2006 Prize of the Chairman of ECCJ

Reduction of Electricity used by Blast Equipment at Sewage Plant

Osaka City, City Environment Bureau, Northern District Management Office
Ebie Sewage Treatment Plant

◎ **Keywords: Rationalization of conversion of electrical energy to motive power, heat, etc.**

◎ Outline of Theme

While sewage plants contribute to water quality preservation of public waters, it is also true that they use a great deal of energy for sewage treatment and give an environmental burden. The sewage plants set up blast equipment for supplying oxygen which is necessary for sewage purification, and the power consumption of the blast equipment accounts for 50% of the total power consumption of the sewage plants as a whole. Therefore, to realize energy conservation, it is important to cut the electricity used by the blast equipment. We could cut the power consumption of our plant by approximately 10% by building an unprecedented operating standard, while maintaining the sewage purification.

◎ Implementation Period for the Said Example

September 2005 –

- Project Planning Period　August 2005 – September 2005　Total 2 months
- Measures Implementation Period　September 2005 –
- Measures Effect Verification Period　October 2005 – July 2006　Total 10 months

◎ Outline of the Business Establishment

- Business Type　Sewage
- No. of Employees　55
- Annual Energy Usage Amount (Actual results for fiscal year 2005)
  - Heavy oil　69,200 L
  - Electricity　24,771 MWh

◎ Process Flow of Target Facility

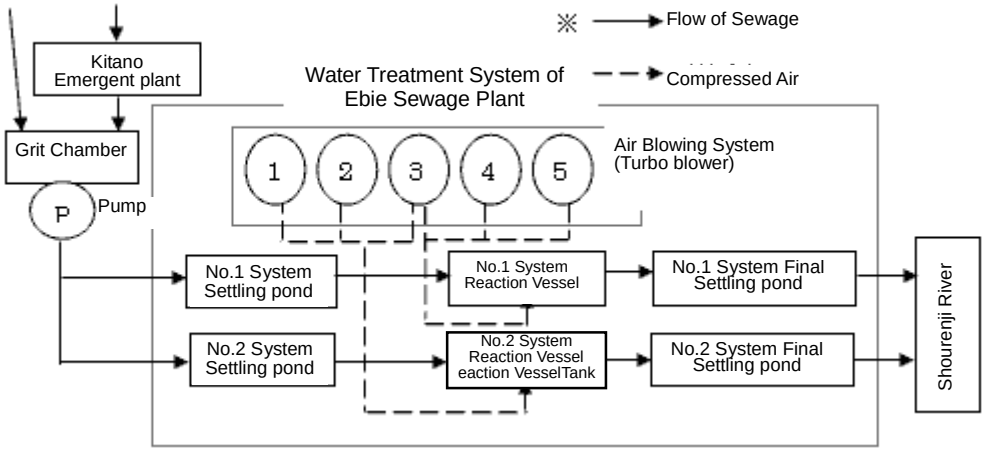


Fig. 1 Flow of Target Equipment

1. Reasons for Theme Selection

The sewage plant is a water treatment facility for treating sewage discharged from houses, etc. and discharging the treated water to public waters such as rivers, sea area, etc. While it contributes to water quality preservation of public waters, it is also true that the plant gives environmental burden by the use of energy for its business.

A sewage plant has blast equipment which supply oxygen necessary for treating the sewage, and our Ebie Sewage Plant used to constantly operate 3 turbo blowers of 460 kW rated output to send 1.2 million m^3 compressed air a day to the reaction tanks. The electricity used by the blowers accounted for 50% of the total electricity used by the plant as a whole, so it was pressing issue for us to cut the electricity of the blast equipments to realize energy conservation. However, if we simply reduce the air volume of the turbo blowers, there was fear of worsening the quality of the water treated. So we had to manage the system from comprehensive perspective to realize the energy conservation while maintaining the water quality.

We had been improving the equipment to send the air efficiently before implementing the measures hereunder, but there was limitation with the operation so far we have been doing for proceeding further energy conservation. So from a new point of view, we tried to build an unprecedented operating standard which enables us to achieve energy conservation operation of the blast equipments while maintaining the sewage purification.

