Trends and Future Prospects of Water and Sewage Treatment System Technology

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1. Introduction

Since developing the first computer control system for waterworks and sewage treatment plants in Japan 30 years ago, Fuji Electric has done much to develop new technologies and put them to practical use to meet the diversified, sophisticated needs of the water treatment market.

Water and sewerage system technologies have faced social problems and subsequent regulation, but these have acted as driving forces for technical development and have resulted in progress in the technologies.

Fuji Electric has developed many systems that were firsts in Japan, for example: water distribution control with demand prediction, development of a numerical formula for the activated sludge process for sewage, practical application of fuzzy control to water quality control, installation of optical fibers in sewers, and use of multimedia communications.

Environments surrounding the water system have greatly changed. The development of new water resources has been difficult and the problem of water quality has been complicated and diversified. A higher level of quality and quantity than before is required for the water system to fulfill its social responsibility.

As for the sewerage system, with the rising level of servicing, such as sewage being regarded as an important component factor in the circulation of water, and with social changes, the role to be played by the sewerage system has become more diversified and sophisticated.

The trends and future prospects of water and sewerage system technology are described below.

2. Trends and Future Prospects of Water and Sewerage System Technology

In water and sewerage systems, facilities scattered over a wide area are connected by water channels and conduits. These facilities influence each other while implementing an overall function.

Therefore, the proper control of water quantity, quality, and pressure is important. In water systems, there occur changes in source water quality and in service water demand. In sewerage systems, changes in treatment quantity and drainage quality due to rainwater inflow and abnormalities (water shortages, typhoons, conduit damages, and equipment failures) may occur. It is the responsibility of these systems to attain and maintain high-level service while coping with these various changing conditions.

To attain this purpose, a system that can gather the necessary information for management and control facilities in a centralized manner is indispensable.

Water and sewerage system technology must satisfy these requirements and can fulfill its functions by integrating component technologies for electric, instrumentation, computer, and mechanical systems.

2.1 Open monitor and control systems

The rapid spread of personal computers has made data processing technology popular, and created demand for end user computing such that users could freely collect data from monitor and control systems, store that data in their personal computer and utilize that data in various formats.

However, this demand was contradictory because it required that manufacturers guarantee monitor and control systems even if those systems were modified by users.

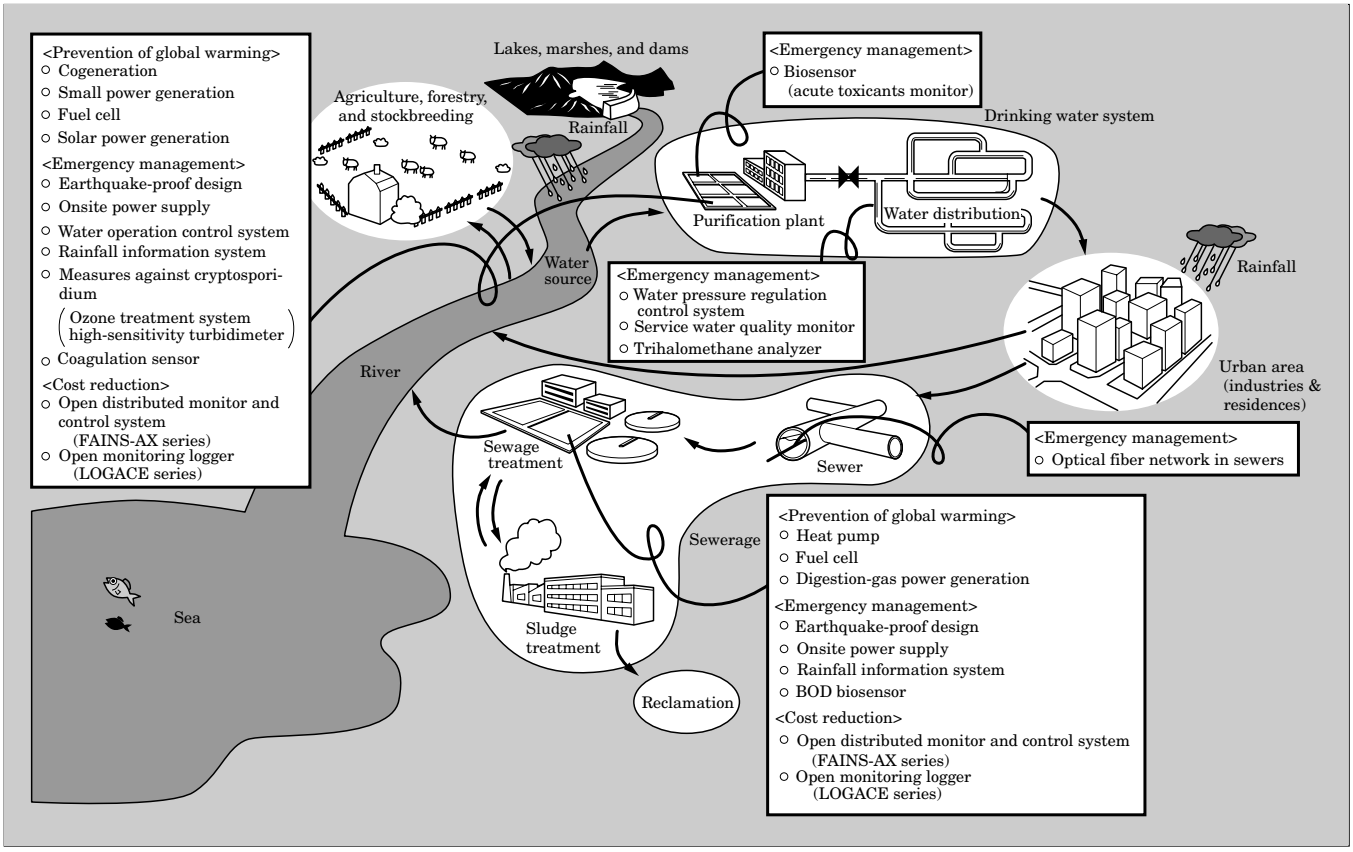
Open systems were created in response to this contradictory demand. Fuji Electric developed the FAINS-AX series of new open distributed monitor and control systems and the LOGACE series of open monitoring loggers.

