7. Transfer of Japanese Technology and Assessment of its Applicability

Japanese state-of-the-art eutrophication technologies, such as those for control and monitoring, have been transferred to developing countries, with emphasis on the efficiency of technological transfer by focusing on energy conservation, cost saving, and low maintenance. This chapter will discuss some case studies of technology transfer, as well as the applicability of these technologies, including water purifiers and monitoring equipment, in the recipient countries.

7-1 Lake Hongfeng Hu and Lake Bai Huau Restoration Project in China (Ministry of Environment)

7-1-1 Objective of the Project

In many developing countries, water pollution in lakes is progressing faster as social and industrial activities are being stepped up. China, in particular, suffers from manifest proliferation of toxic algae in many hypertrophic lakes, which threatens the security of water resources to the extent that toxigenic cyanobacteria control is urgently required. Although an efficient control technology focusing on nitrogen and phosphorus needs to be introduced to abate eutrophication, very little has been done concerning the fact-finding survey of noxious algae bloom and development of its control technique. Under these circumstances, the Ministry of Environment of Japan allocated one of its FY2000 projects to the feasibility study concerning the applicability of national engineering for decentralized control of water pollution in Lake Hongfeng Hu and Lake Bai Huau in Xizhou Province of Western China, as model lakes, in order to determine the applicability of the water pollution control devices of Japanese technology considered suitable for Western China by actually putting them to use on site. Although initially a single-year project, the study proved itself important enough to be followed up in FY2001, which still continues at present. This research project pays attention to the newly emerged, urgent challenge to the global water environment, the cyanobacteria producing microcystin, which is more poisonous than potassium cyanide and is now regulated in the WHO Guidelines for Drinking Water Quality. The microcystin biomass in the eutrophic lakes in the Province was surveyed, and concurrently, the research project strived to upgrade the treatment of the toxin by making use of bioengineering-based water-treatment engineering and the eco-engineering.

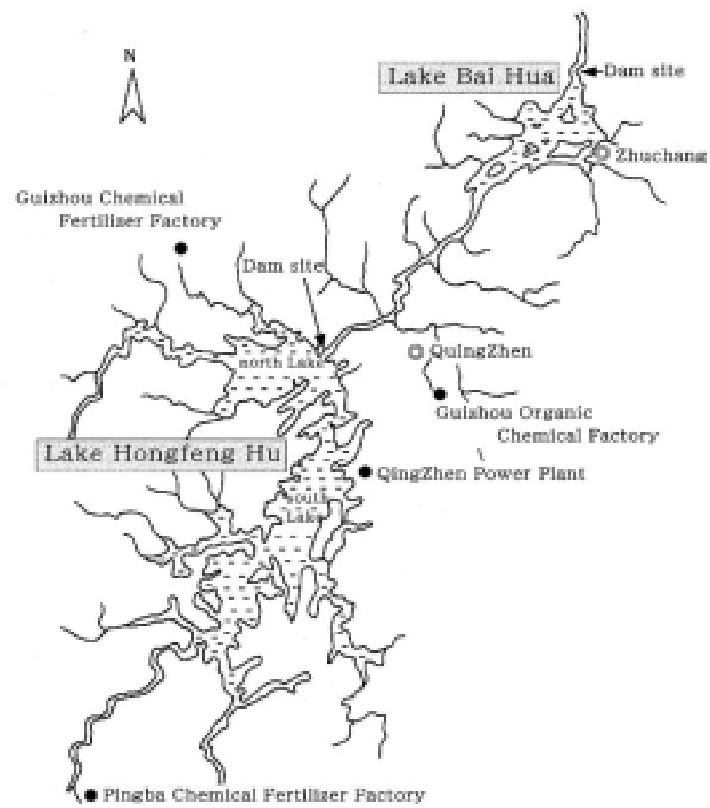

Fig.7-1-1 Topography of Lake Hongfeng Hu and Lake Bai Hua

7-1-2 Outline of the Project

This research project is an international collaboration participated in by the Ministry of Environment and the National Institute for Environmental Studies from Japan, and the Chinese Research Academy of Environmental Sciences, Guizhou Research and Designing Institute of Environmental Science, and Shanghai JiaoTong University from China. The water purification devices of Japanese technology introduced through this project were two medium-sized private sewerage systems, two small-sized private sewerage systems, one soil trench system, and one aeration pumping tube, all regarded to be suitable to the locality of Western China. Described in China as "no three days of fine weather in the sky, no three miles of plain on the earth, or no three grams of silver for the people", Guizhou Province has many rainy and cloudy days, and a rough terrain. The following section will outline the characteristics and the catchment effluent control measures of Lake Hongfeng Hu and Lake Bai Huau (Fig. 7-1-1), located at N 26º and E 106º and 1,000 m above sea level.

Photo 7-1-1 Lake Hongfeng

(1) Lake Hongfeng Hu

Lake Hongfeng Hu (see Fig. 7-1-1) is a dam completed in 1960, with a catchment area of 1,610 km^2, a lake surface area of 57.2 km^2, a gross capacity of 601×10^6 m^3, a mean capacity of 300×10^6 m^3, a maximum depth of approximately 45 m, and a mean depth 10.5 m. The lake is divided into two, the North Lake and South Lake. It embraces various industries such as tourism, boat transportation, and fish cultivation, although the latter will be phased out for anti-eutrophication purpose. The lake serves as an important water source for the provincial capital Guiyang (population of 2.6 million), supplying 40,000 m^3/day to the city. The sewerage development in the catchment area is significantly underdeveloped: a roughing tank is installed at each house for digestion and sedimentation, and the supernatant is discharged into the nearby streams via open channels and sewer culverts. Excreta from public and domestic toilets are used as a fertilizer in farmland. Although the wastewater from tourist facilities is partially treated by the roughing tanks, they can merely remove 20 % of BOD, 15 % of COD, and 50 % of SS. Moreover, due to poor maintenance, the tank's performance is reduced so much to probably be capable of SS elimination only. As for the pollutant sources in the catchment, industrial effluent, domestic wastewater, and cultivation in the lake are among the point sources, whereas paddy fields, farmlands, and forests are among the non-point sources. The past studies revealed that electric, chemical, and other factories around Lake Hongfeng Hu are the major polluters of the lake through their effluent, which tends to be high in nitrogen. A typical factory around the lake forms almost like a town as it is, with its population reaching 10,000 including the family members of the employees. The domestic wastewater drained from there, however, is hardly treated, and effluent control is still at the discussion stage initiated by the administration. In regard to any upcoming plans of enhancing tourist facilities, sightseeing, vacation and health establishments which are scheduled for building, these must equip themselves with their own effluent treatment facilities. All in all, with the current state of eutrophication control in the Lake Hongfeng Hu catchment area, the administration has finally set out to address domestic effluent.

(2) Lake Bai Huau

Completed in 1966, Lake Bai Huau is a dam downstream from Lake Hongfeng Hu, with a catchment area of 319 km^2, a lake surface area of 14.5 km^2, a gross capacity of 182×10^6 m^3, a mean capacity of 110×10^6 m^3, a maximum depth of approximately 45 m, and a mean depth 10.8 m. It embraces various industries such as tourism, boat transportation, and fish cultivation, and also serves as an important water source for Guiyang City, supplying 25,000 m^3/day to the city. Past studies revealed that various industrial effluents and domestic wastewater from around the lake are the chief polluters, which tend to be high in COD load. Wastewater in the catchment is hardly treated, and such domestic wastewater is discharged into the lake via streams and drainage canals (see Photo 7-1-2). The pollution load per capita as of 2000 is 100-150 *l*/day, whereas the 2005 figure is expected to increase to 200 *l*/day, which is the basis for designing the standards. Fish culture in the lake has been basically banned since 1998 as part of the eutrophication control measures. There are, however, more than a few fishers who still make a living from the fishery, and for them fish breading in some areas is still allowed under certain conditions within the set compensatory period. In this sense, the fish-breeding ban has not covered the entire lake yet. The government legislated for phasing out phosphate-containing detergents to abate the phosphorus load to the lake, although phosphate-free detergents are presently too expensive to be in common use. Such a situation holds true for not only the Lake Bai Huau basin, but also the entire Guizhou Province.

Photo 7-1-2 Lake Bai Hua where domestic wastewater directly

As described above, the typical administrative measures in the Lake Hongfeng Hu and Lake Bai Huau basin are domestic drain control, industrial effluent regulation, development of a sewage disposal facility, and a total ban on the fish cultivation. In introducing Japanese engineering in these circumstances, the focus needed to be on the domestic wastewater control, which confronted the Province as a critical issue. For this reason, it was decided to apply water purification devices that work to abate the toxigenic-algae-boosting nitrogen and phosphorus, namely, an advanced private sewage treatment tank, at the level of bioengineering, and a soil trench, at the level of eco-engineering. At the same time, an aeration pump was to be introduced to arrest the proliferation of the already-existing algae in the lake. Device selection criteria entailed cost saving, energy conservation, and easy maintenance, but the priority was on suitableness for the conditions in Guizhou. This research project pursued the applicability of these selected devices to

Western China, and in addition, it extended to the checkup of continuous and constant treatment performance in its follow-up survey.

7-1-3 Achievement of the Project

(1) Toxigenic Algae Biomass

In Lake Hongfeng Hu, Lake Bai Huau, and XiaoGuan Reservoir, all of which supply service water to Guiyang City, algae biomass and the toxic microcystin biomass were monitored in October 2000. The observation method was as follows: first, the algae were collected and concentrated using a quantitative plankton net NXX25 for the purpose of sampling the toxigenic cyanobacteria; second, the noxious algae were identified by optical microscope; and finally the microcystin biomass was determined by high performance liquid chromatography (HPLC). XiaoGuan Reservoir registered the largest algae propagation (19,350 individuals/*l*), followed by Chafan downstream from Lake Bai Huau (4,280 individuals/*l*), Jiangjundong in the center of South Lake of Lake Hongfeng Hu (3,940 individuals/*l*), and the dam site of Lake Hongfeng Hu (320 individuals/*l*), in descending order. Breakdown of the algae according to species indicated that the *Microcystis* genus of the Cyanophyceae group dominated the XiaoGuan Reservoir, whereas the *Fragilaria* genus of the Bacillariophtceae group, and the *Pediastrum* genus of Chlorophyceae group and the *Microcystis* genus of the Cyanophyceae group were the dominant species in Lake Bai Huau and Lake Hongfeng Hu, respectively. Subsequent identification of the algae found that the toxic types blooming in the Lake Bai Huau and Lake Hongfeng Hu catchment were *Microcystis aeruginosa* and *Microcystis viridis*. It was also revealed that the XiaoGuan Reservoir registered 18,100 *Microcystis* colonies per liter, a larger standing crop than in any other water area surveyed in the study.

