Wastewater Management in the Lake Biwa Basin

琵琶湖流域における排水管理

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1. Lake Biwa and the Yodo River Basin

(1) Overview of the Yodo River Basin

The Yodo River originates from Lake Biwa, the largest lake in Japan. It flows toward the south as the Seta River as it enters Otsu City in Shiga Prefecture. Continuing toward the Kyoto Basin, it becomes the Uji River in Kyoto Prefecture. Within the Kyoto basin, after joining the Kizu River from the south and the Katsura River from the north, it becomes the Yodo River. The river flows to the southwest, through the Osaka Plain, finally flowing into Osaka Bay. The Yodo River Basin is enormous, with a total catchment area of 8,240 km^2. The basin covers six prefectures; Shiga, Kyoto, Mie, Nara, Osaka and Hyogo. It has created the foundation for the development of the society, the economy and the culture of the entire Kinki region. Moreover, with respect to the climate and basin condition, as compared to other Japanese rivers and lakes, the water of Lake Biwa and the Yodo River is calm, contains abundant life and possess an almost divine quality. The Yodo River has contributed to the prosperity of agriculture since the Yayoi period and, since ancient times has also played an important role as a water transportation route. For many years, river improvement and irrigation constriction activities have been promoted, thus the Yodo River has held a leading role in the development of Japan's water resource management.

In general, upstream areas tend toward a greater amount of agriculture usage, while downstream areas are utilized more for residential, commercial and industrial purposes. In particular, since the high economic growth period of the late 1960s, the accumulation of population and industry has progressed tremendously. Furthermore, as a result of increasing urbanization, land usage has changed very rapidly within the suburbs of the large cities of Kyoto, Osaka and Kobe as well as around the outskirts of Lake Biwa.

Fig.1 Lake Biwa and the Yodo River Basin

The water from Lake Biwa and the Yodo River is utilized for a variety of purposes, such as domestic water supplies, for industrial and agricultural applications, in power generation, for environmental usage and the other purposes. Water in the basin is used repeatedly. It is utilized in upstream areas, such as the upper stream of the Seta River and in dams, then used again in the middle stream via the Lake Biwa Canal and the Uji River, mainly as it passes through Kyoto City. The same water is again used in the

downstream area within the Osaka Plain. As the result, there are many sewer outlets in upstream areas and water supply intakes are located in its downstream areas.

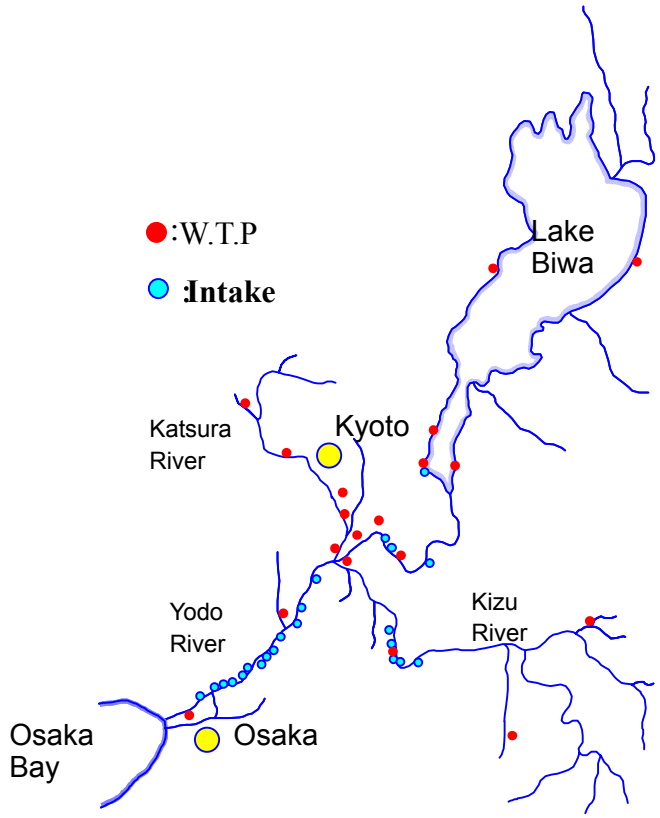

Fig.2 Intake and Discharge System

(2) Overview of the Lake Biwa Basin

Lake Biwa, located in the center of Shiga Prefecture, is the third oldest, after Lake Baykal and Lake Tanganyika. Due to its 4 million year history, Lake Biwa possesses abundant biological diversity, being habited by approximately 600 species of animals and 500 plant species including 50 endemic ones. There are approximately 460 rivers, ranging in size from small to large, that flow into the lake. However, the only outflows from Lake Biwa are the Seta River and the man-made Lake Biwa Canal. It is estimated that the complete exchange of all water in the lake requires approximately 19 years. Lake Biwa is a national treasure that continues to provide numerous benefits to the 14 million people in the Kinki region, supplying vital water to their households and industries, providing an abundant source of fishery products and offering tourists and residents alike a venue for rest and relaxation.

