also selected to stabilize the sludge. Biogas was expected to be recovered from the process, and the gas was to be reused for power generation. Gaobei Dian Wastewater Treatment Plant is the name of the new plant. The first-phase of construction work had started in 1990, and Beijing City itself executed the entire work under its direct management.

In March 1993, when the work was almost 80% completed, Beijing City requested Tokyo Metropolitan Sewerage Bureau to provide them with training for sewerage operation and

management. At the same time, they requested OECF (later JBIC) the funding of the cost for the training by utilizing a part of the ODA loan. The Beijing study mission consisted of three groups. Each group included 12 members. The first and second groups consisted of manager class members. They were interested in administration, and finance for sewage works. The training program for them covered lectures and field trips including visits to national governmental agencies and local municipalities other than Tokyo. The third group was composed of the personnel who would be engaged in actual operation of Gaobei Dian sewage plant. A practical training for 14 days was arranged for the third group at one of the sewage plants of Tokyo Metropolitan Sewerage Bureau, which is as large as Gaobei Dian Plant. The training program covered such areas as operation of a biological process, maintenance of machineries, chemical analysis and recording.

The training in Tokyo proved to be very effective later. After returning to Beijing, the mission members had played an important role in operation of Gaobei Dian sewage plant. Most of them are now key members of organizations related to sewage works, including Beijing Drainage Group Co. Ltd, which was set up in February, 2002 and is responsible for operating sewage plants in Beijing. Today, its service covers eight sewage plants, three water reclamation plants, one sludge handling station, and sewers of 3000km. In addition to the routine works, research works and even international seminars are managed by the company. It is now indeed a leading company of its kind for the whole of China. From them, about 30 experts were transferred to newly built sewage plants in Beijing. In addition to this, experts of engineering and management were sent to Qinghai province for help with a research project for water pollution control. Human resource exchange between Tokyo Metropolitan Sewerage Bureau and Beijing City has continued until the present day, in such a way that an ex-official of the former is appointed as an adviser to Beijing Municipal Design Institute.

Water Pollution Control Achieved

In late 1993, Gaobei Dian Plant started operations. Its service area is 96km³ which is almost 25% of the urban area of Beijing. The sewered population is 2,400,000 people. At the

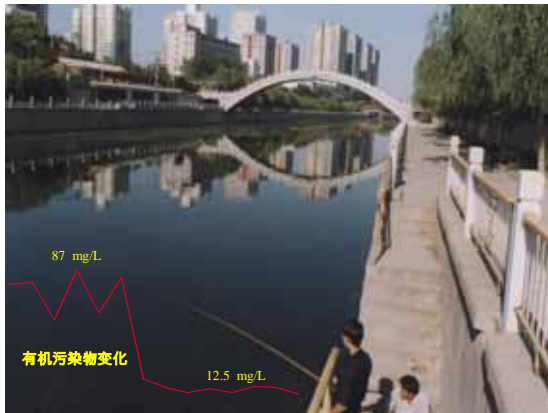


Fig-3 Tong Hui River in 2002



Fig-4 Gaobei Dian Lake in 2003



Fig-5 South Moat in 2003

first stage, the capacity of the plant was 500,000m³ a day, which has increased to 1,000,000m³ a day in 1999. This amount is about 40% of the total waste water generated in Beijing. It is one of the biggest sewage treatment plants in China even now.

All the effluent from the plant is discharged to Tong Hui River. While the inflow BOD ranged from 150 to 300ppm, effluent BOD has stayed with around 10ppm for the last 10 years. The red line in Fig 3 represents BOD of the river water. At one time, this was over 80ppm. It may be clearly seen that the quality is improving, as it is now 12ppm. Fig 4 showed the outlook of Gaobei Dian Lake. Sound ecology was identified in the Lake in 2002; fish, shrimps, snail and amphibian come to the lake. Fishermen have come back too. The latest outlook of the South Moat is shown in Fig. 5. The moat faces the Southern edge of urban Beijing. It was nothing more than open sewer in 1990, because of discharge of untreated sewage. Thanks to the Gaobei Dian

Wastewater Treatment Plant, this has completely changed. All the sewage discharged to the

moat is now intercepted and treated. The plant has been a key factor in conserving a better water environment in the main area of Beijing.

At present, in whole Beijing area, there are eight waste water treatment plants. The amount of the sewage which is secondary treated is 1.88 million m³ a day, 60% of the total sewage. A further six plants are scheduled to be added before 2010.

