〈研究発表〉

Development of Water Usage Index for waterfront in U-Eco City Using Tele-monitoring System

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Abstract

In order to increase the sustainability of urban water circulation and the usage of reclaimed water in the urban area, integrated water management system networked with real time water quantity and quality data of various water resources is required. In this study, ubiquitous-based eco lake and river management systems to monitor water quantity and quality, to detect contaminants, to evaluate the aquatic ecosystems were developed. The developed ubiquitous-based eco lake and river management systems were applied to real artificial lake located in urban area. Using those systems, real-time water usage index for waterfront in U-eco city was successfully developed, and water management guidelines were successfully provided.

Keyword: sustainability of urban water circulation, ubiquitous-based eco lake and river management systems, water management guidelines, water usage index

1. Introduction

The urban water circulating system (so called blue-network) is required to restore the natural ecological functions and to reduce the pollution load to urban environment. The urban water circulating system can network, integrate, and manage the various water resources (i.e., streamflow, eco river/lake, reclaimed water, rain water, groundwater etc.) to increase the sustainability of urban water circulation and the usage of reclaimed water in the urban area. In order to make the urban water circulating system sustainable, the development of ubiquitous-based eco lake and river management systems is required to monitor real time water quantity and quality, to detect contaminants, to evaluate the aquatic ecosystems. Also, water usage index should be developed to provide the guidelines for waterfront to citizens. Although various index related to water resource usage and management were previously developed, most of index were available for large-scale area (Sullivan 2001). Few, if any, index were available for small-scale waterfront such as eco lake or eco river in urban area.

In this study, using tele-monitoring system with various water quality (i.e., SS, pH, Temp, DO, Chl-a, COD, Turbidity, T-N, T-P) and quantity (i.e., flow rate meter, ultrasonic water level guage), the ubiquitous-based eco lake and river management systems and real time water usage index for real artificial lake in urban area were developed. Then, the real time water usage index and its indication for aquatic life and recreational use were evaluated.

2. Materials and Method

2.1 Artificial lake in urban area

The artificial lake investigated was built in 2002, and its depth and reservoir amount were 0.5~3.0m and 27,000 m^3, respectively. Major water resources for this artificial lake were both reclaimed water and groundwater, and water treatment facilities (i.e., coagulation and dissolved air floatation) were occasionally operated to treat both input and recycled water. According to the analysis of water mass balance, 18 m^3/d of water should be supplemented for spring and fall while no supplement of water is required for summer and winter.

2.2 Tele-monitoring system with sensors

Tele-monitoring system with various water quality (i.e., SS, pH, Temp, DO, Chl-*a*, COD, Turbidity, T-N, T-P) and quantity (i.e., flow rate meter, ultrasonic water level guage) were installed, as shown in Fig. 1. Thus, data regarding water quality and quantity were collected every hour, and calibration and maintenance of sensors were performed every week. At rain events, manual sampling and lab analysis were performed since some data were greater than the detection ranges of the sensors.

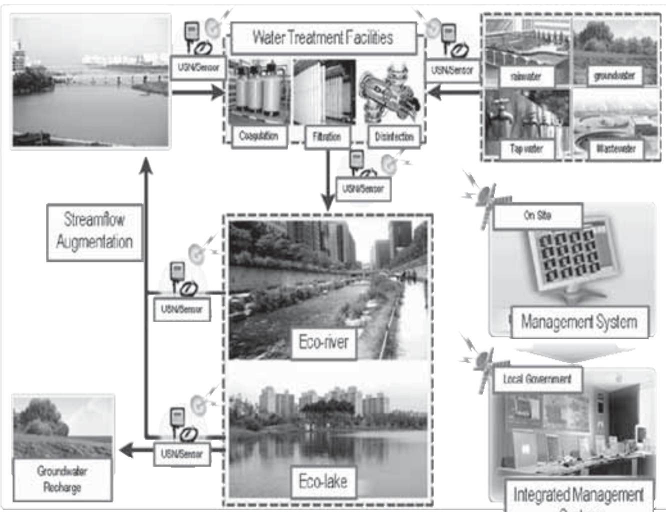

Fig. 1 Prototype of the ubiquitous-based eco lake and river management systems

2.3 Water Usage Index

Numerous variations of water quality indices have been addressed in literature over the past four decades (Walaski and Parker, 1974; Smith, 1990; Said et al., 2004, Sarkar and Abassi, 2006). A water quality index basically acts as a mathematical tool to transform the bulk of water quality data into a single digit, cumulatively derived, numerical expression indicating the level of water quality. This, in turn, is essential for comparing the water quality of different sources and in monitoring the changes in the water quality of a given source as a function of time and other influencing factors. Using this water quality index concept, water usage index were suggested in this study to give the water usage guidance and safety to citizens around the waterfront. As suggested in Eq. 1, the water usage index can be calculated based on water quality index (Q) and weighting factor (W) depending on water usage type (i.e., ecological conservation, landscape, recreational use etc.).

$$\text{WUI (Water Usage Index)} = \sum(Q \times W) \quad \text{Eq. (1)}$$

Where Q is the water quality index for each parameter, and W is the weighting factor as a function of water usage.

