Wastewater Treatment in Moving-Bed Biofilm Reactor operated by Flow Reversal Intermittent Aeration System

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***Abstract*—**Intermittent aeration process can be easily applied on the existing activated sludge system and is highly reliable against the loading changes. It can be operated in a relatively simple way as well. Since the moving-bed biofilm reactor method processes pollutants by attaching and securing the microorganisms on the media, the process efficiency can be higher compared to the suspended growth biological treatment process, and can reduce the return of sludge. In this study, the existing intermittent aeration process with alternating flow being applied on the oxidation ditch is applied on the continuous flow stirred tank reactor with advantages from both processes, and we would like to develop the process to significantly reduce the return of sludge in the clarifier and to secure the reliable quality of treated water by adding the moving media. Corresponding process has the appropriate form as an infrastructure based on u- environment in future u- City and is expected to accelerate the implementation of u-Eco city in conjunction with city based services. The system being conducted in a laboratory scale has been operated in HRT 8hours except for the final clarifier and showed the removal efficiency of 97.7 %, 73.1 % and 9.4 % in organic matters, TN and TP, respectively with operating range of 4hour cycle on system SRT 10days. After adding the media, the removal efficiency of phosphorus showed a similar level compared to that before the addition, but the removal efficiency of nitrogen was improved by 7~10 %. In addition, the solids which were maintained in MLSS 1200~1400 at 25 % of media packing were attached all onto the media, which produced no sludge entering the clarifier. Therefore, the return of sludge is not needed any longer.

***Keywords*—**Municipal wastewater treatment, Biological nutrient removal, Alternating flow intermittent aeration system, Reversal flow intermittent aeration system, Moving-bed biofilm reactor, CFSTR, u-City, u-Eco city

I. INTRODUCTION

WATER supply and wastewater facilities are closely related to the standards of living and quality of life of citizens as city infrastructures. In particular, since the wastewater facilities affect directly the environment of water quality, the national government makes many efforts with different aspects to build the systematic system to manage it as well as to improve and enhance it in order to meet the processing power which the currently changing situation demands. As the global interest in the environment of water quality has been increasing, the regulations on standards for water quality has continuously enhanced to improve the low carbon green growth which is one of national business and the water quality of river in Korea [1]. Under this situation, as the national government recognizes the importance of ubiquitous environment which may lead the future society, the project of 'u- Korea' is established and the u-City construction project associating the ubiquitous environment with local governments has been promoted now [2]. The wastewater facilities as u-Environment-based infrastructure are associated with city-based services and are expected to increase the quality of life of citizens as well as to accelerate the implementation of u-Eco city [3] [4] [5].Upon installing the wastewater facilities to remove the organic matters and nutrient salts, the facilities should be excellent in adaptability to load changes and take less space and have the automated process to be selected. Until now, the intermittent aeration process secures the advantages mentioned before, but there are some big disadvantages in which it is very difficult to apply it on the existing process or to improve it since most processes target the oxidation ditch and need facilities related to selector, final clarifier and return of sludge and treated water. Biofilm process has been developed to increase the concentration of microorganisms in the aeration tank and to reduce the volume in the reactor. In particular, the moving- bed biofilm reactor (MBBR) developed by the Norwegian company, Kaldnes Miljoteknologi, does not need the return of sludge nor back washing. MBBR process has some advantages in which the treatment facilities can be improved to produce the economic benefits by reducing the solids load of existing secondary clarifier [6] [7] [8].Therefore, the purpose of this study is to develop the biological wastewater treatment process which can be effectively applied in the future u- City in which the existing intermittent aeration process with changing flow is applied onto the completely mixed reactor and mobile media is added to significantly reduce the return of clarifier as well as to secure the reliable quality of water and economic efficiency.Thus, this study has been conducted in a laboratory scale to examine the characteristics to remove the organic matters, nitrogen and phosphorus in a system before and after addition of media.

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II. Materials And Methods

In this study, once the existing intermittent aeration process with changing flow is applied to the completely mixed reactor in which front anaerobic reactor is removed, mobile media is added to convert it into the MBBR. The system consists of two intermittent aeration reactors and clarifier. The real volume of each reactor is 5.5 L and that of clarifier is 8 L and is made of acrylic resin. Outlet is installed as high as the effective height of water and the hydraulic gradient is made in the reactor and the clarifier to let the effluent flow into the clarifier naturally. The overall control such as influx into the system, the intermittent aeration reactor and opening and closing the valve is automatically done using PLC. The influent water uses the artificial wastewater and it is being operated under the condition for 8hours of HRT, 4 hours of Cycle time (An: Ox = 1.5: 2.5), 10days of SRT and 50 % return of sludge. In all the analysis, the effluent water run for 14 hours is targeted and experimental methods are in accordance with the water pollution process test in the Ministry of Environment. Media added into the reactor was BioCube of Kolon(Inc.) and characteristics are shown in Table I.

