Examination of Operating Conditions for Improving Nitrogen and Phosphorus Treatment of Recycle Flow

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Abstract: Recycle flow, i.e., the effluents separated out from sewage sludge in the process of dewatering, contains high concentrations of nitrogen and phosphorus. To treat this recycle flow, the Yokohama Hokubu Sludge Treatment Plant newly introduced facilities utilizing the–Five-stage Bardenpho process in 2011. The facilities succeeded in controlling the treatment status for nitrogen at an early stage, but phosphorus treatment presented certain issues, and various efforts have been made to improve the treatment from startup of the facility to the present. These efforts succeeded in increasing the phosphorus removal rate to over 70 percent in 2016, and placed the treatment on stable footing. This paper reports on the results of an examination undertaken to reduce concentrations of nitrogen and phosphorus.

Key words: Recycle flow, Five-stage Bardenpho process, biological phosphorus removal

1. Centralized treatment of sewage sludge and introduction of facilities for recycle flow treatment

Yokohama has 11 wastewater treatment plants (WTPs). The sewage sludge derived at each of these plants is centrally treated at two sludge treatment plants (STPs) located in the northern and southern parts of the city. The sludge is sent to these plants through sludge transportation pipelines. After going through the processes of thickening, digestion, and dewatering, it is finally incinerated (Fig. 1). The recycle flow, i.e., the water separated out in the sludge thickening and dewatering processes, contain high concentrations of nitrogen and phosphorus. Because this recycle flow would be difficult to treat directly at the adjacent WTP, it had to be pretreated. In 2011, the Hokubu STP newly introduced facilities for recycle flow treatment by the Five-stage Bardenpho process, which replaced the previous pretreatment facilities applying the anaerobic-anoxic-oxic (A^2/O) process (Fig. 2). The treated recycle flow is sent to the Hokubu-Daini WTP, where it is blended with wastewater and treated again. This treated recycle flow accounts for about 10 % of the entire inflow into this plant, and the load on it depends largely on the status of recycle flow treatment. For this reason, it is important to remove nitrogen and phosphorus by the new facilities.

