

# Development of a unified treatment system for public use of discharged water from a Korean apartment complex for urban infrastructure regeneration

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## Abstract

The purpose of this study was to enhance major economies and compatibilities of the system, comparing the differences of footprints between outdated and updated systems. In addition, the research provided ways to verify the effluent quality during the pilot-plant scale operation of a unified treatment system (MBR and Coagulation-LPCF) and estimate the great economical efficiency in the proper construction and operation. As the results of a real pilot plant, the effluents contained low concentrations for BOD, at 3.3 mg/L, followed by 7.2 mg/L COD, 8.47 mg/L T-N and 0.1 mg/L T-P. The MBR-LPCF system was reported to occupy a plot of 384m<sup>2</sup>, which had a two times lower square compared to the outdated system (RBC; Rotating Biological Contactor). What is more, by comparing prices, the reclaimed water system experienced a decrease of nearly 76% in a unit cost of tap water involving facility renovation and operation. Consequently, if the MBR-LPCF system starts to be operational in an apartment complex, it can significantly not only enhance the amenity of the housing complex, but also increase green efficiency to decrease the use of water resources.

*Keywords:* urban infrastructure regeneration, reclaimed water and water recycling.



## 1 Introduction

In order to point towards green growth, technological innovations have been introduced and defined as an ascent work in terms of increasing recycling, renewable energy and sustainable thriving development [1–3]. The targets of these technologies can be matched to the needs of the urban infrastructure systems concerned. From a practical point of view, this ensures that the design can be adapted successfully to each unit of a housing complex. Hence, it is expected that the new design using reclaimed water will bring considerable advantage in water spaces and facilities, which provide an amenity for local residents in a housing complex.

The results of the study have shown that the unified treatment system will derive potential benefit from discharging water, purifying rainwater, ground water and wastewater to the apartment complex. The new system is a winning combination process of MBR (Membrane bioreactor) and LPCF (Lifted pore control fibre) filter and both of them use filtration after biological treatment and coagulation [4]. It results a massive increase in the recycling rate of producing reclaimed water for public use and improvement in effluent's water quality in a complex. In this manner, effluent quality, footprint and economical efficiency should be investigated ahead of the application as the new system is adopted.

There are the regenerable facilities of 109,508 sites ( $>10\text{m}^3/\text{day}$ ), including 45,938 plants not in use at a building and APT complex because of the operation of municipal wastewater treatment facility [5]. These facilities can be fully used for both water recycling and unified treatment system for rainwater, groundwater and wastewater by a simple renewal in each and every complex. It leads to an increase of recycling rate producing reclaimed water for public use. In this way, effluent quality, footprint and economical efficiency should be investigated ahead of the field application of the new system. Therefore, this study helps to enhance the economical and compactable system, compare the differences of footprints between outdated and updated systems, verify the effluent quality through the pilot-plant scale operation of new system and estimate the great economical efficiency in constructing and operating.

## 2 System configuration

The combination process of MBR and LPCF can also obtained with the new system in which they both use filtration after biological treatment and coagulation process. In the course of this operation, an in-line device is installed before the LPCF process to address the coagulation process. While MBR focuses particularly on detection and removal of the organic matter, SS (suspended solid), nitrogen and bacteria by assimilation and separation, LPCF removes the fine SS, phosphate and bacteria by coagulation and filtration. Hence, The MBR-LPCF system is to be expected to meets the standards of quality required for the reclaimed water and also achieves both compactness and economy of which set up the system.



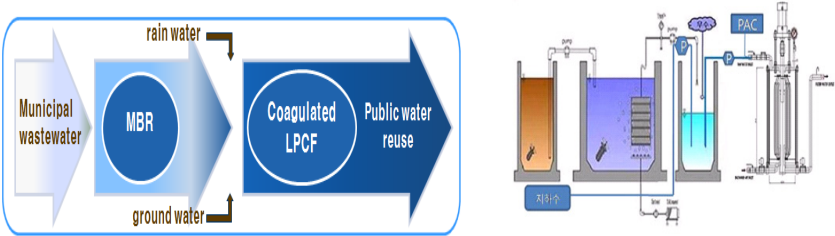


Figure 1: Introduction of unified treatment system for reclaimed water production.



Figure 2: Field plant of a unified treatment system.