2. Understanding and Analysis of Current Situation

Fig. 2 shows the balance of BOD (biochemical oxygen demand) in Ebie Sewage Plant. The BOD means the amount of organic pollutant in water and it is widely used as pollution indicators of rivers, etc. As the figure shows, this plant removes 90% or more of the organic pollutant in the sewage but on the other side it consumes 72,200 kWh electricity a day. Besides, it is requested to remove nitrogen and phosphorus too as the cause of eutrophication in recent years, so it became necessary for us to do further efficient operation management.

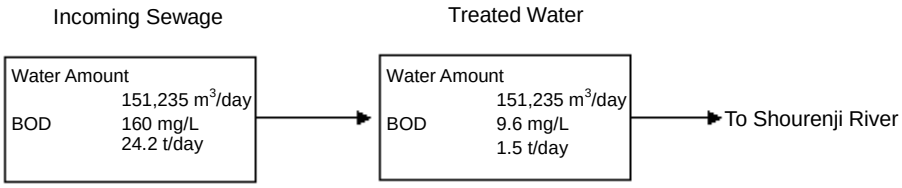
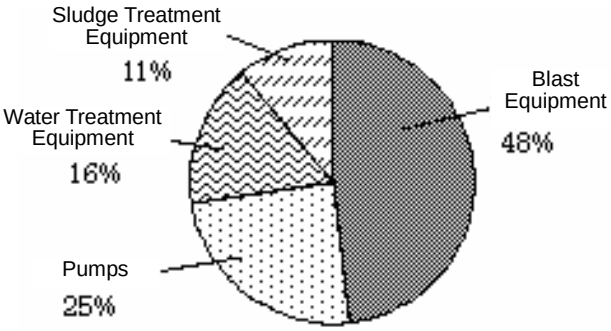


Fig. 2 BOD Balance of the Water Treatment Plant (FY2004)

Fig. 3 shows the breakdown of the power consumption, where the power consumption of the blast equipment accounts for approx. 50% of the whole. To reduce the electricity amount of the plant as a whole, it is effective to cut the electricity of the blast equipment.

The electricity used by the pumps is mainly the electricity for the water treatment facility which includes the electricity used by the water treatment equipments and by the office. The electricity used by the sludge treatment facility is the electricity used by the equipment which is used for reducing the sludge amount generated from the sewage treating process.



	Electricity Amount Used
Air BlastEquipment	34,758 kWh/day
Pumps	17,654 kWh/day
Water Treatment Equipment	11,853 kWh/day
Sludge Treatment Equipment	7,989 kWh/day
Total	72,254 kWh/day

Fig. 3 Breakdown of Electricity used by Ebie Sewage Plant (FY2004)

3. Progress of Activities

(1) Implementation Structure

As the improvement activities were supposed to involve the operation of the pumps and blast equipment, and as it was necessary to take water and analyze its quality at night, etc, we studied the new operation method communicating with each monitor room of the operation management group. Besides, we communicated with Kitano Emergent Plant which was sending sewage to Ebie Sewage Plant to do the activities across the Treatment Plant Area as a whole.

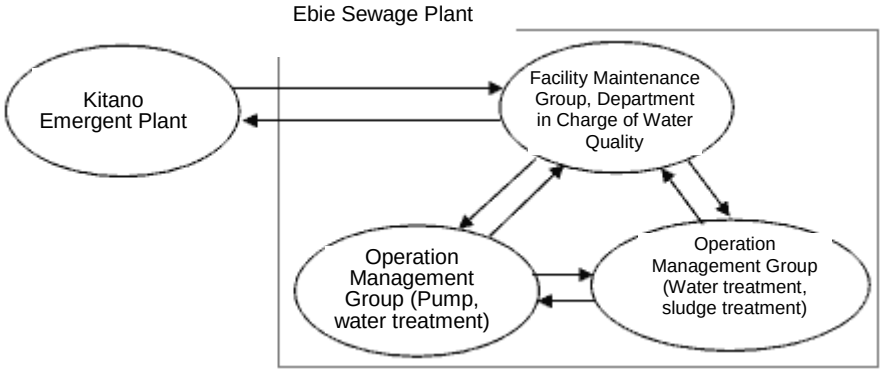


Fig. 4 Program Structure

(2) Target Settings

We set up a target which aimed to reduce the use of the electricity by lessening the number of turbo blowers operated from 3 to 2, while maintaining the sewage purification.

