Studies of Biological or Physical Treatment and Water Quality in a Combined Sewer System in Wet Weather

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1. Introduction

In wet weather, huge amount of sewage water flows into combined sewer system (CSS) and sometimes excesses a capacity of the sewage treatment plant (STP) in CSS. In this case, to prevent failure of biological treatment system, excess sewage overflows from stormy outlet in CSS and/or is treated with settlement and bypasses biological treatment followed by disinfection in the STP. This causes deterioration of water quality in receiving water, sanitary hazard and toxicity on aquatic organisms.

In Japan, the Sewerage Law Enforcement Order was amended in 2003 and stipulated structural standard for combined sewer overflow (CSO). In the law, it is obligated to complete the improvement within 10 years (20 years for large cities) from FY2004 (MLIT, 2003). And the current improvement goals are to reduce overflow pollution loads, to reduce the frequency of discharge of untreated water and to reduce runoff of debris in wet weather. Japanese government led collaboration project (SPIRIT 21) among industry, government and academia from 2002 to 2004 to develop countermeasure technology for CSO. Developed technologies were categorized into six types: screen, high-rate filtration, coagulation, disinfection, monitoring techniques and retrofitted outfall chamber. These technologies can be effective for reduction of CSO and pollution load (e.g. BOD and phosphorus) derived from suspended solid (SS). These goals, however, only focus on solid materials like oil ball and organic matter discharged from sewage outfall.

Storage pipe system is also used in Japan as a stormwater storage and/or flood control facility, although it needs vast space and huge sum of money. More recently, the Manual for the Determination of Efficient and Emergency Improvement Plans for Combined Sewer System was announced (MLIT, 2008). In the manual, countermeasure to the important area, in where water is used for source of drinking water and recreation is active (e.g. Lake Biwa), was mentioned first time as well as cost effectiveness. In the manual, however, specific area and technical standards in terms of water quality were not set yet.

Recently developed techniques were mainly for the storage of huge amount of storm water and for removal of SS by additional facility not by modification of operational change except a few techniques (e.g. activated sludge process for wet weather wastewater: 3W treatment process applied in Osaka and Omuta City (Shiroi, 2006; Koga, 2006)). Furthermore, countermeasure and monitoring data are shortage in the important area. Ammonia in stormy wastewater interferes with disinfection effects and causes adverse effects of combined chlorine on ecosystems and drinking water sources.

From the above view point, we conducted several studies as follow:

1. monitoring of water qualities in fine and wet weather in a STP in CSS and an important area Lake Biwa
2. development of biological or physical sewage treatment for reducing ammonia and improve disinfection effects in wet weather

2. Investigation

2. 1. Wastewater quality monitoring

We conducted several surveys in a STP in CSS and in Lake Biwa in both fine and rain days to grasp time-trends and differences in water qualities. Plant influent, primary effluent, secondary effluent, and final effluent were collected and measured for several water quality parameters not only SS and BOD but also nitrogen, phosphate, and coli forms. Lake waters were also collected at a point close to outlet of the STP and outfall of the lake. As a result, some typical trends of water quality changes such as increased concentration of water quality parameters in the beginning of a rainy event (first flush) and dilution by storm water. Water quality characteristics were different between suspended and dissolved matters. The characteristics of suspended matters were represented by SS, while the dissolved matters were represented by $NH_4^{+-}N$. First flush was obviously observed the increased concentration of suspended matters (Uekado, 2007; Hinoue, 2010).

2.2. Biological treatment

To reduce $NH_4^{+-}N$ discharge during wet weather, a pilot scale reactor (three anoxic and three aerobic tanks, total volume is 540 L) experiment was conducted. The combination among aeration method in aerobic tanks, recirculation and return sludge quantity was investigated. The results show that nitrification in biological tanks was performed even in relative high influent volume by increasing in return sludge volume.

2.3. Physical treatment

We suggested a new treatment process reducing *E.coli*, SS and ammonium nitrogen in stormy wastewater in CSS during wet weather. The system consists of ceramic membrane. We conducted preliminary experiments of condensation/separation of activated sludge by ceramic membrane. As a result, SS and *E.coli* removals were observed. And TP was more than 98% removed at the same time. Through several trials, we optimized operation conditions, e.g. frequency of feed and permeate water pump and water volume of backwash in terms of permeate flux, TMP and MLSS concentration (Hinoue et al., 2011).

3. Acknowledgement

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4. References

Shiroi, (2006). Combined Sewer Improvement Plan in Osaka, Journal of Japan Sewage Works Association, Vol.43, No.528, Japan, p.24 -29.

Koga, (2006). Combined Sewer Improvement by Activated Sludge Process Method for Rainwater at South Area Combined Sewer Treatment Plant in Omuta, Journal of Japan Sewage Works Association, Vol.43, No.528, Japan, p.35-39.

Sewerage and Wastewater Management Department, City and Regional Development Bureau, Ministry of Land, Infrastructure, Transportation and Tourism, 2008 guideline of developing an efficiently urgent plan of combined sewer improvement, Japan

Furuya et.al, 2007 Study of Biological Treatment for Rainy Events in Advanced Treatment, Sewage Works Exhibition Journal, Japan, p. 577-579.

Uekado et.al, 2007 The Rainy Event Survey in a Combined Sewer Treatment Plant, Sewage Works Exhibition Journal, Japan, p. 580-582.

Hinoue et al., 2010, Impact of Combined Sewer Effluent on a Lake and River in Rainy Days, Proceedings of EICA 2010, pp. 117.

Hinoue et al., Preliminary Experiment of Combined Sewer Treatment by Ceramic Membrane, ASPIRE 2011 (submitted).