The water quality index used in this study was shown in Table 1. As illustrated in Table 1, each parameter has the value of excellent, good, average, fair, and poor. The water quality index is a statistic designed to approximate to index from other study.

Table 1 Water quality index and ranges for each parameter

parameter	unit	Excellent (Q=100)	Good (Q=80)	Average (Q=60)	Fair (Q=40)	Poor (Q=20)
Flow rate	m^3/d	R/T[1)]≥0.9	0.8≤R/T <0.9	0.7≤R/T <0.8	0.6≤R/T <0.7	R/T<0.6
pH	-	7.0≤pH≤ 8.5	8.5<pH≤ 8.8	8.8<pH≤ 9.2	9.2<pH≤ 9.6	pH>9.6
			6.7≤pH< 7.0	6.4≤pH< 6.7	6.1≤pH< 6.4	pH<6.1
SS	mg/L	SS<1.0	1.0≤SS< 5.0	5.0≤SS< 15.0	15≤SS<30	SS≥30
DO	mg/L	DO≥7.5	5.0≤DO< 7.5	3.5≤DO< 5.0	2.0≤DO< 3.5	DO<2.0
COD_{Mn}	mg/L	COD<2	2≤COD< 4	4≤COD< 5	5≤COD< 8	COD≥8
T-N	mg/L	T-N<0.2	0.2≤T-N <0.4	0.4≤T-N <0.6	0.6≤T-N <1.0	T-N≥1.0
T-P	mg/L	T-P <0.01	0.01≤T-p <0.03	0.03≤T-P<0.05	0.05≤T-P<0.1	T-P≥0.1
Chl-a	mg/ m3	Chl-a<5	5≤Chl-a <14	14≤Chl-a<20	20≤Chl-a<70	Chl-a ≥70
Fecal Coliform	MPN/ 100mL	ECL<50	50≤ECL <500	500≤ECL<1,000	1,000≤ECL<5,000	ECL ≥5,000

1) R/T means the ratio of real supply to target supply

3. Results and Discussion

Both water quality index and water usage index were obtained every hour, and both indices were not significantly changed during the dry season. However, at rain events, both indices were significantly changed as a function of rain intensity and duration time, indicating that rain intensity and duration time affect water quality and water usage. As shown in Fig. 2, the variation of average water usage index of artificial lake through the year is considerable. For example, during the spring season (March~May), the values of COD, SS, T-N, T-P, and Chl-*a* increased significantly due to the lower rain intensity and greater hydraulic retention time. For those reasons, water usage index was lower relative to summer season. However, as the rain intensity and duration time increased gradually during the summer season, water quality of artificial lake was improved, hence, water usage index increased.

Water usage index ranges and indication for aquatic life and recreational use were summarized in Table 2. Depending on water usage index and water quality based on the measurements of various water quality and quantity, indication to aquatic life and recreational use have been changed. According to Fig. 2, the water usage index of artificial lake generally ranged from 25 (bad) to 58 (medium). Thus, these low water usage index indicates no body contact, limited contact only, and use with caution for citizens. Consequently, this artificial lake located in urban area should be used with caution for waterfront. In other words, swimming or body contact should be prohibited, and the main purpose of this artificial lake is landscape or ecological conservation. For aquatic life, very limited species or low diversity of aquatic ecosystems were expected.

Table 2 Water usage index ranges and indication for aquatic life and recreational use

Water Usage Index	Water Quality	Aquatic Life	Recreational Use
0-25	Extremely Bad	Very limited	No body contact
26-50	Bad	Low diversity	Limited contact
51-70	Medium	Under Stress	Use with caution
71-90	Good	Medium diversity	Very few limits
91-100	Excellent	High Diversity	Fully usable

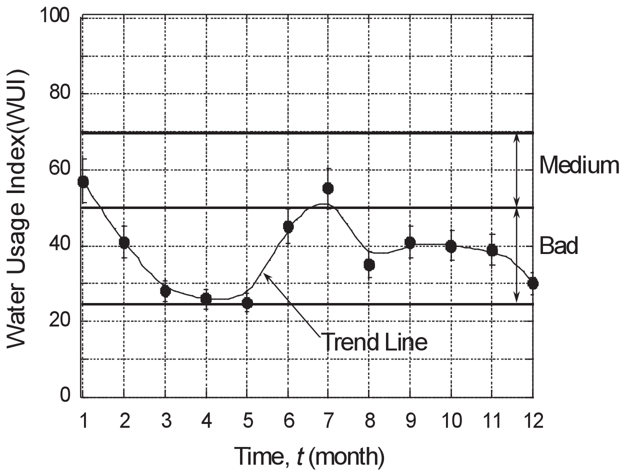

Fig. 2 The variation of water usage index of artificial lake through the year

4. Conclusions

Water usage index is a weighted calculation based on the measurements of various water quality (i.e., SS, pH, Temp, DO, Chl-a, COD, Turbidity, T-N, T-P) and quantity (i.e., flow rate meter, ultrasonic water level guage), and successfully provides the indication for aquatic life and recreational use. Also, the developed ubiquitous-based eco lake and river management systems were efficiently applied to real artificial lake located in urban area. However, further research is warranted to develop the relationship between water usage index and indication for aquatic life and recreational use.

5. References

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