The catchment area of Lake Biwa encompasses 80% of the total 4,017km^2 area of Shiga Prefecture. Within Shiga Prefecture, about one half of the total land area is forests and mountains. The remaining half is apportioned into Lake Biwa itself, agricultural lands used mainly as paddy fields and urban areas/roads. These forests and paddy fields have been useful for conservation of Lake Biwa's environment, through their ability to recharge water sources, prevent sediment runoff and retain/purify water.

Table 1　Overview of Lake Biwa

Shiga Prefecture Land Area	4,017 km^2
Lake Biwa Catchment Area	3,174 km^2
Lake Surface Area	670.25 km^2
Shoreline	235.20 km
Storage Capacity	27.5 billion m^3
Maximum Depth	103.58 m
Average Depth	41.20 m
Average Depth of the Northern Lake	approximately 43 m
Average Depth of the Southern Lake	approximately 4 m

2. Lake Biwa Comprehensive Development Project

(1) Overview

The Lake Biwa Comprehensive Development Project was launched in 1972 as a national program based on a special measures act of the Diet, and was concluded in March 1997. The primary objectives of the project were to develop additional water resource for the downstream region and to reduce the threat of floods in the lakeshore areas, while preserving the natural environment of the lake and restoring a water quality that was rapidly showing the effects of pollution. The project was a system that integrated all water resource development projects undertaken on behalf of Lake Biwa. The project consisted of three major areas; water utilization, flood control and conservation, and cost approximately 1,905.5 billion yen.

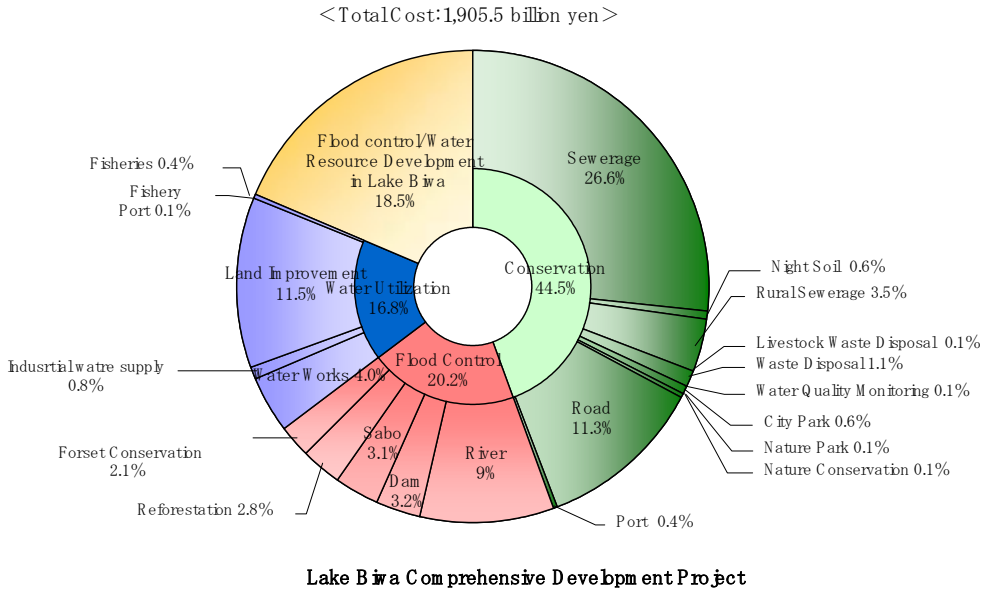

Fig.3　Lake Biwa Comprehensive Development Project

(2) Special Financial Measures

One of the most remarkable features of the Lake Biwa Comprehensive Development Project is a special financial framework established under the act, and this framework became the pioneering approach of the legal system for the water resource developments in Japan.

○Special Subsidies from the national government

The national government provided special subsides for various programs of the Lake Biwa Comprehensive Development Project.

○Cost sharing of local government in river basin

The local governments in the downstream areas that benefit form water resource development were required to share some cost for the Lake Biwa Comprehensive Development Project implemented by Shiga Prefecture or municipalities in the prefecture. The share of local governments was determined based on the allocation rates of the newly developed water volume (40 m^3/sec), and the total amount was approximately 60.2 billion yen. In addition, Osaka and Hyogo Prefectures were further requested to loan 5 billion yen to Shiga Prefecture.

○The Lake Biwa Management Fund

In order to secure the financial resource for operating, maintaining and managing facilities regarding Lake Biwa, Shiga Prefecture was approved to establish the Lake Biwa Management Fund. The fund was established with approximately 10 billion yen in 1997 when the Lake Biwa Comprehensive Development Project was completed.