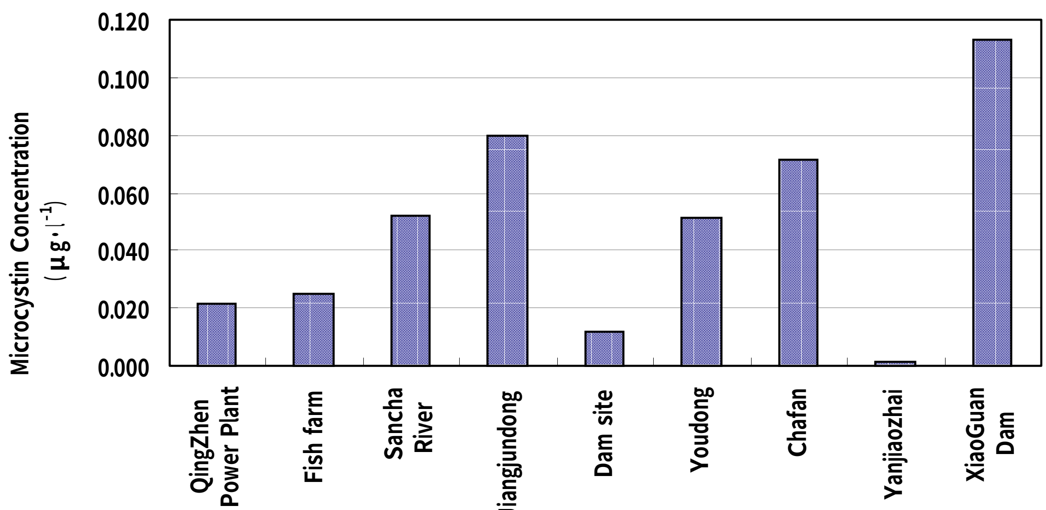

Fig.7-1-2 Concentration of Microcystin in Lake Hongfeng Hu, Lake Bai Hua, and at the XiaoGuan Dam

Fig. 7-1-2 shows the analysis of the toxic substance microcystin, which indicates that the largest microcystin biomass of 0.11338 μg/*l* was found in XiaoGuan Reservoir, followed by 0.07988 μg/*l* of Jiangjundong in Lake Hongfeng Hu and 0.07148 μg/*l* of Chafan near the intake gate of Lake Bai Huau. From a study of the correlation of the Microcystis biomass and the microcystin concentration based on these results, we concluded the correlation coefficient as 0.767 and the linear expression as y = 0.000043x + 0.021973. From these results, the microcystin content per Microcystis colony (500-1,000 cells per colony) was derived as 0.000043 μg, which led to the estimate that as many as 23,000 colonies of Microcystis would be required to exceed the guideline value of 1 μg for microcystin set under the WHO Guidelines for Drinking Water Quality. The number of samples in this survey session, however, was too small to ensure reliability, which means that the data needs further accumulating to strengthen its credibility in the future. Besides, since the session this time was carried out during the low season of toxic algae bloom, another observation will have to be conducted in the high biomass season. At any rate, the fruits of this survey session have extreme value as the first detection of microcystin of toxigenic algae origin in Guizhou Province, offering significant information concerning the future direction of the water resource conservation of the lake. In parallel with the microcystin survey, other harmful algae than Microcystis were also investigated, since Lake Hongfeng Hu, Lake Bai Huau, and XiaoGuan Reservoir all supply the city water. The study found the emergence of musty-odor-producing *Phormidium tenue* in the fish-breeding areas in Lake Hongfeng Hu and XiaoGuan Reservoir, which indicates possible odor and taste impairment of the drinking water. The above findings revealed the propagation of such harmful algae as Microcystis genus and *Phormidium tenue* in Lake Hongfeng Hu, Lake Bai Huau, and XiaoGuan Reservoir, which pointed to the urgent need for eutrophication control in order to conserve the environmental health of the waters.

(2) Advanced Private Sewage Treatment Tank

Advanced private sewerage tanks using bioengineering technology were installed at the Guizhou Chemical Fertilizer Factory and Guizhou Research and Designing Institute of Environmental Science to study the applicability of the devices which employ Japanese technology. Both were equipped with two medium-sized private sewerage systems and two compact private sewerage systems, respectively, for pursuing comparative study of the removability of organic matters, nitrogen, and phosphorus.

1) Guizhou Chemical Fertilizer Factory

Located in the northern catchment area of Lake Hongfeng Hu, the Guizhou Chemical Fertilizer Factory (shown in Photo 7-1-3) is a large factory with 3,000 employees (7,000 including their family members) that produces 120,000 tons of principally urea fertilizers per year. The factory drains 55×10^3 t daily, where its effluent fails to meet the nitrogen (NH_3-N) and SS values of the first-degree national standard due to the existing effluent treatment facility lacking in capacity/performance and operation/maintenance. Recently, a clean production facility construction project at the

Photo 7-1-3 Medium-sized private sewrage system

Guizhou Chemical Fertilizer Factory was launched by the State government to examine the anti-pollution provisions at the factory. Meanwhile, the domestic wastewater drained from the employee accommodation facilities are released via a roughing tank within the factory, although it is mostly untreated and without any particular control measures under discussion. Against this background, the household effluent from the chemical fertilizer factory was chosen as the subject of an applicability test for Japanese engineered technology. As for the medium-sized private sewerage systems for the factory, a batch-type denitrification/dephosphorization system (batch-type activated sludge method) and an intermittent-aeration-type denitrification/dephosphorization system (continuous activated sludge method) were employed, whose treatment flowcharts are shown in Fig. 7-1-3. The operation flowchart of each approach is detailed below, and the operation commenced in March 2001.

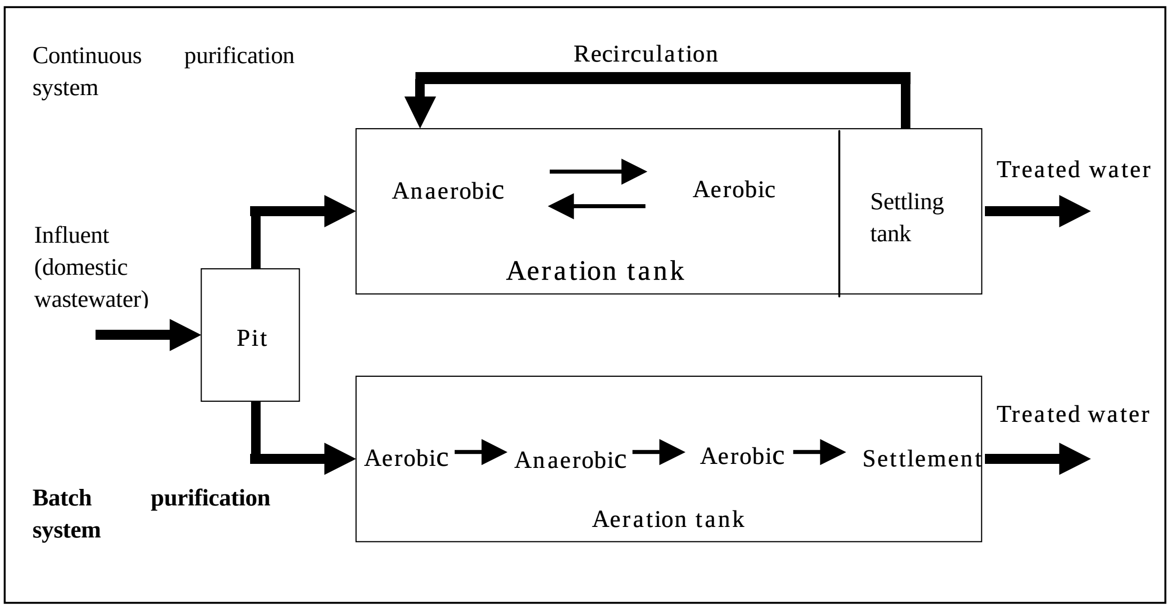

Figure 7-1-3 Medium Size Domestic Wastewater Treatment Systems at the Guizhou Chemical Fertilizer Plant

Operation Flowchart of the Batch-Type Denitrification/Dephosphorization System (6 hrs. per running cycle)

Inflow Process→	Aerobic Process→	Anaerobic Process→	Aerobic Process→	Sedimentation Process→	Drain Process
60 min.	90 min.	60 min.	30 min.	60min.	60 min.

Operation Flowchart of the intermittent-aeration-type Denitrification/Dephosphorization System (3 hrs. per running cycle)

Inflow Process→	Aerobic Process→	Anaerobic Process→	Sedimentation Process→	Drain Process
Constant	120 min.	60 min.	Constant	Constant

The volume of daily treatment of each system is 20 m^3. Both systems receive voltage stabilization provision through a control completely independent of the distribution panel, the control panel, and other components. While the flocculant-dosing tank and the pH controlling tank are fully automated, the electric system employs a relay combination. Ferric chloride was used as the flocculant, with its concentration set at 30 ppm on the assumption of an influent T-P level of 4 ppm. The pH sensor was adjusted so that it would feed sodium hydroxide under 6.5 to neutralize the water up to 7.0. In order to prevent excessive aeration, the aeration operation was programmed to stop at the DO level above 4. In the intermittent aeration approach, the sludge (circulation) rate was set as 200 %.

The water quality figures for the influent raw sewage between March and September 2001 were T-N 15-40 mg/*l*, T-P 2-4 mg/*l*, BOD 30-70 mg/*l*, and COD_{Cr} 90-140 mg/*l*. During this period, the batch-type system treated the water to reach T-N 9-25 mg/*l*, T-P 0.7-2.1 mg/*l*, BOD 1-10 mg/*l*, and COD_{Cr} 18-60 mg/*l*. At the same time, the intermittent aeration type attained the treatment levels of T-N 6-17 mg/*l*, T-P 0.5-1.7 mg/*l*, BOD 0.4-6 mg/*l*, and COD_{Cr} 18-60 mg/*l*. Based on these monitoring data, the treatment performances (average removal rates) for T-N, T-P, and other substances of each system are summarized in Fig. 7-1-4. It revealed that both systems delivered satisfactory performances in BOD and COD elimination, whereas T-N was only removed at the rate of 59 % by the intermittent aeration type and 45 % by the batch type. T-P removability was unsatisfactory with both the intermittent aeration type and the batch type, registering a mere 47 % and 17 %, respectively. The low removability of nitrogen and phosphorus largely results from poor operation and maintenance: specifically, inadequate DO control is presumably responsible for the nitrogen problem, and the phosphorus problem is possibly ascribable to flocculant feeding failure due to a clogged dosing pump or some other blockage. As seen above, the medium-sized private sewerage systems installed at the Guizhou Chemical Fertilizer Factory could exert an adequate effect in eliminating organic matters, although further simplification of operation and maintenance must be pursued for a better result with nitrogen and phosphorus treatment.