(3) Problem Points and their Investigation

The amount of the sewage flowing into the sewer varies between daytime and night corresponding to the social and production activities and the pumps of the sewage plant are operated linking to the change of the sewage amount. So the maximum carried water amount is approximately twice the minimum amount, as Fig. 5 shows. Also, the water quality of incoming sewage similarly changes, i.e. when the water flow is much, the water with high organic pollutant density etc flows in and when the water flow is less, the water with low pollutant etc density is low flows in. Therefore, the change of the pollutant amount is bigger than the change of the water flow. 3 units of the turbo blowers had been operated all day regardless of the change of the pollutant amount so that the plant could treat the water stably even if the pollutant amount becomes the maximum.

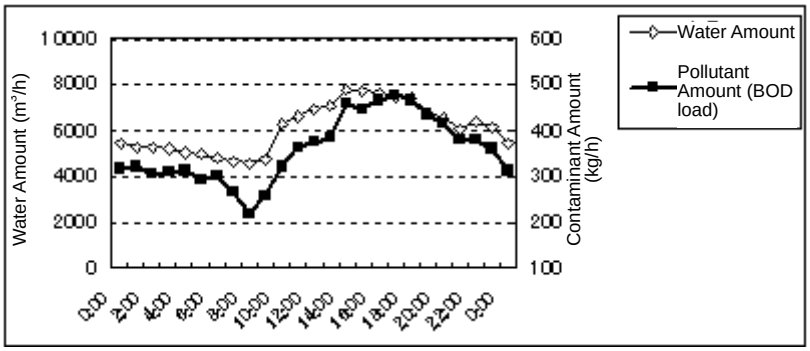


Fig. 5 Transition of Water Amount and Pollutant Amount of the Incoming Sewage

Fig. 6 shows the overview of reaction vessel. The reaction vessel is the facility for treating organic substance, nitrogen, phosphorus, etc. in the sewage mainly biologically and it is the base of the sewage plant. In the reaction vessel, the pollutant in the sewage such as organic substances is removed by microbes which take the organic substances as their nutrition source. By sending air into the liquid mixing the microbes and the sewage, the microbes become active and the organic substances are removed. Thus, the sewage is treated if the microbes, oxygen and organic substances as nutrition are properly mixed in the reaction vessel.

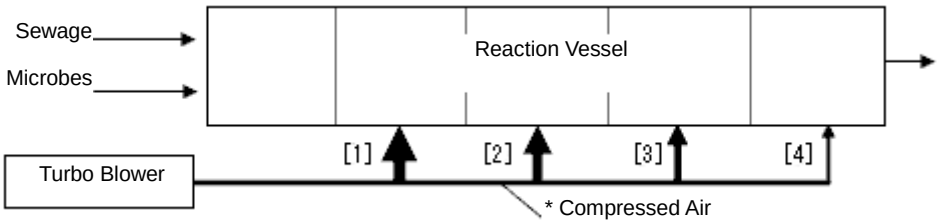


Fig. 6 Overview of Reaction Vessel

The time passing the sewage flows in and flows out the reaction vessel is approx. 8 hours in case of Ebie Sewage Plant,. The oxygen consumption in the vessel is high at the entrance and becomes low as it goes toward the exit. So to make the maximum use of the turbo blower's air volume, we studied the distribution order of the air volume making of [1] > [2] > [3] > [4] (Fig. 6). It was also necessary to adjust the entire air volume by watching the dissolved oxygen meter installed at the exit of the reaction vessel making the dissolved oxygen level of the last section of the reaction vessel correct.

However, there was a problem to be solved, i.e. the quantity and quality of the incoming sewage changes as time passes. It takes the sewage 8 hours to go out of the vessel after

entering and being treated there. During the hours, new sewage of different quality flows into the reaction vessel, so the oxygen amount consumed in sections [1] to [4] of Fig. 6 changes as time passes. Therefore, even if the dissolved oxygen density at the last section of the reaction vessel is correct, it might be occur that the density in the section [1] is insufficient. So it was necessary to operate 3 turbo blowers even when the load was low.