(3)Outcome

Various programs undertaken as Lake Biwa Comprehensive Development Project have brought about improvement of infrastructures for not only the Lake Biwa Basin but also the entire Lake Biwa and the Yodo River Basin. The flood damages were eliminated by the construction of embankment and drainage facilities. Furthermore, due to the various measures taken for the low water level control, damages during the drought periods became quite less. Moreover, among 22 programs of the Project, 11 programs were concerning environmental conservation, and therefore living and natural environment in the Lake Biwa Basin have improved tremendously. Regarding the water quality, in spite of the population increase in the basin, the amount of pollution loads was greatly reduced in line with the progress of sewerage developments. The water quality of the rivers in the basin, especially, that of the rivers flowing into Southern Lake Biwa, was improved, and also eutrophication of Lake Biwa was suppressed.

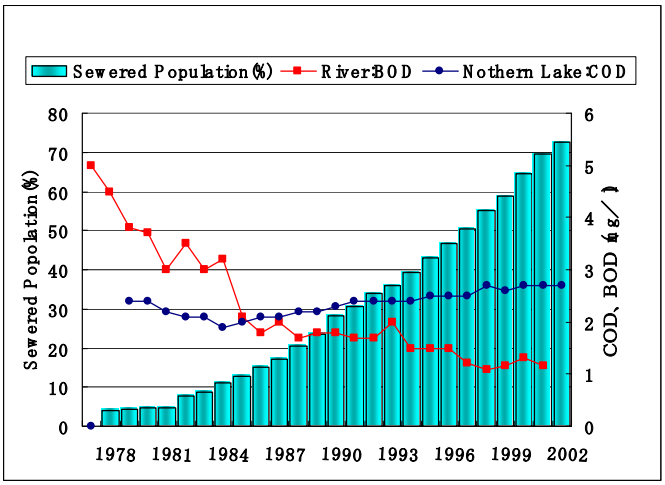

Fig.4 Effect of Sewage Works

3. Lake Biwa Comprehensive Conservation Plan (Mother Lake 21)

(1)Overview

Lake Biwa Comprehensive Development Project succeeded in providing a more effective utilization of the water resources of the lake and in significantly reducing flood damage. However, achievements were much more modest in the areas of environmental preservation and water quality conservation. Due to rapid economic growth and current material consumption, the past few decades have brought transformation of nature and culture in and around Lake Biwa. Despite active efforts to protect the environment, the lake is constantly plagued with problems such as foul odors from tap water, freshwater red tides, outbreaks of aoko water blooms, and the displacement of native species by a proliferation of introduced species. Around the lake, there are worrisome developments, such as the deterioration of the natural environment and scenic landscapes, including reduction in the area of reed beds, the attached lakes, shoreline forests, farmland, and upland forests, as well as the degradation of the natural water cycle.

Considering this situation, Lake Biwa Comprehensive Conservation Plan (Mother Lake 21) was compiled in 2000 to pass a healthy and bountiful lake to the next generation. Under a guiding principle “Symbiosis between Lake Biwa and the people”, it is to develop collaboration among local people, business entities and governments. The plan consists of three areas; 1) maintaining water quality, 2) improving the recharge capacity of the soil and 3) preserving the natural environment and scenic landscapes.

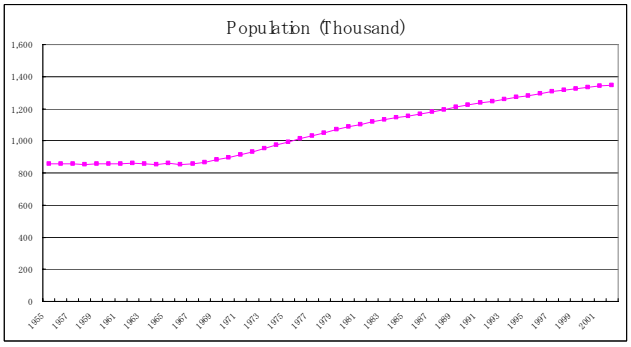

Fig.5 Population in Shiga Prefecture

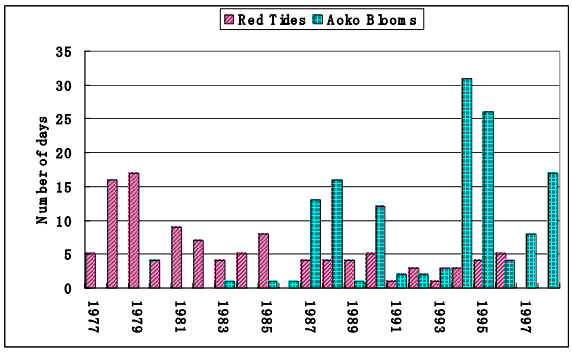

Fig.6 Water Condition in Lake Biwa

(2) Water Quality Conservation

So far, efforts to protect the quality of water in Lake Biwa have centered on point source discharges. Emphasis has been placed on wastewater treatment in the provision of sewerage systems and the issuing of effluent regulations from factories and work places. Nonetheless, the water quality of Lake Biwa has not improved. The reasons are complex, including changes in the structure of effluent runoff, increase in pollutant loads and the accumulation of nutrients in the lake.