TABLE I
PHYSICAL CHARACTERISTICS OF THE PACKING MEDIA

Parameters	BioCube
Materials	Polyurethane
Specification (cm)	1.5 × 1.5 × 1.5
Volume (cm^3)	3.375
Weight (g)	0.14
Density (g/cm^3)	0.041
Porosity (%V/V)	95.1
Tensile strength (kgf/cm^2)	2.1
Tearing strength (kgf/cm)	1.2
Elongation percentage (%)	186
Image	

TABLE II
OVERALL PERFORMANCE RESULTS OF FLOW REVERSAL INTERMITTENT AERATION SYSTEM

Parameters	Results					
	Before conversion			After conversion into MBBR		
	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)
pH	6.5~8.1 (7.2)	7.2~8.4 (7.7)	-	6.7~8.0 (7.3)	7.1~8.1 (7.7)	-
Temperature (℃)	20~23 (21)	18~24 (21)	-	13~18 (16)	18~21 (20)	-
DO (mg/L)	0.2~7.8	4.7~6.8 (6.2)	-	0.1~8.2	4.2~6.6 (6.1)	-
Alkalinity (mg $CaCO_3$/L)	164~204 (187)	68~134 (107)	-	172~214 (193)	74~122 (110)	-
TCODcr (mg/L)	183~212 (198)	2.9~14.2 (7.5)	92.6~98.6 (96.2)	176~211 (192)	1.2~9.4 (4.6)	95.6~98.8 (97.7)
SCODcr (mg/L)	183~209 (197)	3.1~13.7 (7.2)	92.7~98.3 (96.3)	173~204 (188)	1.1~9.0 (4.5)	95.7~98.6 (97.6)
BOD_5 (mg/L)	143~162 (156)	5.1~19.5 (9.9)	88.0~95.8 (93.8)	143~170 (160)	6.6~11.5 (8.6)	91.5~97.2 (94.6)
TN (mg/L)	20.5~24.1 (22.2)	6.7~8.7 (7.6)	59.6~70.2 (65.2)	20.2~24.0 (22.3)	4.6~7.4 (6.0)	64.5~80.5 (73.1)
Ammonia (mg/L)	20.1~23.6 (21.9)	0~1.0 (0.2)	96~100 (99.4)	20.2~23.2 (22.0)	0~1.0 (0.2)	93~100 (99.1)
NO_3^--N (mg/L)	0~1.4 (0.3)	6.7~8.2 (7.4)	-	0~0.8 (0.3)	4.6~6.4 (5.8)	-
TP (mg/L)	4.6~6.3 (5.0)	4.2~5.0 (4.6)	3.8~15.0 (10.1)	4.2~5.8 (5.2)	4.0~5.2 (4.8)	6.8~11.0 (7.7)
PO_4^--P (mg/L)	4.6~5.3 (5.0)	4.3~4.9 (4.5)	5.1~12.8 (9.8)	4.2~5.7 (5.2)	3.8~4.9 (4.7)	6.5~10.6 (9.6)

minimum~maximum (average)

III. Result And Discussion

The removal efficiency is examined before the addition of media and after the conversion to MBBR. Before addition of media, the removal efficiency of organic matters, total nitrogen and total phosphorous are average 96.2 %, 65.2 % and 10.1 %, respectively. After conversion into MBBR with the addition of media, the removal efficiency is 97.7 %, 73.1 % and 7.7 %, respectively. Overall results from system operation are shown in Table 2.