Then, we thought it must be possible to use only 2 turbo blowers if we can transfer the pollutant of the peak time to the low load time at night to make even the change of the incoming sewage's quality and quantity caused by time and lessen the maximum amount of the pollutant coming into the reaction vessel, as shown in Fig. 7.

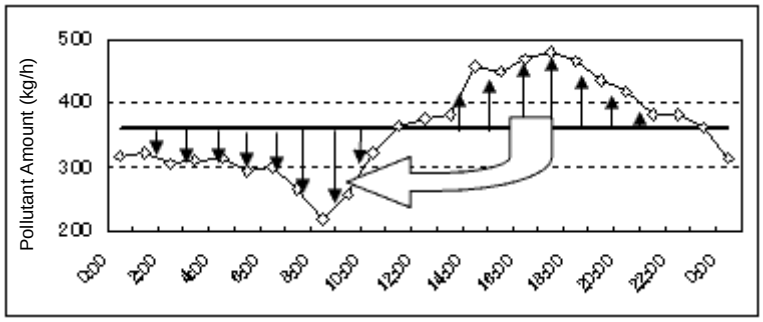


Fig. 7 Making Pollutant Amount Even (Outline)

4. Details of Measures

To make the pressure loss less and air blow efficient, we had made improvement of the facility, which included [1] changing of the check valve at the turbo blower's discharging side to that of the weight type which could make the pressure loss less, [2] installation of a drain pipe to remove the water from the air blow pipe and [3] periodic washing of air discharge port with a high pressure jetter.

In addition to these improvements, to implement the measures studied as mentioned above, we studied the new way to operate the water feeding pump which could make the pollutant amount going into the sewage treatment facilities constant by temporarily storing the sewage of the peak time. To be more specific, it intended to temporarily store the peak sewage in the grit chamber and in the arterial inflow in daytime and send the water thus stored in the low load time of night, as Fig. 8 shows.

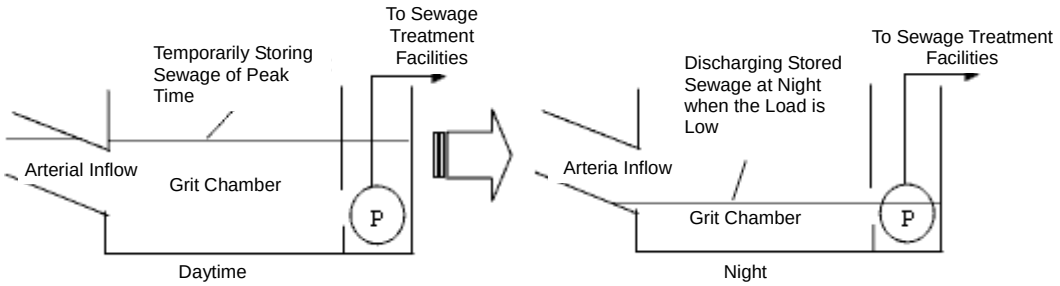


Fig. 8 Outline of Sewage Sending with Constant Pollutant Amount

As shown above, it is possible to make the pollutant amount sent to the sewage treatment facilities constant by changing the water level of the grit chamber. However, the grit chamber is an important facility which lets the soil, sand, gravels, etc. in the sewage settle and makes the sewage treatment smooth. Practically, if the water level is raised too much, the flow becomes slow not only letting sludge or decaying organic matter easily settle but also soil, sand, etc. easily deposit in the sewage pipe. To the contrary, if the water level becomes too low, the flow becomes fast, so the soil, sand etc. flows into the sewage treatment facility without being deposited in the grit chamber.

To solve this problem, we set the upper and lower limits of water level at the grit chamber as the new operation method, trying to make the pollutant amount constant within the range between the upper and lower limits. As regards the upper limit water level, the level was set at the upper limit level of the water level of the grit chamber at constant operation as is so that the likelihood of deposition of soil, sand, etc. in the sewage pipe or the risk of odor generation can be avoided. As regards the lower limit water level, the level was lowered by approx. 2.5 m from the conventional management water level of the grit chamber at constant operation. This level was adopted by knowing that soil, sand, etc. could not flow into the sewage treatment facility when the level is kept resulting from the analysis of the quality of the water flowing into the sewage treatment facility.