In addition to continuing the current wastewater treatment strategy, introducing new technologies to upgrade the standards of treatment, we will tackle non-point sources. Our goal is coverage of 100% in domestic wastewater treatment by the year 2010. To do so, we intend to promote more efficient and effective uses of various facilities such as off-site system; sewerage and on-site system; purification tank, considering their characters and local conditions.

Table 2 Objectives in the Mother Lake21 Plan

Area	First Stage Objectives (Year 1999 to 2010)	Second Stage Objectives (Until Year 2020)	Desired State (Until Year 2050)
Maintaining Water Quality	Restore the influent load to that of the late 1960s	Return water quality to the level before malodorous tap water, freshwater red tides and the blue-green algae began to be commonly observed in the late 1960s	Water quality returned to the level of the late 1950s
Improving the Recharge Capacity of Soil	Secure an adequate area of forests and farmland for rainfall infiltration	Improve the rainfall infiltration and hold capacity of forests and farmland	Living together with forests to make full use of the natural water cycle
Preserving the Natural Environment and Scenic Landscapes	Secure strategic points for creation of networks to be linked with biotopes	Establish a framework of biotope networks	Lake Biwa that presents beautiful and unique scenery in all four seasons, containing a variety of living creatures in a rich natural ecosystem that preserves the environment of the lake

Table 3 Water Quality in the Mother Lake21 Plan

	COD	Total Nitrogen	Total Phosphorus
Environmental Quality Standards	1.0 mg/L	0.2 mg/L	0.01 mg/L
Southern Lake (Year 2002)	3.3 mg/L	0.34 mg/L	0.018 mg/L
(Late 1960s)	2.0 mg/L	0.28 mg/L	0.016 mg/L
Northern Lake (Year 2002)	2.7 mg/L	0.25 mg/L	0.008 mg/L
(Late 1960s)	1.8 mg/L	0.22 mg/L	Current Situation

The current shares of non-point source loadings flowing into Lake Biwa, from other land uses and nature as well as agriculture, remain at 47% of COD, 55% of total nitrogen, and 32% of total phosphorous. Therefore we will promote measures to maintain water quality in agricultural areas, while launching full-scale measures aimed at cutting the load from urban areas.

Agriculture authorities intend

Fig.7 Outbreak of Aoko Water Bloom

to promote “environmentally conscious agriculture (ECA)”. ECA refers to agricultural practices in which the use of chemical inputs is reduced more than ordinal practices, organic quality materials are properly used, and water discharge from farms is properly managed. Agricultural products can be labeled as ECA Products if they are produced be using chemical inputs of which the quantity is smaller than that used in the codes of practices by 50% or more and by reducing negative impact on Lake Biwa and environment. To do so, Shiga prefecture provides farmers with financial incentives based on contracts between the Governor and farmers for implementing ECA.

River authorities intend to implement some river purification projects, including removing sludge from lake bottom and controlling pollution loads from inflowing rivers. When the water level is normal, river water will be purified by aquatic plants such as reeds (vegetation purification) in lagoon areas, in consideration of the lakeshore ecosystem as well as landscape. At the initial stage of flooding, river water is temporarily held in a detention pond to settle pollutants and discharge only supernatant. At the later flood stages, pollutants are naturally settled in the lagoon (flow settlement) to reduce pollution inflow to the lake.