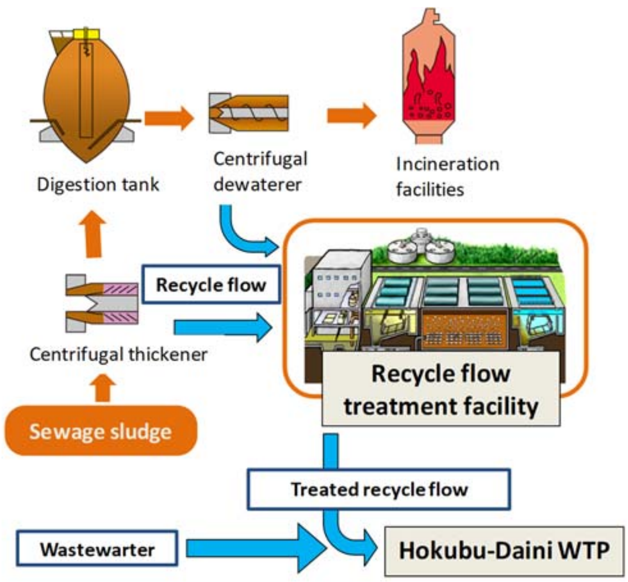

Fig.1. Sludge treatment and Recycle flow

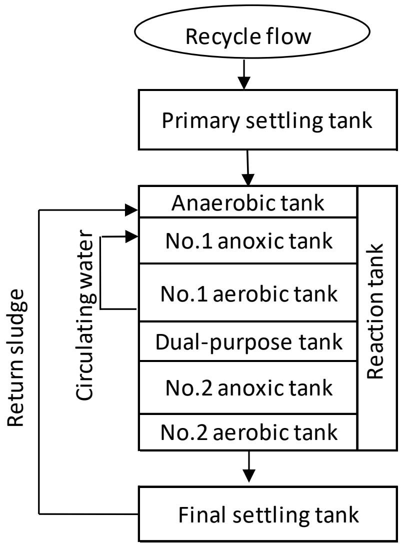

Fig.2. Outline of new recycle flow facilities

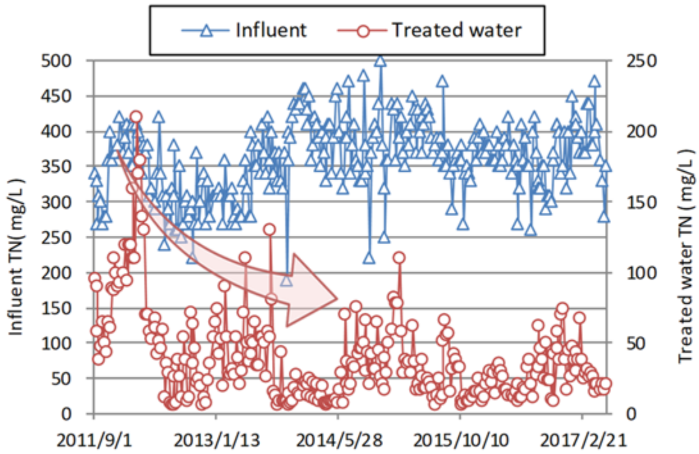

Fig.3. Total nitrogen concentration in the recycle flow treatment facilities

For the first two years after the startup of the facilities, we adjusted the treatment while searching for the optimal levels of activated sludge volume and aeration quantity. Up until the middle of 2013, nitrification often did not proceed smoothly because of the restriction on the number of blowers that could be operated. Thereafter, however, it could blow at the maximum amount of aeration. This improved the nitrogen treatment and reduced any significant worsening of treatment depending on seasonal fluctuation (Fig. 3). As for phosphorus, it took considerable time to stabilize the treatment, partly because of the extremely high concentration in the recycle flow influent water. Because nitrogen and phosphorus require mutually opposed treatment, the promotion of nitrogen removal initially cause the decline of phosphorus removal, and the we experienced difficulties in efforts to find the proper treatment balance. Various approaches were taken to promote removal of phosphorus as well while maintaining the nitrogen treatment. In 2016, the treated recycle flow had a concentration of 26 mg/l for phosphorus and 28 mg/l for nitrogen. These represented removal rates of 74 and 92 %, respectively (Fig. 4).