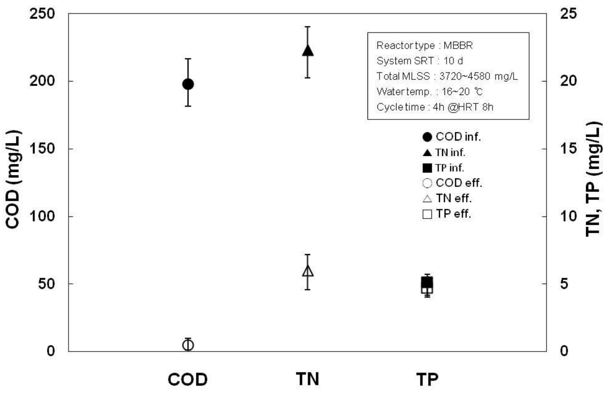

Fig. 1 Removal Efficiency COD, TN and TP

Upon looking at the a wastewater treatment removal efficiency of the system through Figure 1, the reliable quality of the effluent water and high treatment efficiency have been shown. Nitrogen is treated in 4~7 mg/L with range of 20~24 mg/L in influent water, which can remove the average 73 % of nitrogen. However, since there is almost no difference between the influent and effluent water in phosphorous, it implies that it is not treated correctly.

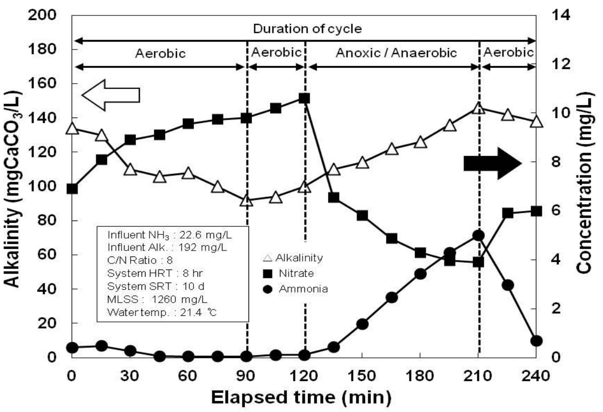

Fig. 2 Profiles of ammonia, nitrate and alkalinity during a cycle in a reactor of laboratory scale system at a SRT of 10 days

Looking at the internal behavior of nitrogen, generation and consumption of alkalinity are verified while the denitrification is being carried out based on phase transition. Due to this, the concentration of ammonia and nitrate are changed. The reason why the concentration of ammonia in the reactor is significantly lower compared to that of influx ammonia is that the dilution effect occurs with the return of sludge and the nitrification is carried out as soon as ammonia is added into the reactor.

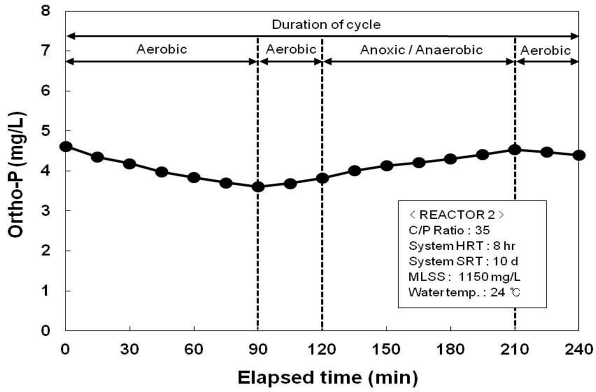

Fig. 3 Profiles of ortho-P during a cycle in a reactor of laboratory scale system at a SRT of 10 days

The internal behavior of phosphate in the unit reactor is shown in Figure 3. It is shown that mechanism of uptake and release of phosphate occurs weakly. This is the reason why the removal of phosphorus is poor.

Even if the cause to remove the phosphorus insufficiently is not dealt in this study, they are largely as follows;

1. Cause by influent (synthetic wastewater)
2. Use of completely mixed reactor (separation of anoxic and anaerobic reactors are not done clearly)
3. The insufficient time of anoxic/anaerobic phase has been speculated as the cause.

IV. Conclusion

The purpose of this study is to apply the existing intermittent aeration system with changing flow in which the front anaerobic reactor is not installed on mobile media biofilm reactor and to examine the performance of wastewater treatment in the system with synthetic wastewater.

1. The efficiency to remove the organic matters, nitrogen and phosphorus shows 97 %, 73 % and 7.7 %, respectively.
2. Upon converting the reactor in the system into MBBR, the efficiency to remove the organic matters and phosphorus shows the similar level compared to that before and after addition of media. However, the efficiency of nitrogen removal is improved by 7~ 10 %.
3. The solids load in the reactor maintained in MLSS 1200 – 1400 at 25 % media packing of reactor volume are all attached onto the media and the return of sludge is not needed since the no sludge enters the clarifier.

Acknowledgment

This work is financially supported by Korea Minister of Ministry of Land, Transport and Maritime Affairs(MLTM) as ‘U-City Master and Doctor Course Grant Program’

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