Development of Remote Water Quality Monitoring System for Integrated of Small-Scale Water Supply System

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***Abstract*—As of the end of 2013, the population using the facilities other than the municipal water service includes 943,000 people using the village waterworks (42.5%), 472,000 people using the small-sized water supply systems (21.3%), 143,000 people using the exclusive waterworks (6.5%), and 659,000 people using well and other means(29.7%). Currently, the dependency on small-sized water supply systems is very high in small cities and rural areas which have relatively low distribution of waterworks compared to metropolitan areas, and 80 to 150 units are installed and operated in each region. Although the small-sized water supply system should be systematically managed as there were 18,383 of them as of 2013, they are mostly managed by the village residents themselves, and only 7.3% of them are equipped with the water purification system such as slow sand filtration and membrane filtration. [1] Therefore, the water purification system to actively cope with pollution of raw water and unmanned management through remote control and other means are needed. This study intended to develop and apply the remote monitoring system to integrate the smaller scale waterworks in order to stabilize the water quality.**

***Index Terms*—small capital facility, Remote control, Water quality monitoring system, Small-scale water supply system**

I. Introduction

It is difficult to assure the safety of water quality of the small-scale waterworks because of lack of investment on facility and aging of equipment. As of 2005, 39% (village waterworks; 40.7% and small-sized water supply systems; 39.1%) of total were at least 25 years old, 59% (295 sites) of water treatment plants were equipped only with slow sand filtration or mechanical sediment filtration and thus have difficulties of processing new chemical substances(pharmaceutical compounds and antibiotics). [1]

The valley water and spring water used as the source of water intake by many regional waterworks have become polluted because of continued development of rural areas. Moreover, the soil pollution by excessive use of pesticides and fertilizers as well as the pollutants generated non-point pollution source such as livestock farms have led to pollution of underground water, and thus even the underground water is not safe to be the source of water intake. [2]

The small-scale waterworks particularly have the operational problems. 19.5% of domestic small-sized waterworks do not have the sterilization facility, and thus the operator manually injects the solid chloride. 23.0% (5,223 sites) nationwide do not sterilize at all. Moreover, they are operated and managed by the village leaders or residents who do not have qualification, and there is no systematic management. [3]

As only 18.3% of the residents using the regional waterworks facilities sterilize them 1~2 times a month, the development and application of the small-sized water supply systems to be efficiently managed are urgently needed. [4]

This study intended to develop and apply the remote monitoring system for integration of small-sized waterworks to ensure safety of water quality. We named it the decentralized water purification integration system. To further develop the system to check the status of the small-scale water supply facilities and monitor the quality of the supply so that it can activate warning and be controlled remotely, the cases currently ongoing in Korea are analyzed, and the developed system is presented in this study.

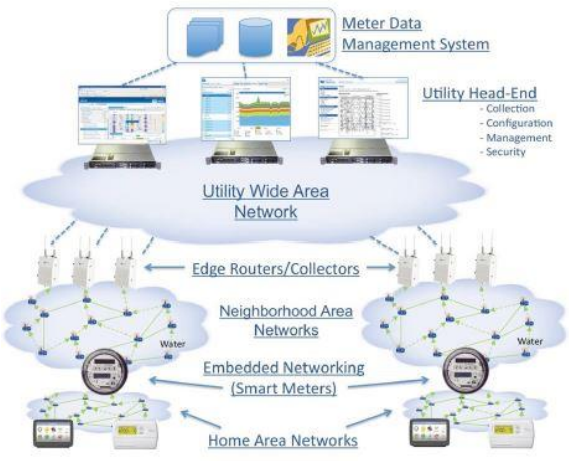

Figure 1. Smart water grid mimetic diagram.

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II. Research Development Tendency

A. Smart Water Grid

The smart water grid developed in Korea is a system that manages the waterworks facilities and disaster related data to strengthen the durability of the waterworks and continuously monitors the relevant facilities to quickly respond to the disaster situations. [5],[6] It can cope with the natural disasters such as drought, overcome the water supply imbalance among the regions, and has greatly contributed to satisfaction of local residents with use of water. Fig. 1 shows a mimetic diagram of a smart water grid system.

The detailed functions of smart water grid include 1) resource management system, 2) real-time decision making, 3) water quality prediction, and 4) efficient operation. It is used as the ICT (Information and Communications Technology) based next-generation water resource management system to improve the efficiency of water resources and waterworks/sewage system by integrating the whole life cycle. [7], [8].