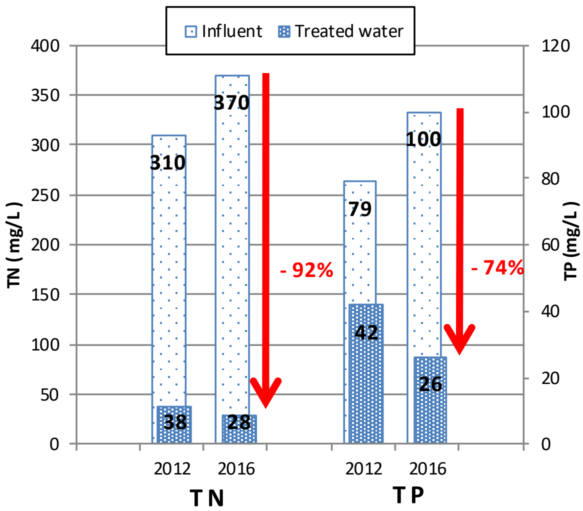

Fig.4. Comparison of nitrogen and phosphorus concentration 2012 and 2016

2. Approaches to improvement of phosphorus removal

The recycle flow treatment facilities simultaneously perform biological removal of phosphorus and removal with the addition of coagulant (polyaluminium chloride, PAC) to supplement the biological removal. Biological removal applies the mechanism that polyphosphate-accumulating organisms (PAOs) release the phosphorus stored in their cells in the anaerobic tank and accumulate more phosphorus than they released in the aerobic tank. In addition, the phosphorus that can be removed in the aerobic tank rises in proportion with the amount of phosphorus released in the anaerobic tank. The release of phosphorus in the anaerobic tank requires organic matter. For this purpose, a part of sludge supplied from the dewaterer was put directly into the reaction tank, and use of the primary settling tank was suspended to deliberately increase the BOD of the influent water. Next, changes were made in the operating conditions such as amount of aeration and retention time in the aerobic tank, to examine situation enabling efficient accumulation of phosphorus in the aerobic tank. At first, much air was sent into the first cell of the No.1 aerobic tank in order to promote nitrification. Beginning in 2016, however, we limited the amount of aeration in the first cell of the No. 1 aerobic tank and used the dual-purpose tank (No.1 aerobic tank / No.2 anoxic tank), which had been used as the No. 2 anoxic tank to that point, as an aerobic tank. This change resulted in a decrease in the overall amount of air and consequently a slight suppression of nitrogen treatment, but the retention time in the aerobic tank was made longer, and this promoted the accumulation of phosphorus. Due to these approaches, the amount of phosphorus release in the anaerobic tank increased and brought a substantial increase in the amount of accumulation in the aerobic tank (Fig. 5). Biological removal of phosphorus, apart from the removal by PAC, also improved (Fig. 6). In addition, in 2016, more DO meters were newly installed in all cells of the aerobic tanks in order to make maintenance and operation more efficient. We consequently started DO control of aeration quantity in all cells. This capability for DO control in each cell made it possible to promote phosphorus treatment while adjusting the pace of nitrification. Besides improving phosphorus treatment, this is also having an effect for reducing power consumption by the decrease in the amount of aeration (Table. 1).

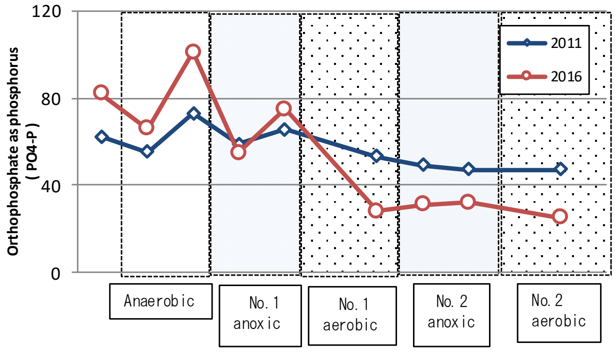

Fig.5. Release and accumulation of in each tank

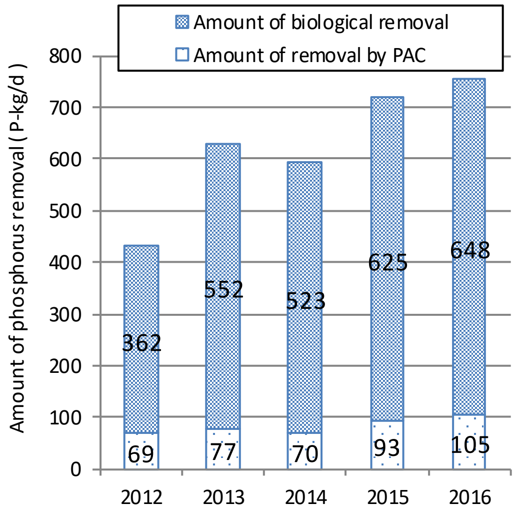

Fig.6. Amount of phosphorus removal

Table.1. Comparison of aeration air and removal amounts before and after increased DO meter installation

	Aeration air quantity (Sm3/d)	Amount of power received (kWh/d)	Amount of nitrogen removal (kg-N/d)	Amount of phosphorus removal (kg-P/d)
Before installation	497,663	22,286	3,584	718
After installation	453,402	21,230	3,451	753
Change	-8.9%	-4.7%	-3.7%	+4.9%

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