As Fig. 1 shows, there are two flows of the sewage in Ebie Sewage Plant, i.e. the sewage directly flowing into the plant as natural flow and the sewage flowing into the plant via the emergent plant. It is difficult to store entire sewage of the peak time only with the adjustment of water level of the grit chamber in Ebie Sewage Plant. So Kitano emergent plant which relays 40% of the sewage to Ebie Sewage Plant stored the sewage in its grit chamber and limited the flow to the Ebie Plant as much as possible. With this the pollutant amount of treating sewage became constant. Fig. 9 shows the water level of the grit chamber after implementing the measures.

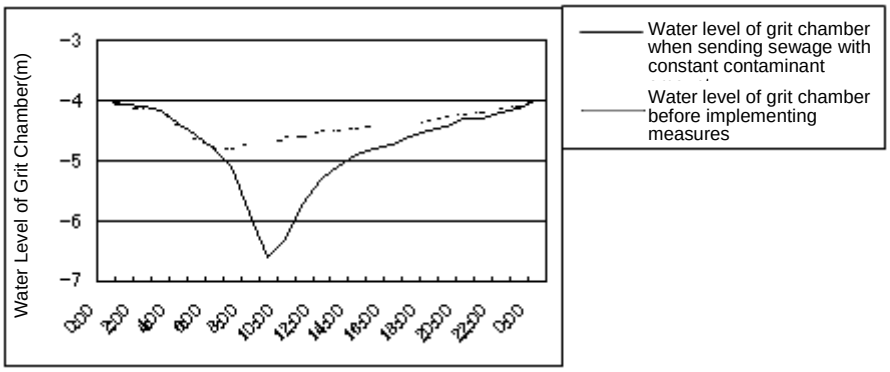


Fig. 9 Water Level Changing at Grit Chamber as Time Passes

5. Effects achieved after Implementing Measures

By sending the sewage to the sewage treatment facility with the pollutant amount constant, the time variation of the oxygen consumption in the sections [1] to [4] in Fig. 6 became less, and the dissolved oxygen density at the exit of the reaction vessel when operating 2 turbo blowers became stable for 24 hours. Before this improvement, 3 turbo blowers had always been operated to stabilize the treatment of the peak time, and when the dissolved oxygen density became high at the exit of the reaction vessel, the air volume had been adjusted by aperture operation of blowers. As we could make the pollutant amount sent to the sewage treatment facility constant, it became possible to operate 2 turbo blowers at their highest efficiency while stopping one blower.

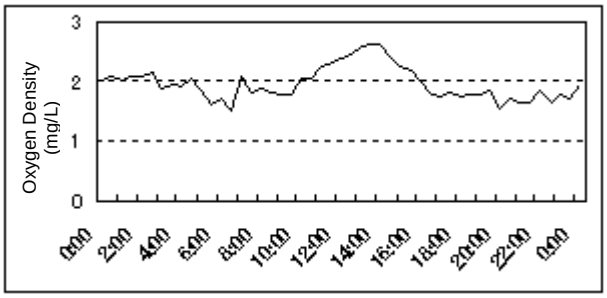


Fig. 10 Oxygen Density at the Exit of the Reaction Vessel when Operating with Constant Air Volume

Table 1 shows the breakdown of the power consumption during the period from October, 2005 to July, 2006 when the measures were implemented and that of the same period of the year before implementing the measures. The power consumption by the air blow system was reduced by 4,322 kWh a day realizing the reduction rate of 12.5%. In the yearly basis, the electricity was reduced by 1,577 MWh, realizing the cost reduction of approx. 18 million

yen a year by the air blowing system alone. Fig. 11 shows the transition of the power consumption by Ebie Sewage Plant as a whole during the period from FY2004 up to July, FY2006.