Table 1: Permeate concentration of a unified treatment system.

	standard	raw	MBR permeate		Coagulation-LPCF	
			Conc.	Eff. (%)	Conc.	Eff. (%)
pH	5.8 ~ 8.5	7.03	6.64	–	6.14	–
SS(mg/L)	6	120	0	100	0	100
COD(mg/L)	40	136.4	14.2	89.6	7.2	94.7
BOD(mg/L)	3	128.3	3.5	97.3	3.3	97.4
Chromaticity	5	–	41.9	–	25.1	–
C l <sup>-</sup> (mg/L)	250	101.4	109.9	–	124.1	–
T-N(mg/L)	10	24.49	8.6	64.9	8.47	65.4
T-P(mg/L)	1	3.8	1	73.7	0.1	97.4
ABS(mg/L)	1	1.012	0.027	97.3	0.05	95.1
Coliform (ea/100mL)	ND	ND	ND	–	ND	–

### 3 Field application

#### 3.1 Pilot test

The pilot plant of this system was conducted at O WWTP (waste water treatment plant). The experimental results obtained in the real pilot plant indicates very low concentrations of BOD, COD, Cl-, T-N, and T-P in the treated effluent at 3.3 mg/L, 7.2 mg/L, 124.1 mg/L, and 8.47 mg/L, 0.1 mg/L, respectively. In particular, both SS and Coliform outcome showed diminished concentrations in the samples at 0 mg/L. It can be seen that every concentrations of effluent meet the water quality standards for the reclaimed water. However, chromaticity is not appropriate for the target, because this system is constituted with two step filtration and filtration process which can merely remove the chromaticity of influent. Therefore, the system is pressing in need of an additional process to solve this problem. The real photo and the concentrations of field plant are described in detail below.

#### 3.2 Space estimation

To investigate the field applicability, it is necessary to examine carefully the possibilities that the system could reside in the real sewage treatment facility of an apartment complex. The process is RBC (Rotating Biological Contactor) operated with two tanks. The MBR-LPCF system is expected to be occupied by comparing 384 m<sup>2</sup> of the new system with 702 m<sup>2</sup> of outdated system and all this proves that recent development is more compactable than that system remains unrepaired. It proves that new system is more compactable than old one.

### 4 Economic analysis and benefit

According to the results from the economic analysis of the reclaimed water usage between MBR-LPCF process and tap water, a unit cost of reclaimed water

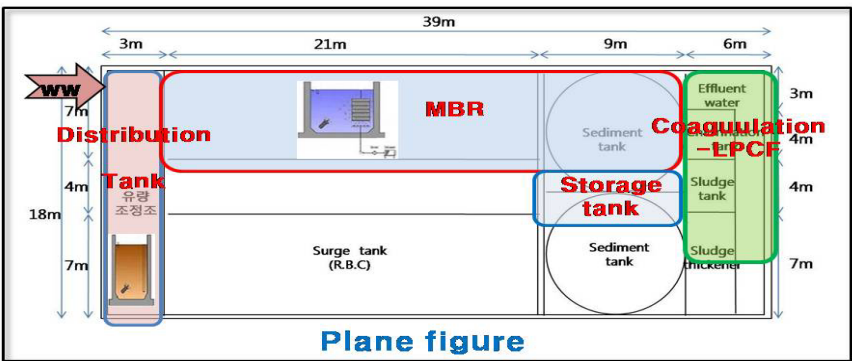


Figure 3: Plane figure of a unified treatment system compared to RBC in the field.



Figure 4: Adaptable water facilities for an amenity enhanced apartment complex.

including facility renovation and operation is  $0.13\text{USD}/\text{m}^3$  which could be compared with  $0.55\text{USD}/\text{m}^3$  of tap water providing a cost for the tap water rate, water pumping, tax and maintenance of municipal sewer treatment facility. This means that  $50,545\text{USD}/\text{yr}$  could be saved and MBR-LPCF application for reclaimed water is remarkably successful in an apartment complex.

By the use of reclaimed water, water spaces can be recovered to make use of waterfalls, aquatic-ecological parks, foot spa, artificial waterway, etc. Eventually, it improves an urban green efficiency and provides an amenity for local residents.

## 5 Conclusion

Through the pilot test, it represents that the unified treatment system can be adopted to produce the reclaimed water. From the estimation of present occupied space for H apartment complex, the new system clearly shows that it is more compactable than the ordinary one before. As the result of economical analysis, a unit cost of reclaimed water including facility renovation and operation is  $0.13\text{USD}/\text{m}^3$  which is better to compare  $0.55\text{USD}/\text{m}^3$  of tap water.

It goes without saying that the results helped the system reach a consensus on the plan for future municipal wastewater infrastructure by means of increasing the recycling rate of wastewater, making various water-friendly spaces for urban regeneration. Therefore, it is possible to provide an amenity for local residents as well as increase green efficiency towards a decrease in the use of water resource.

## Acknowledgement

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