B. U- Water Circulation Integrated Management System

The U-water circulation integrated management system was developed to be applied in new urban systems to develop and efficiently manage the state-of-the-art future cities with strengthened ecological functions. The element technologies required of a water circulation system can be divided into 4 types. The first is the practical application of urban water circulation system led by the regional water reuse system. The second is the municipal water and integrated pollutant management technology. The third is rainfall management system to create the multi-purpose ecological green area. And the fourth is the integrated integrate water circulation management system which acquires, query and manage the data of water circulation between such artificial and natural systems.

The system can increase public's awareness of environment and improve the quality of life by rationally allocate the urban water resources, improve the municipal water reuse rate, and cope with natural disasters such as flooding and drought through demand forecast. The U-water circulation integrated management system utilized in Korea can bring the economic benefits by providing the water circulation data and managing the water resources over the web and recover the soundness of urban water circulation through the decentralized rainwater management of existing urban areas. Moreover, it efficiently contribute to efficient urban management in various ways by improving the urban microclimate through decentralized rainwater management to save heating and cooling energy and stably attaining the steam maintenance water and urban human-friendly water. [9]

C. Decentralized Water Supply System Adopting Vertical Water Treatment Facility

Vertical water purification facilities have been introduced, distributed water supply system is existing centralized water supply system problems and limitations of civil organizations to overcome an advanced Wastewater Treatment Natural Septic Method for research and commercialization of decentralized water supply systems as commercial application reality that calls for the compacts of water purification facilities and Construction Technology Development Uninterruptible have a production number for the provision of any existing connection with the optimal development has been studied to the optimal technologies and drain system of water supply system. This is 1,000 ton group of compacts design technologies for water purification facilities with centrally controlled and secure process horizontal array integer cost 1.4 % or less, contrast, centralized processing facilities horizontal array integer requirement against site aimed at reducing studied, and this system of systems and effective integration, including straddling and drain and efficiency of the existing concerns over the possibility water conveyance of the existing judgement and evaluation of the effectiveness and wait and see and been deemed as necessary the review of the use of water supply system. [2], [10].

III. Theory and Methods

A. Background of Decentralized Water Treatment Integrated Management System

Although the existing metropolitan water purification plants were managed centralized, a new management measures are needed to manage water circulation as the complexity of urban system and importance of reusing the water have increased. In the exiting centralized water supply system, purifies the raw water conveyed from a single water source is proves in the water purification plant and transported to the water reservoir in high ground by a water circulating pump and pipeline. The water is then distributed to consumers through the supply/distribution pipeline. The problem with the system is that it can cause the secondary pollution as the raw water is transported through a pipeline, and the pollution of water can affect the odor and taste. Moreover, the problem of poor water quality has been continuously raised due to the lack of qualified operating manpower. [11]

As such, this study rejected the centralized water supplier and remotely managed by connecting the small-scale water purification systems into a network so that it can be applied to local level water circulation systems and assure the soundness of water circulation and stability of water quality. The developed decentralized water purification integrated management system can be stably managed without having to assign the experts on site.

B. Overview and Development of Decentralized Water Treatment Integrated Management System

Fig. 2 and Fig. 3 show a decentralized portable water treatment integrated management system Diagram and Prototype. The decentralized water purification integrated

management system as part of the decentralized water purification integrated management system, a terminal was developed to monitor and control the small-scale water supply facilities, remote water quality monitoring systems, and remote facility monitoring systems in real time. To check the control data remotely, the data are transmitted from the terminal to a remote server over CDMA, and the remote server saves the received data so that the users can check them through the web UI. Fig. 5 shows a Process used CDMA. The decentralized water purification integrated management system collects the control point signals generated by the small-scale water purification facilities with the control terminal and displays the status with the control indicators on the terminal. The collected signals which show the operating status of the facility are sent to the server over CDMS communication periodically or as an event occur. The server categorizes the data received from the small-scale water supply facilities scatter in different regions and saves them in a database and leaves the log. The user can check the status of the multipurpose decentralized water purification system over web UI with the browser.

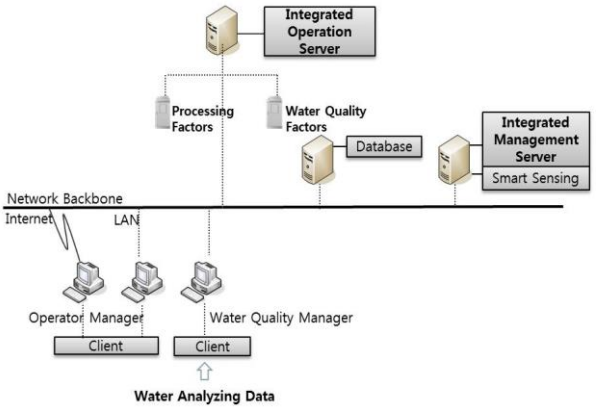

Figure 2. Decentralized portable water treatment integrated management system diagram.