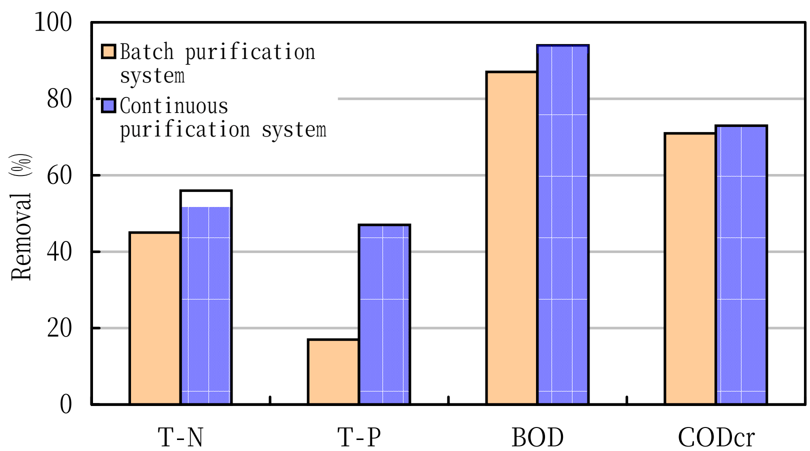

Fig.7-1-4 Comparison of treatment capacity on Medium Size Domestic Wastewater Treatment Systems

2) Guizhou Research and Designing Institute of Environmental Science

Compact private sewerage systems (see Photo 7-1-4), employing the cycle method of aerobe/anaerobe treatment(see Fig.7-1-5), were installed at the Guizhou Research and Designing Institute of Environmental Science to purify the wastewater discharged from its apartment housings. The volume of daily treatment was 2 m^3, and the return (circulation) rate was set at 200 %. The system was originally meant to be operated under the control of a timer according to the daily life cycle, yet, as of September 2001, a responsible employee manually actuated the system with an on-off switch. The sewerage systems were programmed to run for a total eight hours a day, four hours between

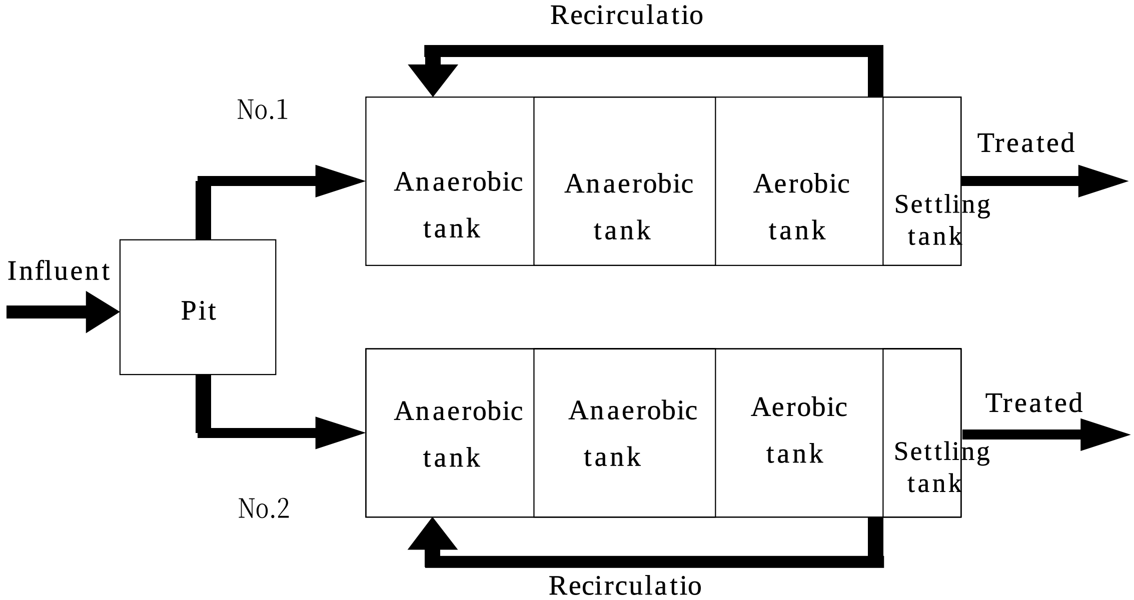

Fig.7-1-5 Minimum Size Domestic Wastewater Treatment Systems at the Guizhou Research and Designing Institute of Environmental Science

Photo 7-1-4 Landscape of researching compact private

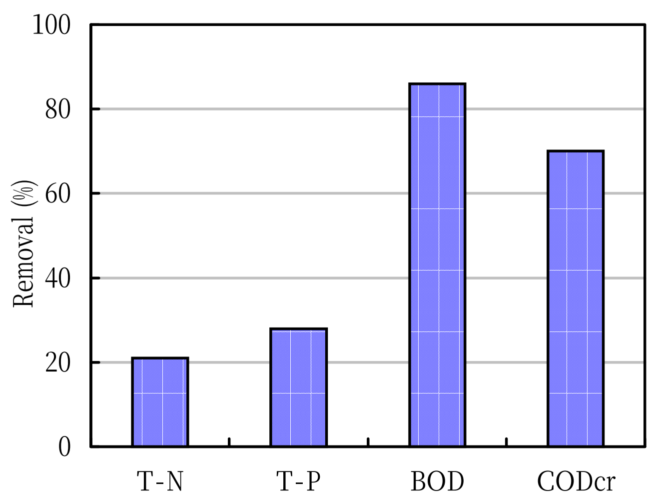

Fig.7-1-6 Treatment capacity on Minimum Size Domestic Wastewater Treatment Systems

8:00 and 12:00 and another four hours between 14:00 and 18:00. At present, two systems are in action under the same conditions. In the future, a comparative study is to be pursued by changing the conditions, including the load volume, to determine the optimal operating condition.

The water quality figures of the influent raw sewage between March and September 2001 were T-N 80-100 mg/*l*, T-P 8-11 mg/*l*, BOD 50-120 mg/*l*, and COD_{Cr} 100-250 mg/*l*. During this period, the sewage system (No. 1) attained the treatment level of T-N 42-100 mg/*l*, T-P 5-11 mg/*l*, BOD 3-15 mg/*l*, and COD_{Cr} 45-100 mg/*l*. The treatment figures at the system No. 2 reached roughly the same level. The treatment performances (average removal rates) of the system for T-N, T-P, and other substances are summarized in Fig. 7-1-6. It revealed that the sewerage system delivered satisfactory performance in BOD elimination, whereas T-N and T-P removability was rather poor. The low T-N elimination rate, in particular, was ascribable to a high concentration of ammonia nitrogen in the influent raw sewage (70-90 mg/*l*). This may have occurred from the imbalanced BOD/N ratio due to a decomposition/elimination of organic substances through pre-treating the apartment housings' wastewater at the septic tank before the raw sewage pit, when a proper BOD/N ratio was crucial to denitrification.

(3) Soil Trench

The Water Sports Training Center, situated on the shore of North Lake of Lake Hongfeng Hu, is a facility to train the Olympian-candidates for water sports, with about 80 people living on the site. A new building is currently under construction, and upon completion, the center will be able to accommodate approximately 300 people. As for effluent control, the wastewater is drained as it is, although development of a treatment facility is currently under review. Among the Japanese effluent control technologies, an eco-engineering-based soil trench (Photo 7-1-5), which is a purification method using soil with an anaerobic filter bed (Fig. 7-1-7), was selected for introduction at the center. This system employs a gravity flow method being free from an aeration device and a chemical feeder, which guarantees extremely easy maintenance. Crumbled topsoil, from corn fields, was brought in and laid out to boost the microbial activity. The volume of daily treatment was 3 m^3.

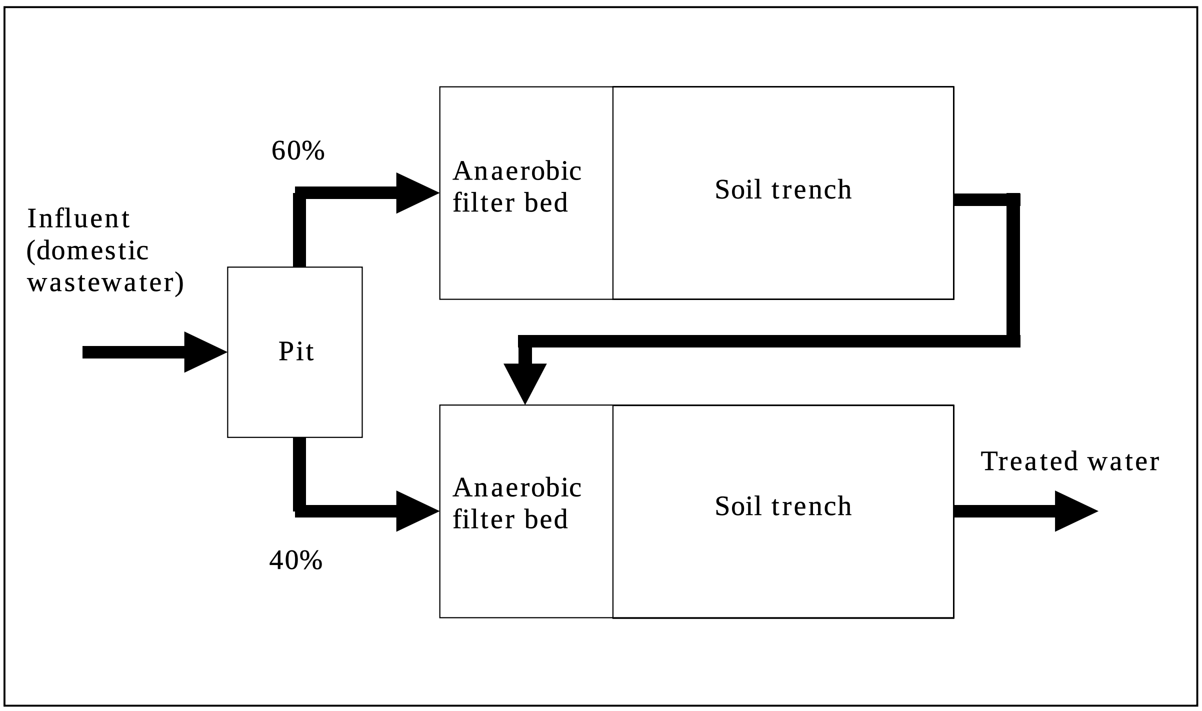

Figure 7-1-7 Soil Trench Treatment Process at the Water Sports Training Camp on Lake Hongfeng Hu

The water quality figures of the influent raw sewage between March and September 2001 were T-N 7-33 mg/*l*, T-P 0.7-2.2 mg/*l*, BOD 30-70 mg/*l*, and COD_{Cr} 55-90 mg/*l*. During this period, the soil trench attained a treatment level of T-N 1.8-7 mg/*l*, T-P 0.08-0.2 mg/*l*, BOD 1.5-10 mg/*l*, and COD_{Cr} 18-33 mg/*l*. The treatment performances (average removal rates) of the system for T-N, T-P, and other substances are summarized in Fig. 7-1-8. It reveled that the treatment system delivered exceptionally satisfactory performances with the elimination rates in all four parameters exceeding 70 %. In fact, this system turned out to record the highest performance in T-N and T-P removal. T-P elimination particularly showed excellent results, sometimes below 0.1 mg/*l* in the treated effluent. This soil trench system with an anaerobic filter bed has the advantages of easy maintenance, minimal construction cost, and low running costs, which proved the system to be an effective denitrification/dephosphorization instrument and a possibly successful measure for pollutant source control.