These series combined Fuji Electric's reliable special-purpose technology with its widely used general-purpose technology, making it possible to offer systems suited to user requirements at a reasonable cost.

2.2 Data transmission, control technology and solutions

To efficiently manage sewerage operations, utilities have recently planned and implemented unmanned pumping plants as well as integrated management systems for entire sewerage systems using optical fiber networks and built in sewer conduits that connect sewerage system facilities with each other.

Fig.1 Solution technologies for water environment



Regarding the plans of optical fiber networks for sewerage systems, based on LAN and optical transmission technologies, Fuji Electric will expand the application range into the remote control of emergency facilities and remote maintenance systems to realize preventive maintenance. Thus, we will offer solution technologies to realize all utility processes from construction to maintenance at a minimum cost.

Figure 1 shows Fuji Electric's solution technologies for water environments. Solution technologies are not limited to the field of communications and control. For example, in the case of installation of an onsite power supply system aiming at global warming prevention and emergency management at an optimized cost, the introduction of a fuel cell system is a solution technology.

The cost optimization of water and sewerage operations can not be attained only by reducing construction expenditures. The cost is closely related to expenses for maintaining facilities and the life of the facilities. That is to say, consideration of the lifecycle cost is very important, and it is necessary to build a system with optimum value using the value engineering (VE) method. Solution technology is attracting attention as it is expected to play an important role.

2.3 Technologies against disasters

Most suspensions of the water supply due to earthquakes or other disasters are the result of "point" damages caused by broken water pipe joints, resulting in "area" damages downstream.

Divisional water distribution and a water pressure regulation system are effective measures against suspension of the water supply because "areas" are made small and easy to control. These methods have more effect when the exchange of water between divisions is taken into consideration. Fuji Electric, with a good record of accomplishment for supplying these systems, has realized stable water pressure regulation and has improved the efficiency of water supply by the early detection of leakage.

Fuji Electric has introduced to the market many systems for coping with disasters, for example: portable water supply systems utilizing membrane treatments, emergency generators, sensors and communication apparatus with onsite solar cell power supplies, preventive maintenance utilizing artificial intelligence and statistic processing, apparatus diagnosis equipment, and remote maintenance systems using ISDN. As a system vendor, Fuji Electric has tackled many equipment-related problems, including the earthquake-proof design of equipment.

3. Contribution to Prevention of Global Warming

It is no exaggeration to say that the prevention of global warming is technically attributable to the problem of energy. Basically, it is necessary to meet the increasing demand by improving the demand

structure (equalization of loads) without increasing the total generated electric energy. This is one important measure to realize so-called zero emission (reduction of the load due to human work on the global environment to approximately zero).

Fuji Electric established "Fuji Electric's basic policy on environmental preservation" in 1992 and has pioneered technical development for problems of the global environment.

3.1 Activities for zero emission in water systems

Recently, unused energy and wide areas within water facilities have attracted attention.