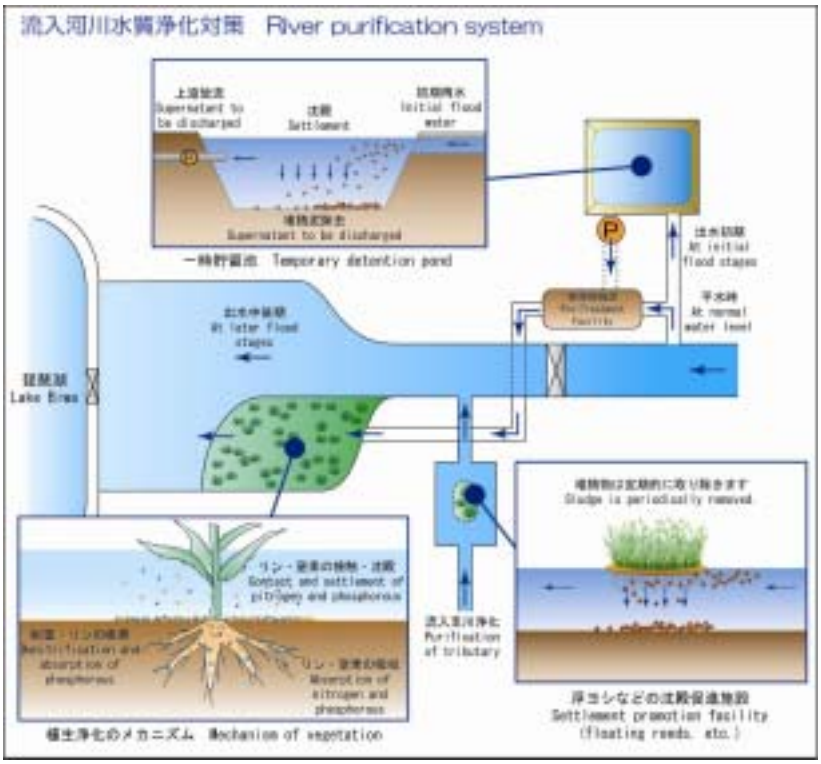

Fig.8 River Purification System

4. Sewerage Development

(1)Ultra Advanced Wastewater

In order to prevent the further eutrophication of Lake Biwa, we have adopted an advanced treatment process in wastewater treatment plants to remove both nitrogen and phosphorus. However, the portion of the pollution load flowing into Lake Biwa from the plants is increasing in line with the expansion of the sewer coverage. We are now introducing “ultra advanced treatment”. The ultra advanced process consists of removing total nitrogen, total phosphorus and COD. For removing total nitrogen, we has begun to adopt a stem inflow multi-stage nitrification denitrication process in newly constructed facilities, which showed a success in achieving target quality. The metallic salt coagulants (PAC) are now added at the end of the biological reaction tank to remove phosphorus. In addition, coagulants will be added before the sand filtration for further removal. Currently COD is removed biological process and sand filter. Since biologically undegradable components can not be removed by the above processes, we decided to adopt a physico-chemical treatment process based on a combined process of ozonization and biological activated carbon treatment. Experiments are being carried out at a pilot plant (design capacity 6,500m^3/day) to establish maintenance/operation method and confirm cost from this year.

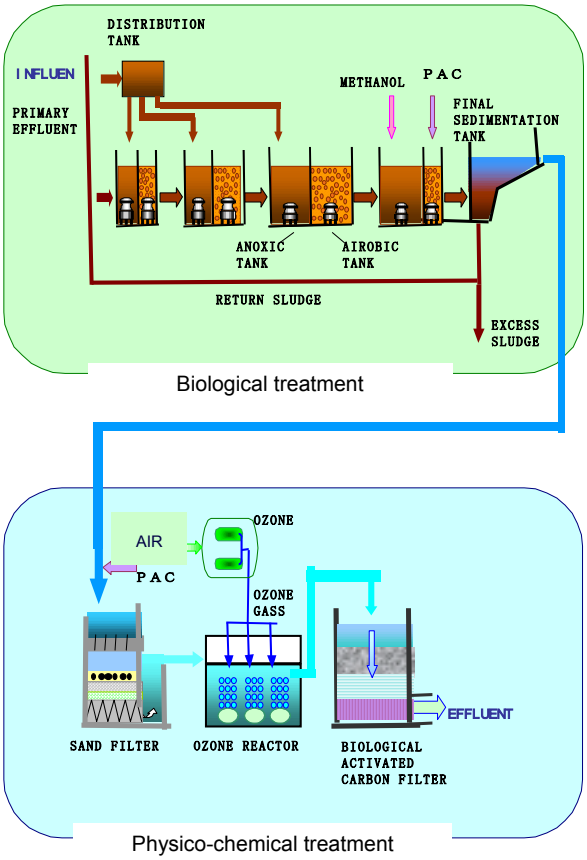

Fig.9 Ultra Advanced Treatment

	COD	T-N	T-P
current	6mg/l	6mg/l	0.05mg/l
target	3mg/l	3mg/l	0.02mg/l

(2)Purification of storm water in urban areas

In sewerage sector, we intend to tackle non-point source loadings, especially urban runoff. Urban drainage purification facility to treat storm water in Yamadera river basin was constructed last September. Drainage area (80 ha) is located in Kusatsu, collecting first flush of rainfall (6mm). This facility consists of storage, sedimentation, contact oxidation, vegetation purification and soil purification. The sludge generated in storage and sedimentation tank is discharged to the wastewater treatment plant through a sanitary sewer.

Fig.10 Yamadera Purification Facilty

Neighboring citizens are involved in this project from planning stage. A council by the citizens, scholars and civil servants was set up to investigate the design. Currently vegetation purification facility is maintained by the citizens, and this facility will be utilized as public environment education.

Table 4 Overview of Yamadera Purification Facility

Design Influent Quality (Removal Ratio)	COD	12 mg/l (70%)
	T-N	4 mg/l (70%, in Winter 40%)
	T-P	1.2 mg/l (80%)
Facilities	Storage and Sedimentation	5tanks W12 m x L24 m x H 4.5 m Volume: 7,200 m^3
	Contact Oxidation	3tanks W0.5 m x L144 m x H1.2 m
	Vegetation purification (Hydroponics type, Filter media type)	4ponds W7m x L20 m x H0.5 m 2ponds W9m x L20 m x H0.5 m 16channel W1m x L25 m x H0.6 m Plants: Watercress, Mint, etc
	Soil purification	4tanks W10 m x L20 m x H1.6 m Filter media: Akadama Soil