Photo 7-1-5 Soil trench

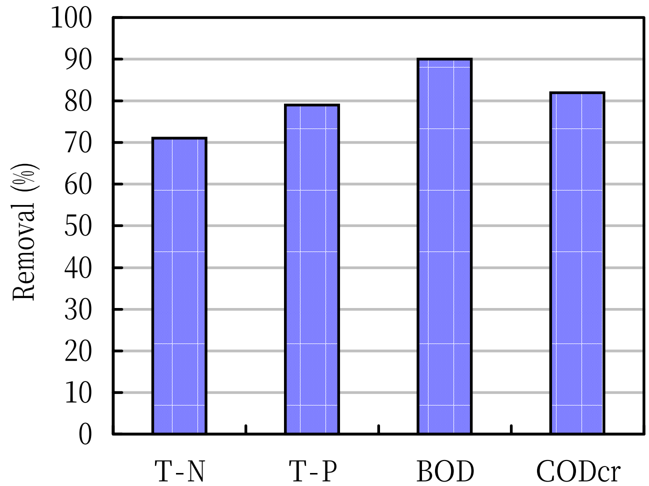

Fig.7-1-8 Treatment capacity of soil trench

(4) Aeration Pump

For the purpose of suppressing the propagation of harmful algae such as toxigenic cyanobacteria, an aeration pump tube was introduced among the Japanese anti-eutrophication technologies. The aeration pump was designed so that it generates a circulating current throughout all of the water area by causing water convection between the surface and bottom layers to transfer the photosynthetic algae from the reproduction-inducible photic zone to the nonreproducible aephobic zone. At the same time, the instrument is also capable of reducing elution of iron, manganese, phosphate and other materials by supplying oxygen to the deep layer, thus exerting its effect in controlling the manganese-origin black water and the phosphorus-derived eutrophication. With due consideration in choosing the installation location of this algae-bloom suppressor, it was found that the XiaoGuan Reservoir is the most suitable place for the aeration pump to deliver its maximum capacity. To be more specific, the reservoir was chosen because, 1) it is a source for the service water supply in Guiyang, 2) the black water which emerged in the city water can be controlled by abating manganese, and 3) the algae biomass survey in this research project found that the reservoir contains the largest standing crop of the algae and of the hazardous microcystin. XiaoGuan Reservoir is an artificial reservoir completed in 1959, with a catchment area of 16.3 km^2, a gross capacity of 2.26×10^6 m^3, and a maximum depth of approximately 14 m. It daily supplies 2,500 m^3 as service water. Fig. 7-1-9 shows the survey results of the stratification in the deepest area in March 2001 before installing the aeration pump. The observations showed that the thermocline was formed between the 1.5- and 2.0-meter area, revealing a lack of convection between the surface and bottom layers. The survey also found the alga biomasses of 2,200 individuals/m*l* at the surface layer, 600 individuals/m*l* at the middle layer (2.5-m deep), and 250 individuals/m*l* at the deepest layer (5.5 m), which revealed that the highest propagation of algae was at the surface. For information, the maximum depth in March registered 5.5 m, with the pondage at the lowest level. The aeration pumping was started in June 2001 when the water capacity at the dam reached a level sufficient for the operation. Fig. 7-1-10 presents the observations in September 2001, which revealed that the aeration pumping destroyed the thermocline and supplied oxygen to the deepest layer by generating water circulation. The 4-hour intermittent operation of aeration pumping managed to disrupt the thermocline yet failed to deliver oxygen to the deep layer. Extension of the running period to 12 hours successfully provided oxygen to the deep layer. The October 2000 observation found the biomass of toxigenic algae as 17,000 individuals/*l*, which significantly dropped down to 2,200 individuals/*l* by September 2001, the blooming period of cyanobacteria. The dam administrator also confirmed that the algae bloom was extremely low that year. Based on the above data, aeration pumping with Japanese technology is estimated to exert effect in destroying the thermocline, supplying oxygen to the deep layer, and reducing the algae reproduction.

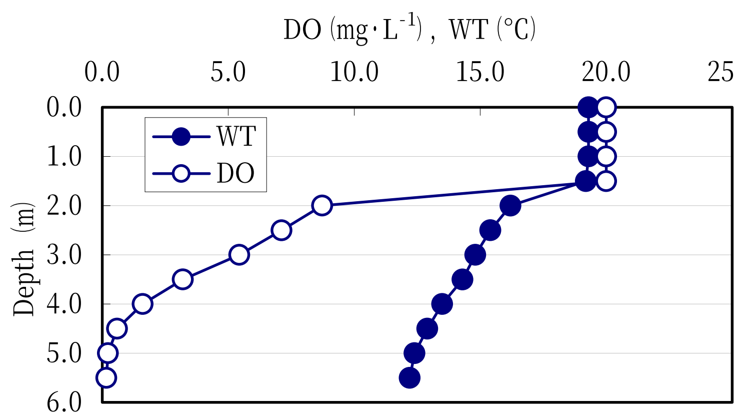

Fig.7-1-9 Thermocline of XiaoGuan Reservoir

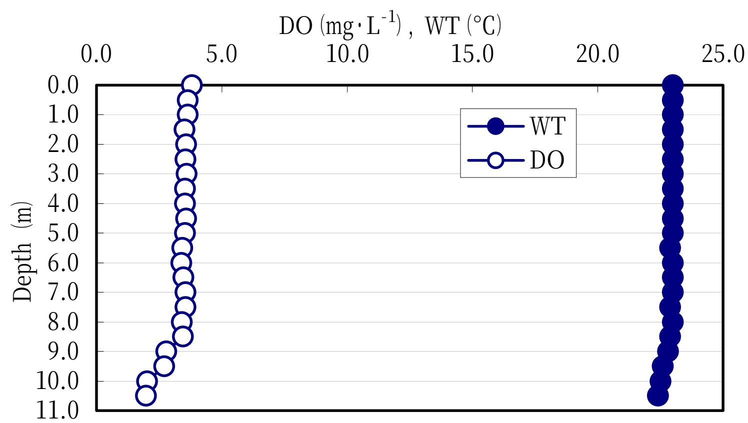

Fig.7-1-10 Distribution of Water Temperature after Air Lift Bubbling in XiaoGuan Reservoir

(5) Evaluation of the Japanese Engineering

As has been described above, Japanese engineering considered suitable to western China was introduced as eutrophication control in Lake Hongfeng Hu and Lake Bai Huau, and its applicability was investigated at the same time. Such engineering is the advanced private sewerage system, the soil trench, and the aeration pump, whose assessment is summarized below.

As for the high-performance private sewerage system using a bioengineering-based water treatment technique, the medium- and small-sized treatment systems proved themselves applicable for eliminating organic substances such as

BOD and COD reduction, whereas nitrogen and phosphorus removal performance varied from time to time, calling for an upgraded operation/maintenance capability. The future technical challenge lies in simplifying the device and adding maintenance-free feature to it. Yet, this project is scheduled to send the local engineer in charge of the system operation to Japan for technical training, which is expected to contribute to better water quality as skill acquisition progresses.

As for the soil trench using the natural purification capacity of soil based on eco-engineering, excellent removability was achieved for nitrogen and phosphorus as well as the organic substances such as BOD and COD. In addition, the soil trench sported easy operation/maintenance and low construction cost, which rendered it effectively applicable as a water treatment method to areas with a vast site and low wastewater volume. Attracted by the treatment efficacy and the low building cost, Chinese government initiated construction of a full-scale soil trench with a daily treatment capacity of 30 m^3 at the Water Sports Training Center where the pilot introduction took place through this project (see Photo 7-1-6).

Photo 7-1-6 The soil trench facility constructed by Chinese

The aeration pump installed at the dam for the purpose of suppressing toxic algae bloom showed its effect in circulating lake water, reducing algae, and turning the deep layer aerobic, which suggested that the device be applicable. This device can be used in eutrophic waters, such as lakes, dams, inland seas, and inner bays, for water quality conservation and restoration, while due consideration must be paid regarding its efficacy for water quality improvement in shallow lakes, cost effectiveness in large lakes, and its impact on the algae colony structure caused by lowered water temperature at the surface layer.

Recapitulation of the above results finds that, among the Japanese engineering, the soil trench and aeration pumping can exert their effects in wastewater treatment right away without modification in Guizhou Province in Western China. Under the operation and maintenance pursuant to the specifications, the high-performance private sewerage system should be able to attain a satisfactory improvement in water quality. At this moment, however, the sophisticated technological nature of the device itself hinders proper operation and maintenance, leaving us the challenge to address that problem. Through the study, it was understood that the water environment restoration on a global-scale would require further advancement of international cooperation to foster technological development as well as the training of local personnel.

7-1-4 Possible Ripple Effects

This research project is part of the strategic policies of science and technology responding to national and social needs; specifically, the Japanese government is to lead the construction and promotion of comprehensive remedial technology for aqueous ecology to control toxigenic algae and lake eutrophication, targeting Lake Hongfeng Hu and Lake Bai Huau in Guizhou Province in China, yet also common to various countries around the globe. Reinforcing and furthering this research project is believed to establish a locally-contained bioengineering- and eco-engineering-based purification system within the lake and the riverhead areas in developing nations, as well as to construct the circulatory and symbiotic ecosystem on an eco-friendly and sustainable development basis by developing the technology suited for each locality.

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7-2 Development Project for the Water Quality Remedial System in Korea (Japan International Cooperation Agency)

7-2-1 Objective of the Project

The Korean economy has achieved a high-level growth centered, first, around industrialization through an initial process of light-industry-concentrated economic development in the early 60's and, second, a transitional period of heavy industry development in the 70's, along with various midcourse corrections. This series of economic growth, however, brought about serious social issues, such as urban population concentration, along with industrialization-led environmental problems, such as air pollution, water contamination, and waste disposal.