Tubular and Francis water turbines are used for hydraulic power generation, utilizing the effective head of water flow from reservoirs to purification plants. Fuji Electric has supplied many small hydraulic power plants so far.

Through adoption of a cogeneration system that utilizes exhaust heat, gas-turbine power generation raises total efficiency and is a superior energy-saving system. Fuji Electric, the first company to supply such a system in the field of water and sewerage systems, delivered a gas-turbine power system to the Higashi-Murayama Purification Plant of the Tokyo Waterworks Bureau.

Purification plants and water stations have wide-open spaces and hold promise for solar power generation. Because the energy demand for water systems is greater during the daytime than at night, solar power generation is advantageous. On the other hand, solar power is dependent upon the weather, and therefore, interconnection with utility power supply or the addition of a storage battery is necessary. Fuji Electric is aggressively making efforts to apply solar power generation to water and sewerage systems.

These onsite power systems are closely related not only to energy problems but also to emergency management. They must be considered as a lifeline in case of a disaster such as an earthquake.

3.2 Activities for zero emission in sewerage systems

The temperature of water from sewage treatment fluctuates within a small range between 8 and 13°C. This small range is characteristic of a stable heat source little influenced by climate.

An abundance of low-level energy has been discharged into the water during sewage treatment. However, technology for the efficient utilization of this low-level energy had not been available until recently, and this energy had been referred to as "unused energy." Recently, the appearance of heat pumps with high thermal efficiency has enabled the utilization of low-level energy.

Digestive gas produced in the process of sludge treatment has nearly the same degree of energy as urban gas. Highly efficient operation can be obtained from gas-turbine power generation using digestion gas as fuel and the heat recovered from a cogeneration system utilizing the gas-turbine exhaust heat. Fuel-cell power generation using digestion gas as fuel is also possible.

Fuel cells have higher power generation efficiency than conventional gas turbines and diesel engines, and fuel-cell power generation combined with the utilization of its exhaust heat can increase the total efficiency to 70 to 80%. Nitrogen oxides in the exhaust gas are as low as several ppm and the fuel cell is an excellent energy source. Fuji Electric has marketed fuel cells, focusing on onsite phosphoric acid fuel cells.

4. Coping with Water Quality Problems

A recent buzzword regarding water systems has been "safety" and people have displayed strong concern for the removal or reduction of pathogenic microbes and harmful substances in raw water and of disinfection byproducts in service water.

Early on, Fuji Electric started development of various water quality analyzers to monitor water system safety and has prepared a line of new water quality analyzers for analysis ranging from raw water to tap water. These analyzers highly integrate chemical, optical, and biological technologies with the physical detection mechanisms used by most of the present sensors, and have a high level of performance equivalent or superior that of the precise analyzers equipped in water quality test rooms.

4.1 Trihalomethane detection and reduction technologies

To solve the problem of carcinogenic trihalomethane currently receiving much attention, it is necessary to continuously monitor the amount generated and increase of trihalomethane in service water and implement measures to reduce the concentration below the permissible limit.