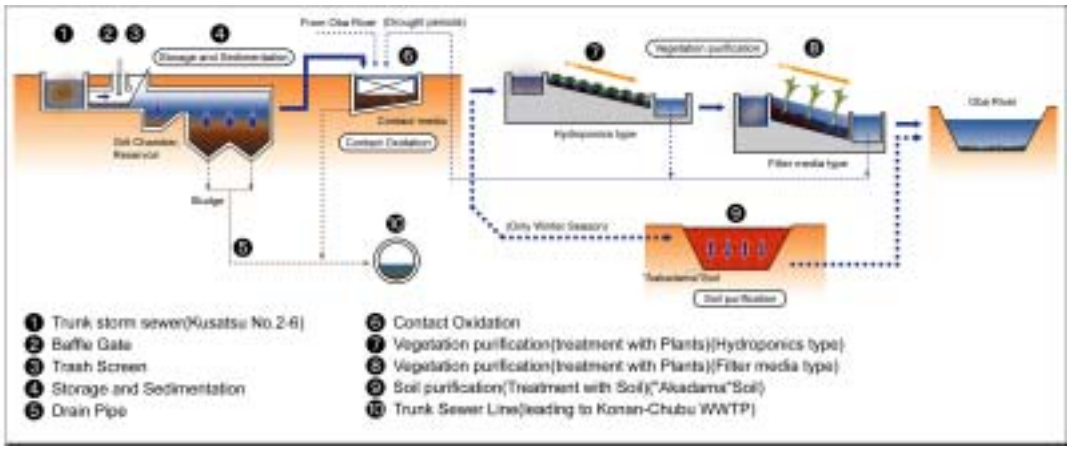

Fig.11 Flowchart of Facility

Table 5 Descriptions and Design Removal Ratio of Each Facility

		Storage and Sedimentation	Contact Oxidation	Vegetation purification		Soil purification	Total
				Hydroponics	Filter media		
Effective depth		4.0m	1.0m	0.05m	0.2m	1.0m	
Volume of flow		$10m^3/s$	$640m^3$/day/tank	$320m^3$/day/pond	$120m^3$/day/channel	$75m^3$/day/tank	
Retention time		12hours	2hours	40minutes	60minutes	24hours	
Design Removal Ratio(%)	COD	45 (45)	30 (-)	30 (-)		- (50)	70 (70)
	T-N	40 (40)	20 (-)	30 (-)		- (-)	70 (40)
	T-P	55 (55)	20 (-)	35 (-)		- (50)	80 (80)

( ) winter season

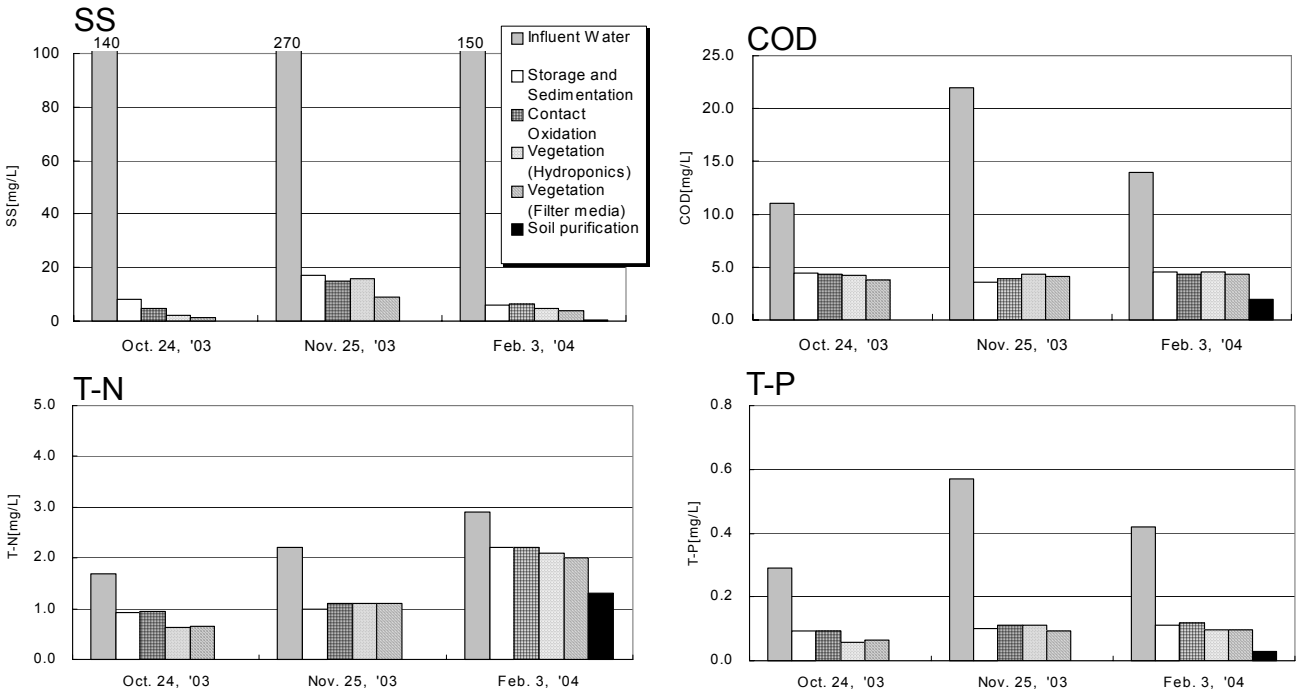

Fig.12 Results of Monitoring (Removal Efficiency)