Table 1 Breakdown of Electricity used before and after Implementing Measures

	Pump Equipment	Blast Equipment	Sludge Treatment Equipment	Water Treatment Equipment	Total
①October, FY2004 to July, FY2005 (Before implementing measures)	16,784 kWh/day	34,632 kWh/day	8,702 kWh/day	11,559 kWh/day	71,677 kWh/day
②October, FY2005 to July, FY2006 (After implementing measures)	16,923 kWh/day	30,310 kWh/day	7,733 kWh/day	10,410 kWh/day	65,375 kWh/day
②－①	+ 139 kWh/day	－ 4,322 kWh/day	－ 969 kWh/day	－ 1,149 kWh/day	－ 6,302 kWh/day

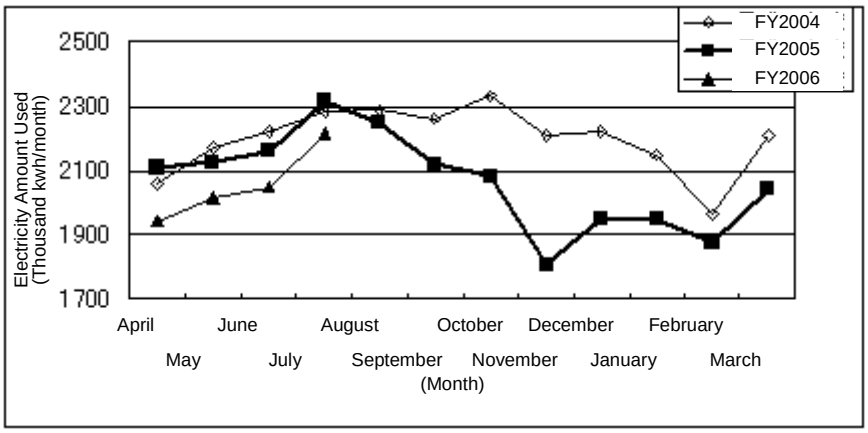


Fig. 11 Transition of Monthly Usage of Electricity (FY2004 and FY2005)

Table-2 shows the state of the sewage treatment before and after implementing the measures. It is noted that the sewage is being treated well even after cutting the power consumption by the blast equipment.

Table 2 State of Sewage Treatment before and after Implementing Measures

		Incoming Sewage	Treated Water
BOD	October, 2004 – July, 2005 (Before implementing measures)	172mg/L	10.4mg/L
	October, 2005 – July, 2006 (After implementing measures)	170mg/L	8.4mg/L
Total Nitrogen	October, 2004 – July, 2005 (Before implementing measures)	27.6mg/L	12.6mg/L
	October, 2005 – July, 2006 (After implementing measures)	27.4mg/L	11.6mg/L
Total Phosphorus	October, 2004 – July, 2005 (Before implementing measures)	3.2mg/L	0.39mg/L
	October, 2005 – July, 2006 (After implementing measures)	3.1mg/L	0.33mg/L

6. Summary

The state of the BOD, nitrogen and phosphorus in the sewage treated by Ebie Sewage Plans became slightly better after cutting the power consumption, so we could achieve 2 targets, i.e. to reduce the power consumption by the sewage treatment facility and to make the pollutant amount discharged less, alleviating the total environmental load. Meanwhile, as we achieved the targets by improving the operation method of existing facilities, we could create a big cost cut effect.

Meanwhile, we cannot forget the fact that the environment of our work place helped us achieve the targets, which includes the staff members of the work places knowing very well the quantity and quality of the incoming sewage which changes as time passes, and staff members well understanding the necessity of alleviating the total environmental load and their flexible way of thinking which quickly turns new ideas into action without being bound to generally accepted operation method.

7. Future Plans

Even with the operation method we established this time, which send the sewage making the pollutant amount constant, it is impossible to maintain the pollutant amount constant for 24 hours in the summer, because it is difficult to store all of the sewage of the peak time with the grit chamber and the arterial inflow in the summer when the quantity of the incoming sewage increases as the consumption of the city water increases. Also, the quantity of the incoming sewage greatly changes every day in the summer, so it becomes difficult to know the pump's water sending amount for maintaining the water level of the grit chamber which is necessary to store the sewage of the peak time. So we need to analyze and understand the daily pattern of the incoming sewage amount which changes every day and to establish an operation method for this season.

Meanwhile, as the sewer system of Osaka City is the confluence type, rain water flows into the facility in addition to the waste water such as living drainage if it rains. Therefore, when it rains, the quantity of the sewage increases and the electricity, fuel, chemicals, etc. necessary for treating the sewage also increase. It is necessary for us to find the way to reduce the pollutant amount in the discharged water when it rains, while maintaining the energy conservation operation.

We will continue to inhibit and reduce the use of energy by further energy conservation operation, etc. and establish sewage business which is friendly to the environment.