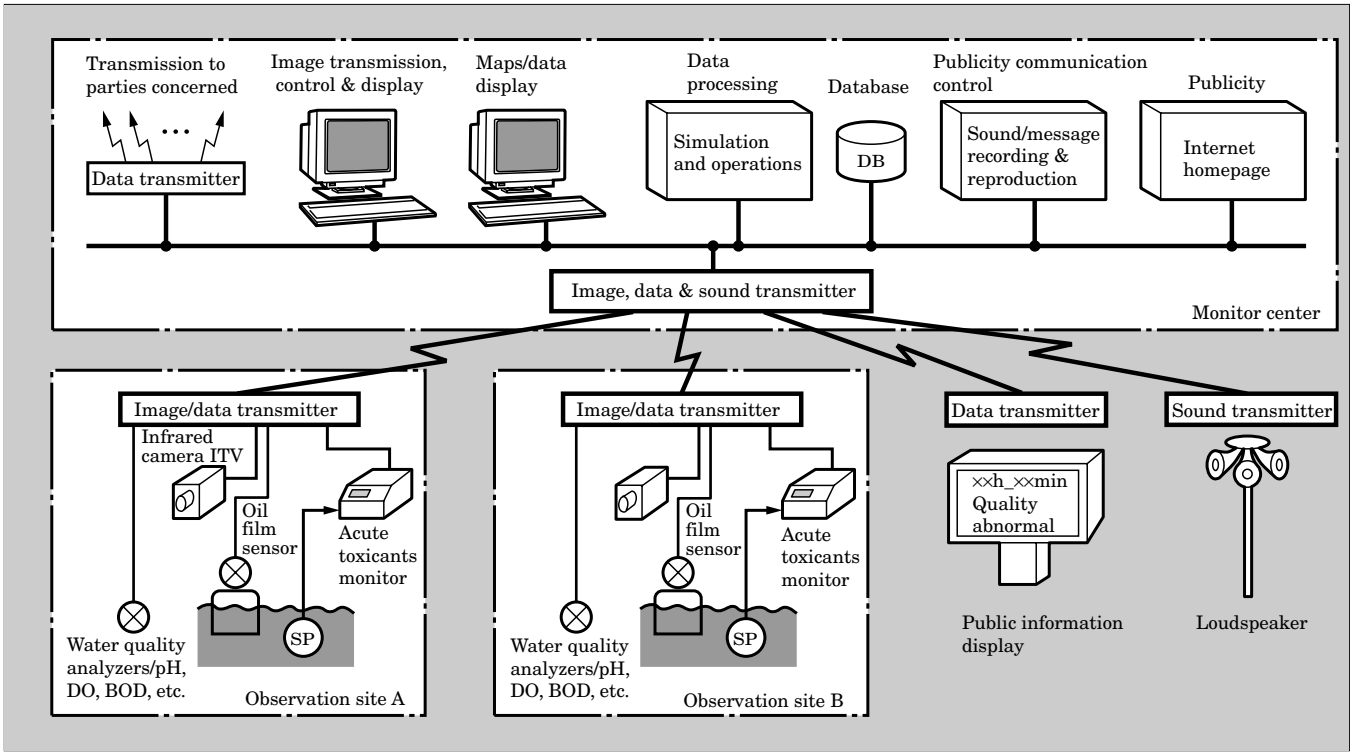
Biodegradation-resistant organic matter such as humic acid and fulvic acid in river water is disinfected by chlorine in the purification or sewage treatment plant. This process forms trihalomethane as a disinfection byproduct.

Fuji Electric developed a trihalomethane analyzer capable of continuous measurement of trihalomethane values in the purification and distribution processes of water systems, a simulation system for predicting increases in trihalomethane formation, and a management system based on both of the above to reduce trihalomethane. These plant solutions can be realized only by integrating sensor, computer, and communications technologies, and Fuji Electric is the only company in the world that possesses this original technology.

4.2 Sensor technology and river water quality management system

When there is a sudden abnormal change in water quality, it is important to detect that abnormality as

Fig.2 Block diagram for a wide-area water quality management system



soon as possible, determine measures to be taken based on the abnormality conditions, and implement those measures promptly. ITV monitoring of the intake and 24-hour observation by the staff of the behavior of fish bred in a water tank have conventionally been performed at water supply utilities as a means of self-protection. However, monitoring by the staff for an abnormality that may or may not occur at an unknown time is unreliable and uneconomical, and in particular, any reduction in night workers is a serious problem for the utilities. Therefore, there is strong demand for automated detection of water quality abnormalities. As abnormality occurrence has spread over a wider area, the necessity for detecting pollution in the total water system and communicating it to parties concerned has increased. In addition, the need to provide decision criteria for the implementation of countermeasures has increased the necessity of river-water quality management systems. Fuji Electric has supplied river-water quality management systems composed of various water quality abnormality detection sensors, data and picture transmission equipment, various displays, database equipment, and public information and communication equipment. Figure 2 shows the system configuration.

4.3 Development of bioassay

Generally, the method of using biological material and evaluating the biological response of an organism to a substance is called a bioassay.

The bioassay is a very effective method for the "evaluation of water toxicity to organisms," "primary screening of toxic substances" and "evaluation of the effect of water treatment," and has already been applied to drainage regulation and risk assessment in Europe and the USA. We suppose that its importance as a new method of water quality evaluation will increase also in Japan, adding to the conventional methods.

Fuji Electric will construct a database of biosensor sensitivity using microbes for various toxic substances and will also develop a higher sensitivity bioassay that can detect harmful chemical substances with concentrations as low as the chronic toxicity level. With this, we will establish a method for evaluating the influence of chronic toxicity from extremely small amounts of substances contained in drinking water.

5. Conclusion

Water and sewerage operations have a close relation with regional and residential environments, and at the same time, have a social responsibility. In addition, utilities are required to quickly respond to social changes and needs.

Fuji Electric will continue its contribution into the 21st century to the development of water and sewerage systems with the control and system technologies for water treatment plants, developed in anticipation of social needs.

In issuing this special edition, we would like to express our gratitude to the individuals and organization of the water and sewerage industry, and will be grateful for your guidance and support in the future.