These social and economic developments contributed to upsurges in the pollution sources and the sewage volume. Sewerage system development in urban areas could not catch up with the growth of the sewage volume, which not only deteriorated river water but also triggered many grave problems caused by acute progress of eutrophication in closed waters, such as dams, that were supposed to supply service water to the cities.

Under a national plan, the central government annually undertook improvement works on wastewater treatment facilities and sewer conduits. Yet, the construction costs of the sewerage system were so phenomenal that sewerage system development alone could not rectify the water quality promptly.

Discussion and study on introducing a decentralized system for effluent treatment, targeting the suburban areas with service water sources, remained at an immature stage; control measures for nitrogen and phosphorus against eutrophication posed especially tough challenges. In this sense, it was assessed through analyzing, evaluating, and predicting the state of pollution in the ever-polluting rivers that a proper water quality management system needed to be established. Based on such an assessment, the urgently necessary measures and engineering were determined as 1) technological development for pollutant reduction that matched the locality, such as for the distribution, size, and variety of pollutant sources, and 2) a purification technology that can be directly applied to the rivers using their self-decontamination capacity. It was also pointed out that both types of technologies must be maintenance-free and cost-effective.

Located in the downstream part of Kyonang River basin, Paldang Dam supplies the service water to Metropolitan Seoul and its 15 million population, which means that it is extremely important to develop a water purification system with direct influence on Seoul’s water quality. For this reason, the Ministry of Environment of the Republic of Korea has already conducted various environmental conservation projects to induce water purification in Kyonang River by designating the Yongin area in the upstream basin as the pilot area for environmental conservation. In this context, both Japan and Korea came to recognize the priority of facilitating improved efficiency in the above projects by conducting a bilateral joint research projects.Based on an Agreement Between the Government of Japan and the Government of the Republic of Korea on Cooperation in the Field of Science and Technology in 1985, the Korea Environment Institute (KEI) concluded a research cooperation agreement for developing environmental conservation technologies with the National Institute for Environmental Studies of Japan (NIES) in March 1988. Furthermore, KEI and the Japan International Cooperation Agency (JICA) agreed regarding environmental management of the Han River basin in November 1989, which launched a three-year research cooperation project. The results of this research disclosed the urgent need to develop a river/lake water quality management system according to the river system, and a decontamination system tailored to the region’s characteristics. The Korean side urged cooperation in the area of a decontamination system particularly, as the most widespread private sewerage system in Korea was the so-called septic tank, which is capable of eliminating only 50 % of the BOD and none whatsoever of the nitrogen or phosphorus, when water pollutants and pollution sources were skyrocketing.

Based on the results of this three-year JICA mini project, the Korean Government requested a project-type technical cooperation from JICA in November 1992, to which JICA responded by sending a preliminary assessment team and a group of long-term researchers to investigate the request details and the adequacy of the cooperation.

Their results found that the transfer of two technologies, the decentralized effluent treatment technology and the purification technology directly applicable to rivers, could greatly contribute to water quality conservation in Korea. To be more specific, the former technology consists of a high-level combined type private sewage treatment system, developed and widely spread in Japan, which can eliminate the BOD as well as nitrogen and phosphorus, and the latter technology is represented by a canal purification scheme by filling the contact materials.

After the preparatory assessment group delivered the results, a study group for project implementation was dispatched to Korea to sign the Record of Discussion (R/D) on August 27, 1993, which launched a five-year cooperation project on September 1. On the occasion of sending the final assessment group in March 1998, the Korean side urged extension of the project, which was met by extending the project for one year until August 31, 1999. This project-type technical cooperation is the only project actually launched out of the 13 propositions based on environmental cooperation agreed by the then Japanese Prime Minister Kiichi Miyazawa and the then Korean President Roh Tae Woo.

The purpose of the technical cooperation is, first, to transfer Japanese technologies to KEI in the fields of aquatic environment remediation and a river/lake water quality management system, next to stimulate research to modify and tailor these technologies to the needs of the Korean situation, and finally, to develop water quality remedial technologies suitable for the locality to contribute to the overall improvement of the aquatic environment in Korea.

7-2-2 Outline of the Project

The technical cooperation under this project targeted the fields listed below.

(1) Water Quality Remedial Technology

a) Advanced and decentralized treatment techniques for domestic wastewater.

b) Advanced treatment technique for livestock effluent.

c) Advanced treatment techniques for polluted canals.

(2) River/Lake Water Quality Management System

a) Environmental capacity determination method.

b) Development of methods countering lake eutrophication.

Since the project focused on the water quality improvement of service-water sources, such as Seoul's water supplier Paldang Dam, around which the population is relatively dispersed, the technical cooperation project chose a decentralized wastewater treatment system, where effluent is treated promptly right at its origin, rather than a centralized wastewater treatment system, such as a sewerage system, where the wastewater is collectively brought through pipes to wastewater disposal plants. The reasons for this decision are listed in Table 7-2-1.

In view of the issues presented in Table 7-2-1, pilot effluent treatment devices, covering the aforementioned cooperation targets, were installed on site for data collection and analysis, optimization of the operation conditions, and cost evaluation, and their data and results were used to tailor the technologies to the locality by providing reasonable guidelines for the structure and operation/maintenance of the device.

At the same time, the river/lake water quality management technology development targets Seoul's water supplier Paldang Dam for study on techniques to determine the environmental capacity and development of technologies to predict and control the algae bloom caused by lake eutrophication.

Table 7-2-1 Issues Considered for the Decentralized Effluent Treatment System Tailored to Korean Situations

1) It is economically advantageous in a sparsely populated area. (A sewerage system is economically disadvantageous due to the length of the pipes.)
2) Prompt wastewater treatment at the pollution source returns the cleansed water quickly into the public water body to be used for maintaining the aquatic environment. (A sewerage system carries the water downstream via conduits, raising a problem of reducing the flow rate in the midcourse rivers.)
3) It is easier to institute a system to recycle water for miscellaneous and landscape uses.

For making use of these advantages

↓

It is necessary to develop wastewater treatment technologies applicable to a decentralized wastewater treatment system to meet various needs such as 1) high-quality treated water, 2) a compact structure, 3) easy maintenance, 4) cost efficiency, and 5) energy conservation.

7-2-3 Achievement of the Project

(1) Technological Transfer Concerning Water Quality Betterment

At the outset of the project, the common system for decentralized wastewater processing at detached houses and apartment buildings in Korea was a septic tank only capable of anaerobic treatment, which also had a serious problem in its maintenance, such as the failure to vacuum out the sludge. In addition, livestock wastewater was treated mainly by septic tanks and lagoons, the processing performance of which was extremely low. This project began under the above circumstances, and also when water pollution scandals repeatedly occurred one after another concerning major rivers, raising national concerns about the aquatic environment as well as great interest and hopes, including in the media, for an advanced wastewater treatment equipment to replace the septic tanks. At the same time, however, the situation in Japan concerning the private sewerage system, in particular the high-performance combined private sewerage, was hardly known and was not anticipated as a means to meet such expectations. Once the project started, and especially after the installation and operation of real-size effluent disposal equipment, their performance drew considerable attention and raised expectations, which accelerated the study, by mainly KEI researchers, on customizing the structure of the provided devices to fit Korean circumstances, and the acquisition of maintenance techniques under the guidance of the Japanese expert team.

Table 7-2-2 lists the equipment provided under this project. As for the small-size combined private sewerage system for detached houses, we chose two systems capable of removing BOD and nitrogen for comparative study: a circulatory system using anaerobic/aerobic filter beds, and a circulatory system using an anaerobic filter bed and biological membrane filtration. Both systems attained favorable results in water quality to their specifications, registering less than 20 mg/*l* for BOD and below 15 mg/*l* for T-N. As for the medium-size combined private sewerage system for apartment housings, we also chose two systems capable of removing BOD, nitrogen, and phosphorus, for comparative study: a sequencing batch reactor processing system, and a circulating intermittent aeration system. Both systems attained satisfactory results in water quality to reach the set targets, registering less than 20 mg/*l* for BOD, below 15 mg/*l* for T-N, and less than 1 mg/*l* for T-P. The livestock wastewater treatment facility, targeting on pig farming,

Table 7-2-2 Equipment Provided under this Project

	Process Method	Matters Removed			No. of Units	Treatment Volume M^3/day
		BOD	N	P		
Household effluent	1.Small-Scale Combined Private Sewerage System for Detached Houses					
	(1) Circulatory System between Anaerobic/Aerobic Filter Beds	○	○		4	1-2
	(2) Circulatory System between the Anaerobic Filter Bed and the Biological Membrane Filtration	○	○		4	1-2
	2. Medium-Size Combined Private Sewerage System for the Apartment Housings					
	(1) Sequencing Batch Reactor Processing System	○	○	○	1	40
	(2) Circulating Intermittent Aeration System	○	○	○	1	40
Livestock Effluent	(1) Sequencing Batch Reactor Processing System for Livestock	○	○	○	1	10
	(2) High-Speed Composter for Livestock Solid Waste Disposal	---	---	---	1	2

achieved great results for BOD and T-N less than 120 mg/*l* and T-P below 70 mg/*l* out of the raw sewage with BOD around 4,000 mg/*l*, T-N around 2,000 mg/*l*, and T-P around 70 mg/*l*. A composter made it possible to combine the composting of solid content from the corral and the surplus sludge through the effluent treatment process, raising the financial expectation of organic fertilizer (compost), which has a high market value in Korea. As described above, the provided equipment fully delivered its intended performances, which means that it achieved the goal of not only technical transfer to the counterpart, but also educating and raising the awareness of the general citizens.

Based on technical transfer through equipment provision, the next step was technological transfer to develop decentralized domestic effluent treatment facilities capable of eliminating nitrogen and phosphorus for eutrophication abatement, livestock wastewater treatment facilities, and comprehensive wastewater treatment facilities to jointly process restaurant effluent and night soil, in cooperation with the Japanese specialist team. Long-term experts led this technical transfer, with extra dispatch of short-term experts without the year limitation of initial plan. This flexible approach brought about fruitful results. In particular, a comprehensive wastewater treatment facility to jointly process restaurant effluent and night soil is now under discussion in Japan, which, to some extent, is a "reverse import" of Japanese technology from Korea. In Korea, effluent from small restaurants in the service-water source areas, such as in the vicinity of dams, had become an important policy issue. The project addressed this problem by developing technology that could significantly reduce the pollutants from such severe levels as the oil content of 500 mg/*l*, BOD of 1,000 mg/*l*, and T-N of 100 mg/*l*, down to less than 20 mg/*l* for both BOD and T-N. Other facilities also delivered similarly excellent performances, coupled with easy maintenance. For these reasons, KEI decided to facilitate the widespread use of these facilities through the pilot projects, indicating the success of the technological development.
In Korea, the private sewerage systems were regulated not by the structural standard but by the performance standard, for which the project successfully suggested technical standards.

