International Conference on Hydroinformatics

8-1-2014

Development Of A Model-Based Decision Support System For Water Treatment In Smart Micro Water Grid

Hyeongrak Cho

Jungwoo Jung

Sangho Lee

Soo Kwen Chae

Recommended Citation

Cho, Hyeongrak; Jung, Jungwoo; Lee, Sangho; and Chae, Soo Kwen, "Development Of A Model-Based Decision Support System For Water Treatment In Smart Micro Water Grid" (2014). *CUNY Academic Works.*
http://academicworks.cuny.edu/cc_conf_hic/441

11th International Conference on Hydroinformatics
HIC 2014, New York City, USA

DEVELOPMENT OF A MODEL-BASED DECISION SUPPORT SYSTEM FOR WATER TREATMENT IN SMART MICRO WATER GRID

HYEONGRAK CHO[1], JUNGWOO JUNG[1], SANGHO LEE[1], SOO KWEN CHAE[2], JAESOON SEO[3]
(1): School of Civil and Environmental Engineering, Kookmin University, College of Engineering, 77 Jeongneung-ro, Seongbuk-gu, Seoul, 136-702, Republic of Korea
(2): Eulji University, 553 Sanseong-daero, Sujeong-gu, Sengnam-Si, Gyeonggi-do, 451-632, Republic of Korea
(3): Wacon Co., Ltd, Jeongwang-dong 1277-5,Siheung-Si, Kyeonggi-do, Republic of Korea

A multi-criteria decision support system (DSS) based was designed and developed to select optimum combinations of water treatment unit processes in micro water grid (MWG).
.

INTRODUCTION

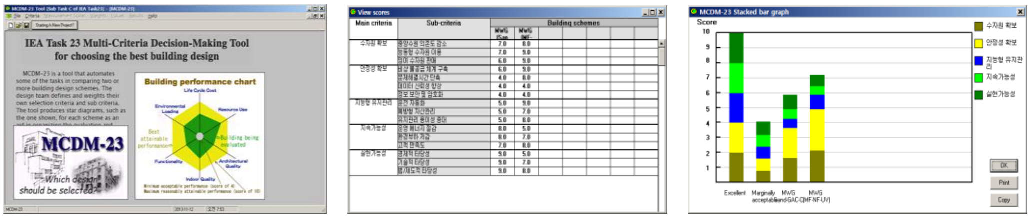
Micro water grid (MWG), which is a subset of smart water grid (SWG), is a novel concept for decentralized water management system for residential, industrial, commercial, and institutional buildings or towns [1, 2]. MWG aims at achieving specific local goals, such as reliability, diversification of water sources, and cost reduction. Unlike micro electricity grid, MWG has not been well-established, leading to a problem of initial design and operation. Thus, a MWG system requires a “smart” infrastructure for water treatment, water distribution, and system control

In this study, a decision support system (DSS) was designed to select optimum combinations of water treatment unit processes in MWG. To begin, key questions on water treatment in MWG systems were identified. Then, the knowledge-based system was developed based on the inputs from experts in related research fields and the prediction of treatment efficiency from theoretical model.

MODELING APPROACH

A multi-criteria decision analysis for MWG was carried based on a scoring method [3, 4]. The Analytical Hierarchy Process (AHP) was applied to calculate the scores for each alternative based on pairwise comparisons. Three types of MWG systems were initially considered, including residential, commercial, and recreational applications. The weighting factors were estimated from a survey to a group of experts in academia and industry.

A decision-tree was created for an expert system of water treatment combinations in MWG systems. Treatment efficiency of pollutant by each water treatment combination was used for developing the knowledge base. The expert system was then developed using a web-based platform, allowing an easy access to people who needs assists for design and operation of water treatment system in MWG.



(a) (b) (c)

Figure 1. Multi-criteria analysis for strategic decision making of MWG

MATERIALS AND METHODS

A series of experiments were carried out to obtain the model parameters for each unit process (i.e. media filtration, microfiltration, GAC, nanofiltration, chlorination, UV). Figure 2 shows the schematic diagram of experimental equipment for obtaining data on treatment efficiency by water treatment combinations. The 1st stage is used for removal of suspended solids and the 2nd stage is used for removal of organic matters. The 3rd stage, which is optional depending on the application, is used for disinfection.

Various feed waters containing rainwater, secondary effluent, ground water, and river water were used. Table 1 summarizes the examples for combinations of water treatment unit processes.