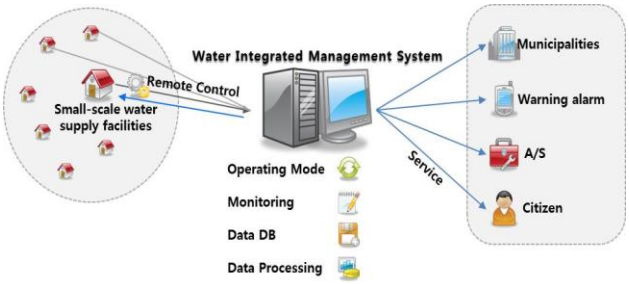

Figure 3. Decentralized portable water purification integrated management system prototype.

The data related to water flux, water quality and operating status of the small-scale waterworks system are collected by the central management system in the metropolitan area, and the data collected in real time sent to the water gateway which manages the water purification status of the metropolitan area in conformation to the government policy concerning the regional waterworks operation. The water gateway can manage the regional water purification and remotely manage and control the water purification status in real time by sending the database to the Water Center which is the integrated management center. The Water Center controls the communication status with small-scale waterworks and constructs the database with the data transfer program. Moreover, it monitors and remote controls the small-scale waterworks in real time and analyzes the data. It can also send the alarms and warnings to the administrators with the surveillance program.

IV. Conclusion

A. Construction and Operation of Decentralized Water Treatment System

Fig. 4 shows a current situation of construction for water treatment integrated management system. One decentralized water purification system developed by this study were installed and have been operating as part of the village waterworks in Ganghwa-gun, Incheon and three are operating in Wonju, Gangwon (Soya, Gomnemi and Suryeon-dong villages) for system checking and enhancement. The system in Incheon combines the ion exchange resin and UF water purification systems while the system in Wonju uses the membrane based water treatment system.

Figure 4. Current situation of construction for water treatment integrated management system.

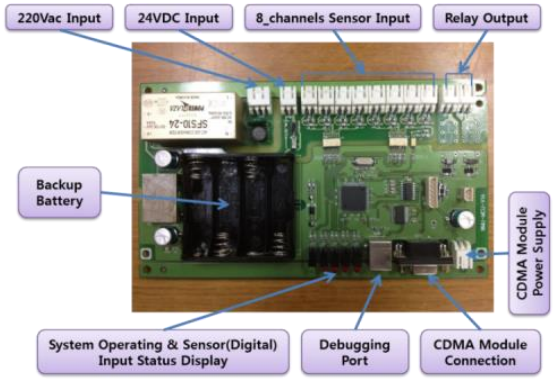

Figure 5. Process used CDMA.

B. Construction and Operation Remote Water Quality Monitoring System

The remote water quality monitoring system checks the status of village waterworks and small-scale water supply facilities and checks the quality of the supplied for alerts and remote control. This system is currently installed in the village waterworks Paju (Gyeonggi-Do) and Wonju (Gangwon-Do) to monitor 6 items (pH,

electrical conductivity, residual chlorine, nitrate nitrogen, temperature and turbidity) of raw water quality in real time. Moreover, a remote water quality monitoring system was installed in a test bed to obtain the continuously monitored water quality data.

C. Construction and Operation of Decentralized Water Treatment Integrated Management System

The decentralized water purification integrated monitoring system was constructed by integrating the decentralized water purification facility, the remote water quality monitoring system, and the remote facility monitoring system. Currently it is installed inside the Korea Institute of Civil Engineering and Building Technology (KICT) to monitor the water quality status of village waterworks and small-scale water supply facilities in Paju (Gyeonggi-Do) and Wonju (Gangwon-Do) through the remote water quality monitoring system and build the database.

Figure 6. Decentralized water purification integrated management system.

Fig. 6 shows the main UI of the decentralized integrated management system installed in KICT. The users can check the real-time and set the process mode according to the raw water type by process or region. If the real-time water quality data exceeds the drinking water criteria, an alarm is activated so that the measures can be taken quickly. Currently, the integrated management center remotely monitors the remote water quality monitoring system in Soya Village in Wonju (Gangwon-Do) and Seolma-ri Village.

In the future, we plan to integrate the decentralized water purification system, remote water quality monitoring system and remote facility monitoring system into a single platform and link it with the integrated management system.

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