(2) Software-wise Technical Transfer Regarding the Legal System

In Korea, regulation previously imposed only the installation of septic tanks for small-scale buildings, such as apartments, for their on-site sewerage systems. Due to the rising social awareness of the water environment issue and the confirmation of technical feasibility through this project, the Act Relating to the Treatment of Sewage, Night Soil and Livestock Wastewater was amended in March 1997 to require the installation of combined type private sewer treatment systems at small buildings. The revised law also explicitly set various standards such as for their installation, and maintenance and for the quality of the discharged treated water. As seen above, the project for technical cooperation attained excellent results in the field of administrative assistance for water purification.

(3) National Award

In recognition of the earnest work of the Japanese project group, the Korean government granted the following national awards.
Republic of Korea Prime Ministerial Award for Contribution to Environmental Conservation: 1 recipient
Republic of Korea Environment Ministerial Award for Services for Environmental Conservation: 3 recipients

The breakdown of personnel dispatched from Japan through this JICA project is outlined as follows.

1) Long-term Specialists (including the project leader): 5 people

2) Short-term Specialists: Over 70 people

3) Study Group Dispatch: 8 times

7-2-4 Possible Ripple Effects

Through a surprisingly organic interaction and match between the Korean situation and the assistance provided, this project in Korea achieved numerous fruitful results both in technical hardware transfer, such as hi-performance private sewage treatment systems capable of removing nitrogen and phosphorus, and technical software transfer, such as revision of related laws. In each area of industry, academia, and administration, active and enthusiastic transfer of technologies took place through highly effective cooperation with the integration of equipment provision and research instructions as one under the project. This unified project was reflected in the determination and establishment of the proper operating conditions and maintenance techniques of the wastewater treatment facilities, using real-sized facilities, and the research and related analytic techniques for determining the design specifications of the wastewater treatment devices by using the provided bench-scale equipment. Consequently, this project turned out to embody what a JICA project-type technical cooperation should be in every possible way, which raises our hopes for its future application and development in many different regions. In addition, it needs to be noted that an Eco-Frontier (EF) Fellow funded by the Global Environment Research Program developed less-global-warming water and solid waste treatment techniques, which significantly contributed to the progress of the project. The EF Fellowship sponsored by Japanese Government aims to foster international exchange in the field of environmental conservation by inviting foreign researchers to Japan for joint research, etc.

These numerous achievements were appreciated in the form of winning the Republic of Korea Prime Ministerial Award for Contribution to Environmental Conservation and the Republic of Korea Environment Ministerial Award for Services for Environmental Conservation. These honors were previously awarded domestically only, which made this event a milestone as the first overseas winner of the awards. Standing on the basis of this project completed in August 1999, JICA and the Korea International Cooperation Agency (KOICA) launched their joint training program for other Asian nations to improve their water environment, in conjunction with the ex-counterpart KEI. The program just completed its first two-year phase in FY 2001, and will move into a second phase with an even closer partnership between Japan and Korea.

The above ripple effects as well as the results of the project themselves can be proudly summarized as consisting of the foundation of a new Korea/Japan partnership in the 21st century in the most critical field of the century, the environment.

7-3 Pilot Project for the Water Environment Remediation at Lake Taihu in China (JICA)

7-3-1 Objective of the Project

The target of this pilot project, Lake Taihu, preciously supplies city water of as much as approximately 1.05×10^9 m^3 annually to some million residents in the surrounding big cities, such as Shanghai, Wuxi, Suzhou, and Huzhou (Fig. 7-3-1). At the same time, however, the lake as a whole suffers from eutrophication, and some parts of the lake suffer serious organic pollution and algae bloom. The Chinese Government has so far designated three lakes and three rivers as the most important areas for environmental control by the state, among which Lake Taihu is top on the agenda. Currently, ongoing pollution control measures focus on industrial and urban wastewater, complying with the ninth five-year plan and the long-tern plan until 2010 to counter water pollution in Lake Taihu. Due to the various measures implemented between 1997 and 2000, the major point sources in its basin are now basically under control. Meanwhile, decentralized (rural) household effluent and non-point-source pollutants are still awaiting to be addressed, owing to technical and financial difficulties. Environmental load cutback requires not only measures to treat the industrial and urban wastewater, but also for the control of decentralized household wastewater sources and organic pollutant sources at the lakeshore. In particular, it is vital to reduce nitrogen and phosphorus, when both are chief culprits of eutrophication.

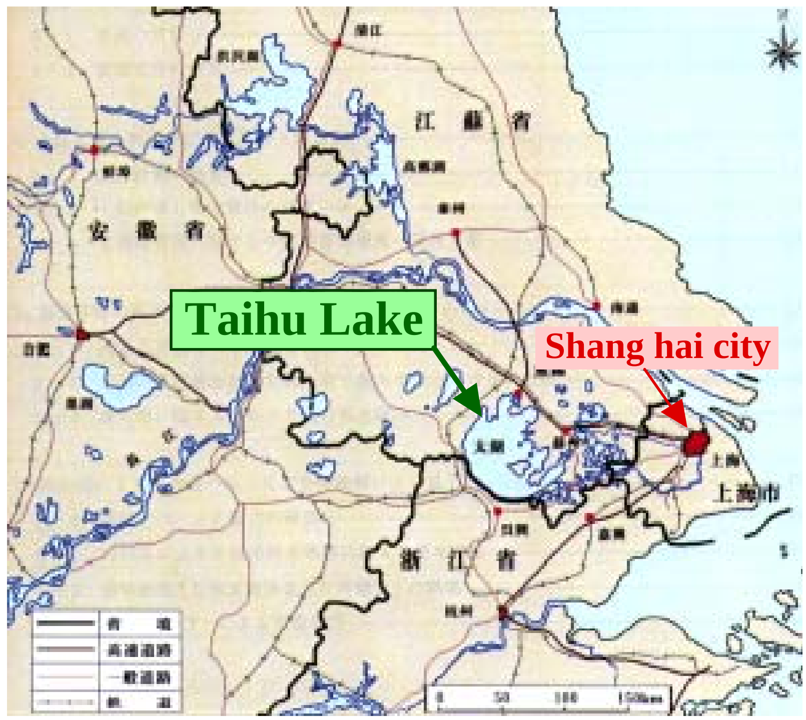

Fig. 7.3.1 Map of the Region Around Taihu Lake 200 Kilometers South-east of Nanjing in Jiangsu Province

Based on the above circumstances, this project aimed a) to research and develop control/processing technologies for household effluent from decentralized sources in the Lake Taihu catchment area applicable to and widely usable in the target area by fitting its social and economic conditions, and b) to render these technologies recognized by the target society. The project put its primary emphasis, in its objectives, on the reduction of the nitrogen and phosphorus influx into Lake Taihu by applying lake water environment remedial technologies developed under this project. Achievements of these goals are expected to deliver the following effects.

1) Developing commercialized technology for an advanced private sewer treatment system targeting rural household effluent.

2) Developing effective eco-engineering-based purification technology targeting rural household effluent.

3) Satisfying the conditions for the developed technologies to be recognized by the targeted society.

In addition, there is great expectation that the technologies scheduled for development under this pilot project will be applicable as aquatic environment remedies to other developing countries than China.

7-3-2 Outline of the Project

This pilot project is a five-year research collaboration launched in FY 2001 under the framework of JICA's project-type technical cooperation jointly participated in by the Ministry of Environment, the National Institute for Environmental Studies, the Ministry of Land, Infrastructure and Transport, and the Public Works Research Institute from Japan, and the China State Environmental Protection Administration, the Chinese Research Academy of Environmental Sciences, the Jiangsu Environmental Protection Department, the Wuxi Environmental Protection Bureau, and Shanghai JiaoTong University of China. The R&D pilot project targets Wuxi, an industrial and tourist city on the north of Lake Taihu with a population of 4.26 million. The most eutrophic area in the lake is the northern water near the city: canals and the lakeshore are particularly infested by toxigenic algae bloom, which raises a big social issue (see Photos 7-3-1 and 7-3-2). Such areas register concentrations of over 1,000 μg/*l* microcystin of cyanobacterial origin, which raises grave environmental and hygiene concerns.

Photo 7-3-1 Abnormal increase of toxigenic algae bloom

Photo 7-3-2 Toxigenic algae at lakeshore in Wuxi

Against that background, this pilot R&D project focuses on Lake Taihu designated as the lake of highest priority by the Chinese Government which places algae bloom control as one of the prime national environmental policies, and aims to reduce the influent loads into the lake. To be more specific, the project gears toward the creation of eco-friendly community systems through development of technology/devices to control household effluent by using a combination of bioengineering and eco-engineering (bio-eco-engineering) and the establishment of standards concerning the structure, maintenance, and performance of the developed technology/devices. The technologies used and developed under this project are, 1) bioengineering as a water treatment technology with the introduction of a private treatment system for household sewer from hotel and apartments, and 2) eco-engineering that facilitates the maximum use of the self-purification capacity of the plants and soils in the water areas polluted by household wastewater. Furthermore, two types of technologies will be systematically combined into a bio-eco-engineering, where each technology is properly applied and allocated in the Taihu catchment to deliver a visible effect in water quality improvement.