Recycling of water resources

The secondary effluent of the plant is reused for irrigation for trees along streets and



washing equipment in factories. Tertiary effluent is transported to the Sixth water purification plant and to Beijing Huaneng thermoelectric plant. Thus, a large amount of water is created, which saves capital investment for water resources. The sludge is

Fig-6 Reuse for irrigation

anaerobically digested, and the biogas produced from the digestion process is used for power generation. The recovered power can cover 20% of the total requirement of the plant.

Policy Reform

In China, historically the “polluter pays” principle had been a basic concept for pollution control. Polluters had to be responsible for managing their wastewater before discharging it into public water bodies. A stringent standard was applied to each industrial effluent and offenders were subject to punishment, but this was difficult to enforce. This concept would not work effectively for water pollution control without a public sewerage system. From the operation of Gaubei Dian Plant, sewage collection and central treatment have proved to be more effective for pollution control and improvement of living conditions too. The centralized

system is less expensive for construction and operation, and site requirements are less. Another advantage of the centralized system was accumulation of know-how in operation and maintenance. Since the success in Gaobei Dian Plant, construction of the centralized system has become a national target, and much money is being invested in this.

In China, before around the mid-1990s, sewage discharge from domestic sources was free of charge. Beijing was not an exception. When it started to operate, Gaobei Dian plant faced deficiencies in income, making it difficult to operate the process at its full capacity. The first trial to stop this problem was an amendment of the law named “water pollution control” in 1996. According to the amendment, a given authority can collect money from local people and industries as a sewer users’ charge. Moreover, a polluters’ charge, in the form of sewer users’ charge, has to be collected from all the people in the city, regardless whether they are connected to the sewage treatment plant or not, once the sewage treatment plant, which covers only a part of the city, is installed. From around year 2000, in some big cities including Beijing, collection of the charges started.

The steps to build a sewage tariff are rather complex. At first, a given committee which is responsible for the sewerage proposes a new tariff. It must be accepted by the cost management department of Beijing City government. Then, this must be accepted by a public hearing. Finally, a local congress should approve it. It is not easy for the first proposal to be accepted by the public hearing.

It was found that the unit cost of the sewage treatment of Gaobei Dian plant, including not only direct costs such as electricity, water, chemicals, small repairs, but also indirect costs such as personnel cost and principal and interest payment, together with maintenance costs of the sewers, would be around 1 yuan per cubic meter of sewage. The sewer users’ charge in Beijing is 0.9 yuan for domestic sewage at present, and is scheduled to increase in the near future. The charge for industries is much higher. For example, a car washing stand is charged 10 yuan for every cubic meter of sewage, and public bathhouses are charged 16 yuan. In

addition, an industry should pay a surcharge, if its wastewater quality exceeds the pre-set standard limitations. Thus, the overall average charge is 1.34 yuan (The charge is progressively proportional to the amount of the water consumed). The sewage charge is collected regardless of whether the person is connected to the public sewer or not. The collection rate of water charge is 85%. As it is quite high, full cost recovery is not an unrealistic prospect.

The rate for water supply is 2.8 yuan per cubic meter for domestic use. The sewer users' charge is collected together with the water charge. The one bill covers both water charge and sewer users' charge. Therefore, a total amount of the charge for every cubic meter of water consumption is 3.7 yuan (about US\$0.48) for the domestic users.

Public Relations and Environmental Education

In order to obtain the support and the acceptance of the general public of the payment of sewage charge, the improvement of public relations and the promotion of environmental



Fig-7 Beijing Water & Wastewater Education Center

education are essential. In Beijing, an environmental education center opened in October, 2005. It is officially called "Beijing Water and Wastewater Science Education Center". The total floor area of the center is

1,500m², and it is placed next door to Gaobei Dian sewage plant. The main

purpose of the center is to give a chance for people to learn environmental problems, such as shortages of water, sever water pollution, and countermeasures as well. The counter measures include a sewage treatment technology. Displayed are documents, pictures, panels, a miniature model of a sewage treatment machinery, and a video-show. In addition to these,

meeting rooms and a large lecture room are also placed in the center building. The center opens for the public from Monday to Friday, providing an educational program for secondary school pupils too. The center helps people to understand prime importance of the sewage works for water pollution control. This center is operated by the Beijing Drainage Group Corporation and is the first trial of its kind in the whole of China.