Table 6 Results of Monitoring

		SS	COD	T-N	T-P
Influent Water (mg/l)	Max.	270	22.0	4.10	0.570
	Min.	10	4.1	0.95	0.065
	Ave.	112	11.0	2.16	0.288
Treated Water (mg/l)	Max.	9.0	4.1	1.30	0.098
	Min.	0.6	2.0	0.66	0.030
	Ave.	3.8	3.2	0.99	0.061
Removal Ratio (%)		97	71	54	79

Monitoring was conducted from September to March, 2003 to clarify removal ratio. Descriptions and design removal ratio of each facility are summarized in table 5. Results of monitoring is Fig.12, Table 6. Compared to design, the ratio for COD is satisfied, but those for T-N and T-P are less than expected. In winter, soil purification is utilized, considering the low purification ability of vegetation. Since this monitoring is based on only six cases, further cases are necessary to be monitored on various rainfall patterns and seasons.

5. Conclusion

Due to recent drastic change related to infrastructure development, such as severe financial difficulties and globalization, the efficiency, cooperation among each sector, accountability and public involvement in public works are required. Therefore it is essential to not only provide citizens with relevant information but also think most of public opinions in the sewerage strategies including development plans and the cost sharing. In March 2003, the third World Water Forum was held in Kyoto, Shiga and Osaka to clarify concrete actions for addressing global water problems. In the Ministerial Declaration titled “Message from the Lake Biwa and Yodo River Basin”, the five themes mentioned to be resolved begin with “Water Resources Management and Benefit Sharing”. In short, it clearly declares that all stakeholders should be participated in the process of developing integrated water resources management and water efficiency plans.

Measures to conserve Lake Biwa, the vital water source for the Kinki region, should be considered in the context of the watershed management. In other words, considerations should be taken not only for the surrounding area of the lake but also for its downstream areas. We think that it is necessary to decide how to develop wastewater management, including advanced wastewater treatment and non-point sources loads control, from the broad viewpoint of the Lake Biwa and the Yodo River Basin, taking public opinions into account.

References

1) Organizing Committee of the 9th International Conference on the Conservation and Management of Lakes (2001), Society and the Water Environment of Lake Biwa and the Yodo River Basin
2) Shiga Prefecture (2000), Mother Lake 21 Plan
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4) Shiga Prefecture (2001), Lake Biwa Sewerage System

Wastewater Management in the Lake Biwa Basin

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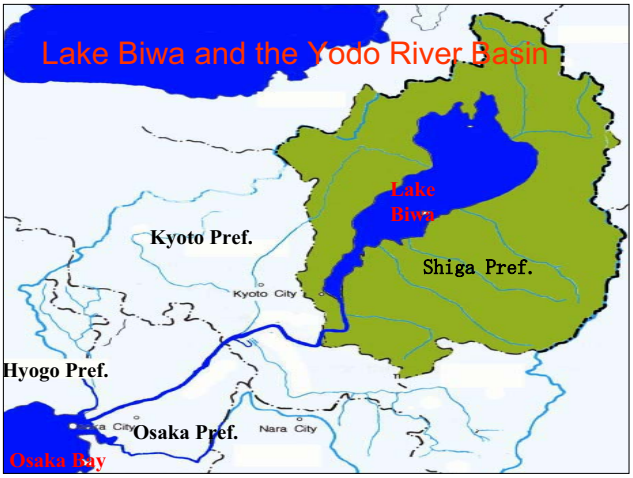
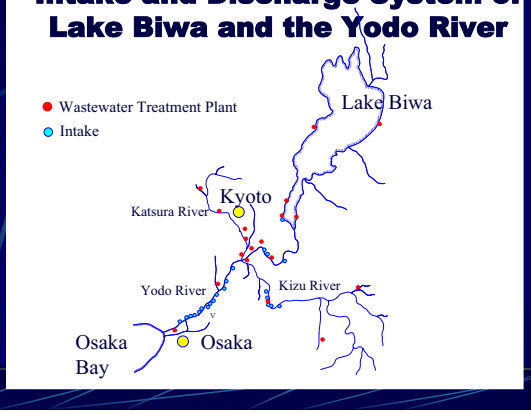
Lake Biwa and the Yodo River Basin



Intake and Discharge System of Lake Biwa and the Yodo River



Overview of Lake Biwa

- One of the most ancient lakes in world
- More than 1,000 species (includ.50 endemic ones)
- Inflows: About 460 Rivers
- Outflows :Seta River / Man-Made Canal
- Water Source for 14 million people in Kinki region