7-3-3 Pilot Bio-Eco-Engineering Facilities Installed in Wuxi City

This pilot project comprises Japanese technical transfer, basic research by the Chinese Research Academy of Environmental Sciences, setting standards for the structure and performance of the purification system by analyzing the data acquired through verification study by the Wuxi Environmental Protection Bureau, the Jiangsu Environmental

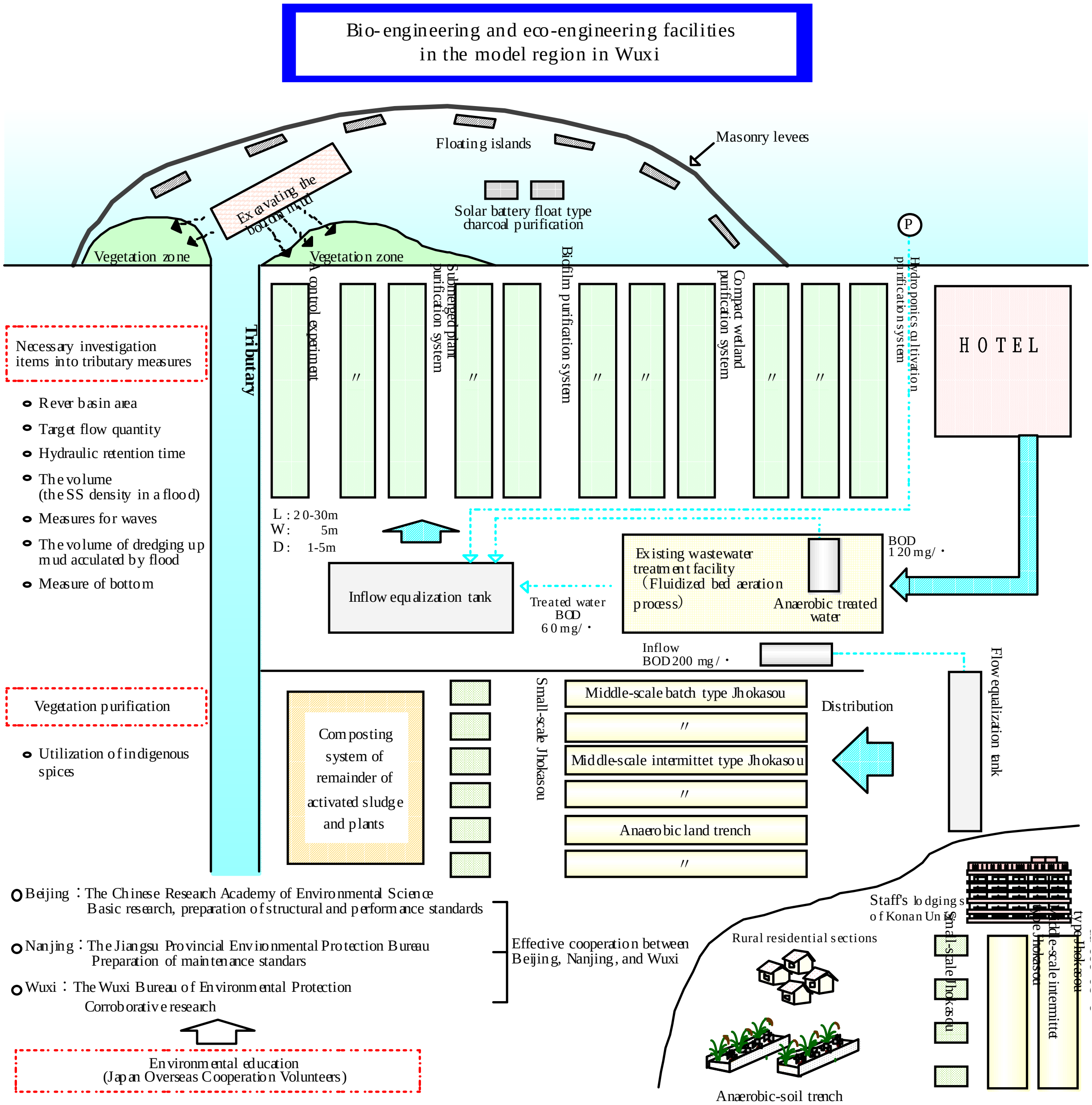

Fig. 7-3-2 Bio-engineering and eco-engineering facilities at the pilot area in Wuxi

Protection Department in Nanjing setting standards for maintenance based on the municipal bureau's verification study, and most importantly, a verification study of the bio-eco-engineering by the Wuxi Environmental Protection Bureau. The conceptual rendering of the pilot area in Wuxi is shown in Fig. 7-3-2, where the private sewerage system is introduced using the bioengineering approach.

As for the eco-engineering approaches, purification through hydroponic plants (biopark), purification by using the soil, and compact wetland purification by using the biological film created by the water plants and the microorganisms proliferated on bonding carriers were all employed. In addition to these conventional approaches, a new eco-engineering attempt is being made through building a new rubble-work bank on the lakeshore near the influx of small rivers carrying household effluent to create lakeshore vegetation zones by digging up its inner sludge, and concurrently introducing a purification method through an artificial vegetated floating island to address the issue of tributary control. The technologies to be developed in this pilot area offer great hope for their international application.

7-3-4 Ripple Effects of the Project

The results of this project, to be obtained through both the basic and applied studies on software and hardware conducted in Beijing, Nanjing, and Wuxi, are expected to earn a high reputation both at home and abroad. Firstly, the project aims to develop the technology for an on-site sewer treatment system capable of eliminating nitrogen and phosphorus to effectively abate lake eutrophication, and simultaneously to construct a standard system set to regulate its maintenance, structure, and performance. When achieved, these promising results will be generalized for use in the regulations to successfully reduce the pollutant loads from household effluent originating from the sources scattered throughout the nation. Secondly, the project can suggest some new lake purification techniques based on energy-saving, low-cost, low-emission, and resource-recycling eco-engineering approaches, such as those using water plants, hydroponic plants, and soils, which have great potentials for having further ripple effects as a nationwide model of lake decontamination in China. The originality of this project lies in the new concept of creating a hybrid system of bioengineering and eco-engineering to maximize the advantages of both approaches, rather than the conventional, individual application of each. In this sense, its achievements are promising for future application on a global basis. As described above, this project should serve as the core for establishing the water environment conservation strategy in the 21st century. Hopes run high that the project will expand its organic partnership beyond Japan and China to the other developing countries to pave the route to water purification tailored to local needs and conditions.

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7-4 Water Quality Remedial Program at Lake Ypakarai in Paraguay

7-4-1 Objective of the Project

The Republic of Paraguay, located inland on the South American Continent, faces a grave social problem of eutrophication at Lake Ypakarai near its capital Asuncion. On this account, the Servicio Nacional de Saneamiento Ambiental (National Environment and Health Service, SENASA) decided to formulate a water pollution control plan, including water quality monitoring and analysis at the lake, and effluent regulations. Against this background, this project aimed to help the SENASA formulate a water pollution control plan, including the water quality monitoring and analysis at Lake Ypakarai, and effluent regulations, and to also upgrade the enforceability of the plan.

7-4-2 Outline of the Project

(1) Targeted Location of the Project

This project targets the Lake Ypakarai catchment area in the vicinity of Asuncion, the capital of the Republic of Paraguay. As shown in Fig. 7-4-1, Paraguay lies in inland Latin American, and is surrounded by Brazil, Argentine, and Bolivia. Lake Ypakarai is located at S 25.2º and W 57.2º, and approximately 30 km to the east of the center of the capital Asuncion (see Fig. 7-4-2). The geometric features of the lake are as follows: a surface area of 59.6×10^6 m^2; a maximum depth of 3 m; a mean depth of 2 m; a surface altitude of 64 m above sea level; a water capacity of 115×10^6 m^3; a shore length of 40 km. Of the area surrounding the lake, farmland, including pastureland, accounts for approximately 65 %, and natural vegetation, such as grassland and wetland, shares approximately 19 %. Its catchment area embraces cities such as San Lorenzo, Luque, Capiata, and San Bernardino, whose household wastewater flows into the lake through 20 influent rivers. The lake has only one effluent river, the Salado, which flows into Rio de la Plata via the Paraguay River to reach the South Atlantic.

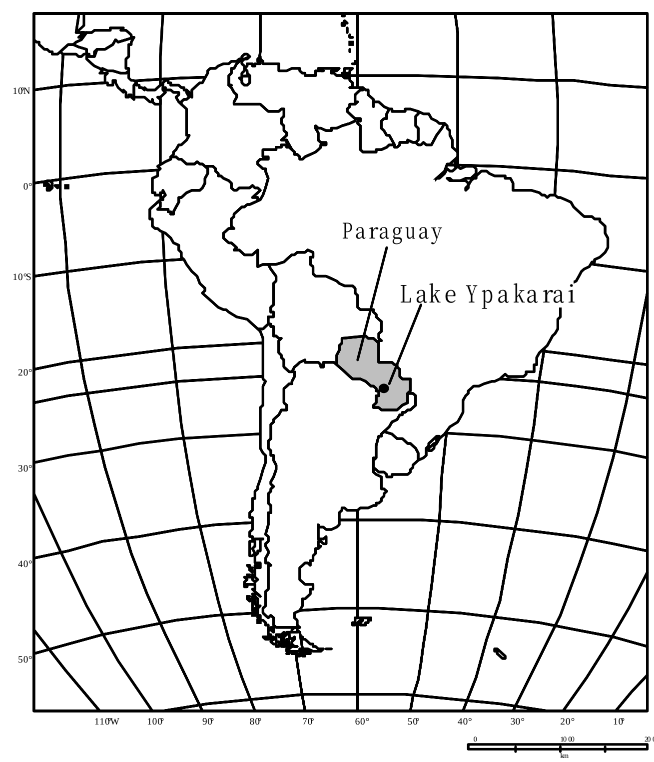

Fig.7-4-1 Situation of Lake Ypakarai

The urban and domestic wastewater in the basin accounts for around 48 % of the loading pollutants that flow into Lake Ypakarai. The industrial effluent from over 80 business establishments in the catchment area is estimated to share approximately 24 %, most of which are ascribable to meat packaging and leather processing. Photo 7-4-1 presents the landscape of Lake Ypakarai. The lake water is colored brown from the influent soil particles due to soil erosion in the catchment area. For this reason, the lake is characterized by significantly low transparency (0.07-0.15 m) and a considerably high SS concentration (70-80 mg/*l*). The water quality figures in Lake Ypakarai are as follows: CODcr 10.3-15.7 mg/*l*; T-N 0.58-0.89 mg/*l*; T-P 0.15-0.30 mg/*l*; DO 6.0-8.9 mg/*l*; and pH 6.0-8.7. The lake is distinctive for its relatively high phosphorus concentration compared to the nitrogen level, thus there is an excessively low ratio between nitrogen and phosphorus of 1.9-5.9. The organization responsible for the technical transfer (counterpart) under this project is SENASA. At the time of inauguration of the project, SENASA mainly consisted of three departments.

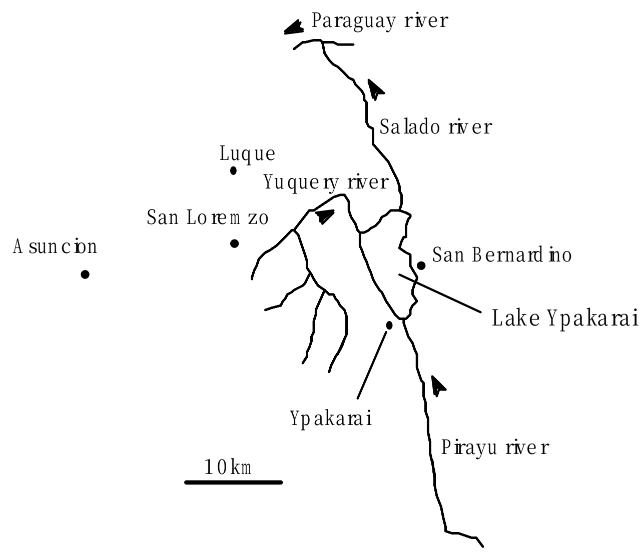

Fig.7-4-2 Drainage of Lake Ypakarai

- Direccion de Proteccion Ambiental (Directorate of Environmental Protection)
- Direccion de Agua y Saneamiento (Directorate of Water and Health)
- Direccion de Administracion y Finanzas (Directorate of Administration and Finances)

The specialists dispatched under the project were affiliated to the Directorate of Environmental Protection, which has jurisdiction over factory effluent regulation, solid waste control, and environmental monitoring and water quality testing.