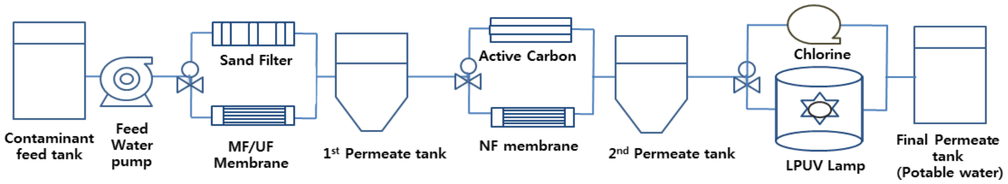


Figure 2. Combinations of water treatment unit process for MWG

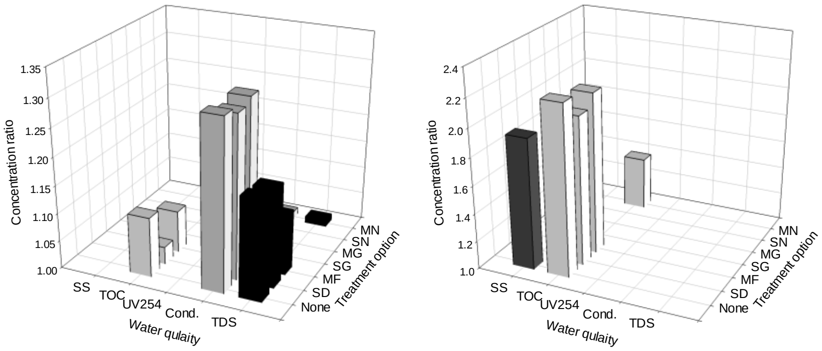
Table 1. Summary of water treatment combinations considered in this study

Name	1st stage	2nd stage	3rd stage
Feed	-	-	-
SD	Sand filtration	-	-
MF	Microfiltration	-	-
SG	Sand filtration	GAC	-
MG	Microfiltration	GAC	-
SN	Sand filtration	NF	-
MN	Microfiltration	NF	-
MGC	Microfiltration	GAC	Chlorination
MGU	Microfiltration	GAC	LPUV

RESULTS AND DISCUSSION

To begin, the multi-criteria decision analysis was performed to obtain the weighting factors. It was found that the weighting factors were different for different applications. For example, the increase in water resource was found to be the most important for residential MWG while water security and stability was the most important for industrial MWG.

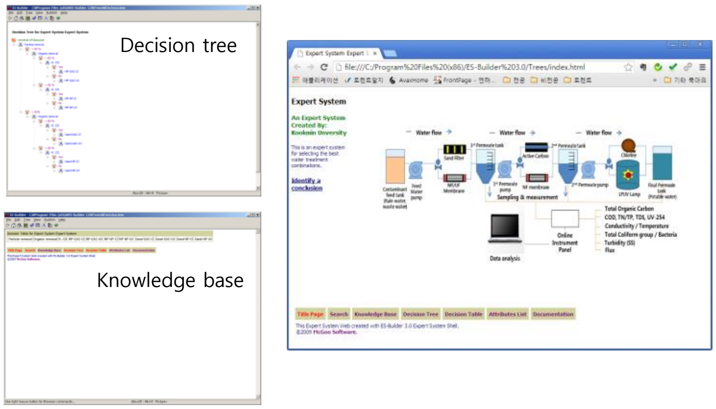
The experiments were carried out to obtain the performance data for each water treatment combination. For example, Figure 3 shows how the optimum water treatment system was selected based on the results of treatment efficiency and the target water quality. Although the treatment efficiency is same, the optimum treatment system may be different for different targe water quality.



(a) (b)

Figure 3. Selection of the optimum water treatment systems based on the concentration ratio of treated water quality to target water quality. Feed water: rainwater : groundwater : river water : wastewater = 1:1:1:1 (a) target water quality: TDS < 300 mgL; conductivity < 250 µS/cm; UV254 < 0.2; TOC < 2000 µg/cm; SS < 5 mg/L (b) target water quality: TDS < 300 mgL; conductivity < 250 µS/cm; UV254 < 0.2; TOC < 2000 µg/cm; SS < 5 mg/L

Based on all the results, the decision support system was developed as a form of web-based expert system. Figure 4 show the fundamental aspects of this system.



An Expert System Created By: Kookmin University

This is an expert system for selecting the best water treatment combinations.

This Expert System Web created with ES-Builder 3.0 Expert System Shell.
©2009 McGoo Software.

Figure 4. A web-based expert system for decision-supporting of water treatment combinations in MWG

CONCLUSIONS

In this study, a decision support system was designed developed based a scoring method and experimental results. A rule-based system was also created. This system has potential to provide useful information for optimum selection of water treatment combinations depending on the type of application and target water quality. Studies are ongoing to reflect the effect of capital and operation costs.

ACKNOWLEDGMENT

This research was supported by a grant (12-TI-C01) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

REFERENCES

[1] Qi, W., J. Liu, and P.D. Christofides, *A distributed control framework for smart grid development: Energy/water system optimal operation and electric grid integration.* Journal of Process Control, Vol.21 No.10, (2011), p.1504-1516.

[2] Ramos, H.M., et al., *Energy recovery in SUDS towards smart water grids: A case study.* Energy Policy, Vol.62 No.0, (2013), p.463-472.

[3] Chen, Z., et al., *Multi-criteria analysis towards the new end use of recycled water for household laundry: A case study in Sydney.* Science of The Total Environment, Vol.438 No.0, (2012), p.59-65.

[4] Zagonari, F. and C. Rossi, *A heterogeneous multi-criteria multi-expert decision-support system for scoring combinations of flood mitigation and recovery options.* Environmental Modelling & Software, Vol.49 No.0, (2013), p.152-165.