Lake Biwa Comprehensive Development Project

Objective: Develop additional Water Resource for downstream

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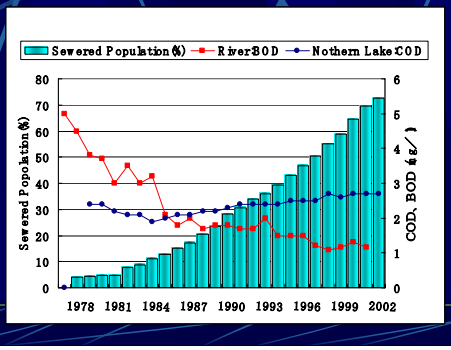
Integrated Water Resource Development Project

- Conservation of Natural Environment / Water Quality
- Flood Control
- Water Utilization

Effect of Sewage Works Development



Lake Biwa Comprehensive Conservation Plan (Mother Lake 21)

Rapid Economic Growth / Material Consumption

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Deterioration of Natural Environment, Scenic Landscapes and Natural Water Cycle

Lake Biwa Comprehensive Conservation Plan (Mother Lake 21)

- Pass sound environment on to next generation
- Symbiosis between Lake Biwa and People

Sector

Water Quality

Recharge Capacity of Soil

Natural Environment / Scenic Landscapes

Collaboration

Local People

Business

Governments

Lake Biwa Comprehensive Conservation Plan (Mother Lake 21)

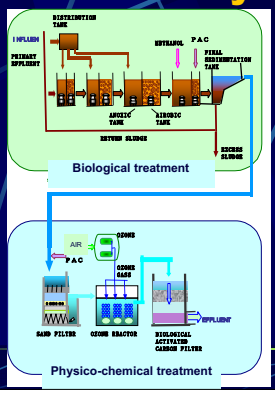
(mg/l)	COD	T-N	T-P
Environmental Standard	1.0	0.20	0.010
Southern Lake (2002) (the late 1960s)	3.3	0.34	0.018
	2.0	0.28	0.016
Northern Lake (2002) (the late 1960s)	2.7	0.25	0.008
	1.8	0.22	Current

First Stage(～2010):Influent Load in Late 1960s
Second Stage（～2020）: Water Quality in late 1960s
Desired State（～2050）: Water Quality in late 1950s

Lake Biwa Comprehensive Conservation Plan (Mother Lake 21)

- ○100% Coverage : Wastewater Treatment
  Efficient and Effective uses of off-site and on-site system
- ○Introduction of Ultra Advanced Treatment System
- ○Measures against Nonpoint sources
  - ・Agriculture Sector
  - ・River Environment Improvement
  - ・Urban Drainage Purification

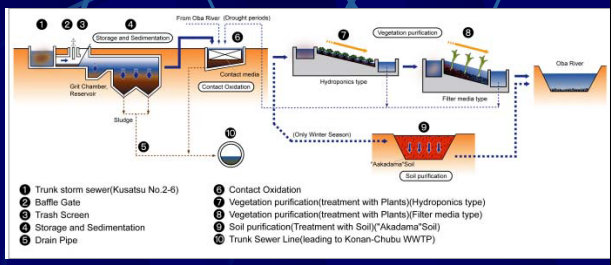
Ultra Advanced Treatment System



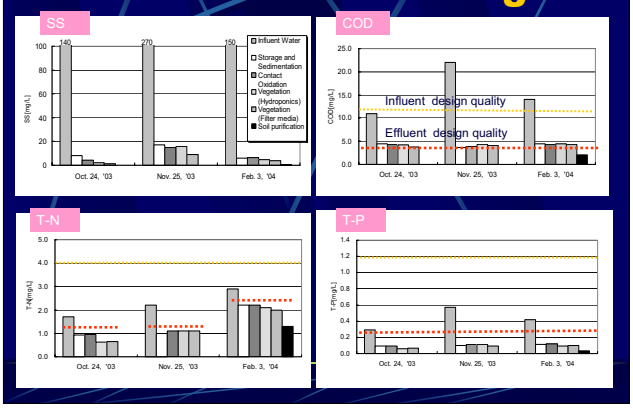
mg/l	COD	T-N	T-P
current	6	6	0.05
target	3	3	0.02

Urban Drainage Purification Facility

Flowchart of Facility



Result of Monitoring



Removal Ratio

	SS	COD	T-N	T-P
Influent Water (mg/l)	112	11 (12)	2.16 (4)	0.288 (1.2)
Treated Water (mg/l)	3.8	3.2 (3.4)	0.99 (1.3～2.4)	0.061 (0.27)
Removal Ratio(%)	97	71 (70)	54 (40～70)	79 (80)

( ) Design figure


Conclusion
○Strict Budget/ Globalization
○Efficiency/Cooperation
○Accountability/P.I
○3rd World WaterForum
「Water Resources Management」
○Lake Biwa：Vital Water Source for Kinki Region
●Developing wastewater management
From viewpoint of watershed and citizen