(2) Background of the Project

Paraguay is an inland country with no sea facing it, which means that Lake Ypakarai serves as a precious water resource not just for water utilization but also for water recreation. Contrary to such a role, the Ypakarai catchment environment was constantly and progressively exacerbated by land development, a population explosion, and industrial development due to either urban sprawl or the capital Asuncion. For this reason, the lake is rapidly losing its value as a

Photo 7-4-1 Landscape of Lake Ypakarai (Paraguay)

water resource and a tourist and holiday resort. In 1988 and 1989, JICA conducted a feasibility survey concerning a water pollution control plan in Lake Ypakarai to address the rapidly ailing water environment. Between 1995 and 1998, individually dispatched experts for water pollution control (mainly for analytical and monitoring guidance) were sent to Paraguay to provide further technical support.

Based on the above background, this three-year technical cooperation project was launched with its objectives to help SENASA analyze the problems of the Ypakarai basin by itself through the process of technical transfer including analysis of newly registered pollutants, administrative guidance, effluent treatment improvement, data analysis, and environmental edification and education, as well as to undertake the review and revision of the current water quality standards and the formulation of a draft for a feasible plan to improve water quality. The ultimate goal of the project is to contribute to the actual water quality improvement of the lake through the results of the project. In July 2000, the final year of the project, Secretaria del Ambiente (Secretariat of Environment, SEAM) was established, which shifted the legal jurisdiction concerning the environment from SENASA to SEAM. In this sense, the counterpart of this project, SENASA, had much reduced administrative authority.

(3) Project Period

The period for technical cooperation under this project is three years, between June 1, 1998 and May 31, 2001.

(4) Range of Activities under the Project

The project initially focused its technical cooperation efforts on monitoring techniques. Once data were acquired through monitoring, the water quality remedial plan, including proposals to related organizations, was formulated on the basis of these data, in order to facilitate further development of measures into activities such as a study on the drafted water quality standards, guidance to the pollutant sources on the effluent treatment renovation, and environmental education. Specifically, the project activities consisted of the six categories listed below.

- Monitoring of, keeping track of, and recording the state of water pollution.
- Formulating a monitoring plan, maintaining the monitoring equipment, introducing new monitoring techniques (including those for agrochemicals, heavy metals, and microorganisms), and compiling a monitoring manual.
- Formulating an enforceable water quality remedial plan.
- Offering instructions on what the water quality standards should be to control the water contamination, and studying their actual water quality standards.
- Training the SENASA personnel so that they themselves can give guidance to the pollutant sources on effluent treatment renovation.
- Conducting edification and PR activities for the general public and those in related fields and industry regarding the actual state of water pollution and the urgency for its control.

7-4-3 Achievement of the Project

(1) Monitoring on the Degree of Pollution

Under the project, the pollutant sources in the Ypakarai catchment area were monitored according to their origins, such as household, industry, and nature. Through the monitoring sessions, several techniques, including those for understanding the degree of pollution, and for elucidating the pollutants, were successfully transferred to the counterpart. Through the project, a whole set of monitoring techniques was passed on, ranging from drafting the plan, conducting the survey based on the plan, sorting the acquired data, and analyzing the data, all the way to compiling the report.

(2) Elucidation of Pollutants and Guidance for Reform

The pollutant investigation covered various sources in the Ypakarai catchment, including illegal waste dumping sites and over 80 business establishments of all size, to elucidate the problems of these sources. Through the technical transfer of administrative guidance and on-the-job training on effluent treatment techniques, the project counterpart became able to provide proper administrative guidance (for reform) to the pollutant sources such as factories.

(3) Maintenance of Survey/Analysis Equipment and Reagents

A register of survey/analysis instruments, reagents, and other equipment and chemicals was created, whereby the management system of these instruments was established through allowing anyone at anytime to access the register. The major equipment and their uses provided under this project (partially the provision of peripherals only) are listed below. These instruments, mainly analyzers, enhanced the transfer of monitoring techniques.

- Gas Chromatograph Mass Spectrometer (GC-MS) (including a solid phase microextracter and a capillary column)

  The GC-MS was used for agrochemical detection. The solid phase microextracter allowed the qualitative analysis and screening for certain agrochemicals, which paved the road for detailed investigation on agrochemical pollution. Through experience in microextraction, an engineer should be able to master the qualitative analysis skills.

- Atomic Absorption Spectrophotometer (including the autosampler)

  The device was used for heavy metals detection within the sediment. The autosampler enhanced efficiency by allowing the automatic and repeatable samplings useful for a large number of samples.

- Oil Concentration Analyzer

  The analyzer was used when the fear of oil pollution arises. It allowed the mechanical analysis of oil, previously conducted manually, which increased the time efficiency at the laboratory.

- High Performance Liquid Chromatograph

  The instrument was used for detection of the organic compounds such as within agrochemicals. Being a complement to the GC-MS, this allowed water ion analysis.

- Biological Microscope System (including photomicrographic equipment, a plankton net for collecting biological samples, and a server net)

  The system was used for the detection and identification of aquatic organisms. The biological observation allowed by this system diversified the evaluations of the state of the water environment, which was hitherto only chemically analyzed.

- Algae Growth Tester

  The instrument allowed test/research on the growth and reproduction of plankton. The algal growth potential (AGP) and other tests are expected to start in the future. Performing these tests vitally requires the acquisition of test/study skills by the engineers in charge through trainings.

- Dissolved oxygen (DO) Meter

  This DO meter was used for the back up and crosschecking of the existing DO meter. The simultaneous DO measurement with the pH level enhanced the time efficiency.

- Ultrasonic Cleaner

  It was used for cleaning glass tools and preparing slightly soluble reagents at the laboratory.

- Ekman-Birge Grab

  The grab was used for sampling the sediment of the lakes and rivers. It allowed sediment sampling under uniform conditions in an efficient way, thus reducing individual differences in the sampling process.

- Multi-Parameter Water Quality Checker

  The analyzer was used for measuring the physical parameters of sampling on the spot. Simultaneous measurements of multiple parameters saved time at the sampling site.

- Liquid-Waste Treatment Device

  It was used for periodic treatment of the effluent containing potassium dichromate. A test/research institute on the environment must not drain the untreated liquid-waste. With this device, it is now possible to publicly announce the clean discharge of effluent.

- Clean Bench

  It was used for the aseptic manipulation such as E. coli culture tests. This instrument enhanced the operation efficiency with bacterial tests, by allowing full-scale aseptic manipulation at the laboratory impossible just by flame sterilization.

- Survey-Use Motorboat

  It was used for the transportation to a fixed point in the regular monitoring session every month.

- Four-Wheel Drive Vehicle

  The automobile was used for sampling activities in the regular monitoring of Lake Ypakarai, factory investigation for the effluent monitoring, and other activities requiring transportation.

- AV Multi-Projector

  The projector was used for environmental edification activities. It allowed the use of ordinary paper, rather than transparency, which eased the preparation work for materials and handouts.

- Photocopier

  It was used for daily business such as paperwork and document preparation.

(4) Development of a Manual

The project produced a manual covering a wide spectrum ranging from samplings, such as of microorganisms, to their analysis using the equipment at the laboratory. This manual will provide a precious guideline to any newly appointed engineers in charge who has no previous experience.

(5) Production of Reports

The project established the system to publish an annual report compiling the data on the Ypakarai catchment area obtained through the monitoring. Those precious data, otherwise likely to be forgotten, are now systematically put together as a report so that they can be effectively used in various ways, including comparative study with past data.

(6) Environmental Edification Activity

Based on knowledge acquired through the study regarding the state of water pollution and the investigation on the pollutant sources, the project sponsored seminars for various groups of people, such as business managers, catchment administrators, catchment area residents, schoolteachers, and the general public, and successfully obtained their understanding on the state of the basin pollution and cooperation for its control measures. It also published a PR kit for citizens and business managers to show the guidelines regarding water pollution control.

(7) Formulation of the Water Quality Remedial Plan and Review on the Water Quality Standard Revision

The water quality remedial plan was formulated on the basis of both the knowledge and technologies transferred under this project, and the ideas and experiences obtained during the project.

7-4-4 Possible Ripple Effects

(1) Local Government

Consejo de Municipalidades de la Cuenca del Lago Ypacarai (CLYMA), composed of 21 municipalities in the Lake Ypakarai catchment area, and *Consejjo de Gobernaciones Municipalidades de la Cuenca del Lago Ypacarai* (CLYGMA), composed of three departments (provinces) in addition to the said municipalities, were established in 1999. These councils, through various activities, are expected to contribute to progress in improvement of the water quality at the lake.

(2) Local Health Council

Every municipality has its own health council (Juntas de Saneamiento) in Paraguay. Authorized as a legal entity, this organization is in charge of development and maintenance of the waterworks and the sewage works. The sewerage department of SENASA, the project’s counterpart, designs and executes the project activities under the control of the local health council. At the request of the health council, Caacupe, though outside the Ypakarai basin, has now been equipped with a sewerage system, and the same initiative was launched to develop sewage treatment systems in other Ypakarai basin cities such as Itagua, Capiata, and Ypakarai. Realization of this vision should contribute to drastic purification of the lake by reducing pollutants in the untreated effluent flowing into the lake.

(3) Catchment Residents

Full-geared implementation of environmental education and edification should be able to raise the awareness of the catchment area community members of the lake pollution, thus slashing the pollutant loads such as through illegal waste dumping. At this moment, however, their ecological ethics have not yet reached an adequate level.

(4) Industrial Guild of Paraguay

In 2000, the Industrial Guild of Paraguay, the Ministry of Industry and Commerce, and the Catholic University jointly started consultation activities for small businesses to improve their productivity and eco-friendliness. These efforts are expected to enable the small businesses in the Ypakarai catchment area to address water pollution control.

<Reference>

1) International Lake Environment Committee, *Survey of the State of World Lake* (2001).

2) Section of Middle and South America, Department of Middle and South America, JICA, *The Final Evaluation Report of the Team Dispatch Project to Paraguay entitled 'Water Quality Remedial Plan at the Lake Ypakarai Catchment'* (2001).