Trends of Solution Technologies Related to Water Quality

Haruo Ito
Kiyoshi Kazama
Masakatsu Fukuda

1. Introduction

In Japan, when viewing urban areas and their water sources such as lakes, marshes, or rivers from the sky, you will see lakes and marshes greened by a water bloom, rivers that are thin, yellowish, and turbid, and waterworks taking in water from the downstream of rivers. As a result, most people feel uneasy about their water supply. The eutrophication of rivers, lakes, and marshes, chronic water shortages, and frequent problems with river water quality are all menaces to urban living. Moreover, people fear contamination of sewage and city water treatment after traffic accidents. There exists the possibility of toxicant effluence from the oils and chemicals carried by motor vehicles. Thus, various problems remain in the water environment. Our administration is promoting measures including the establishment of two laws to preserve city water sources, a plan for returning sewage to the upstream of rivers through superhigh-grade treatment, and the amendment to the River Act incorporating measures for environmental preservation.

Current topics concerning the water environment

Fig.1 Current topics of the water environment

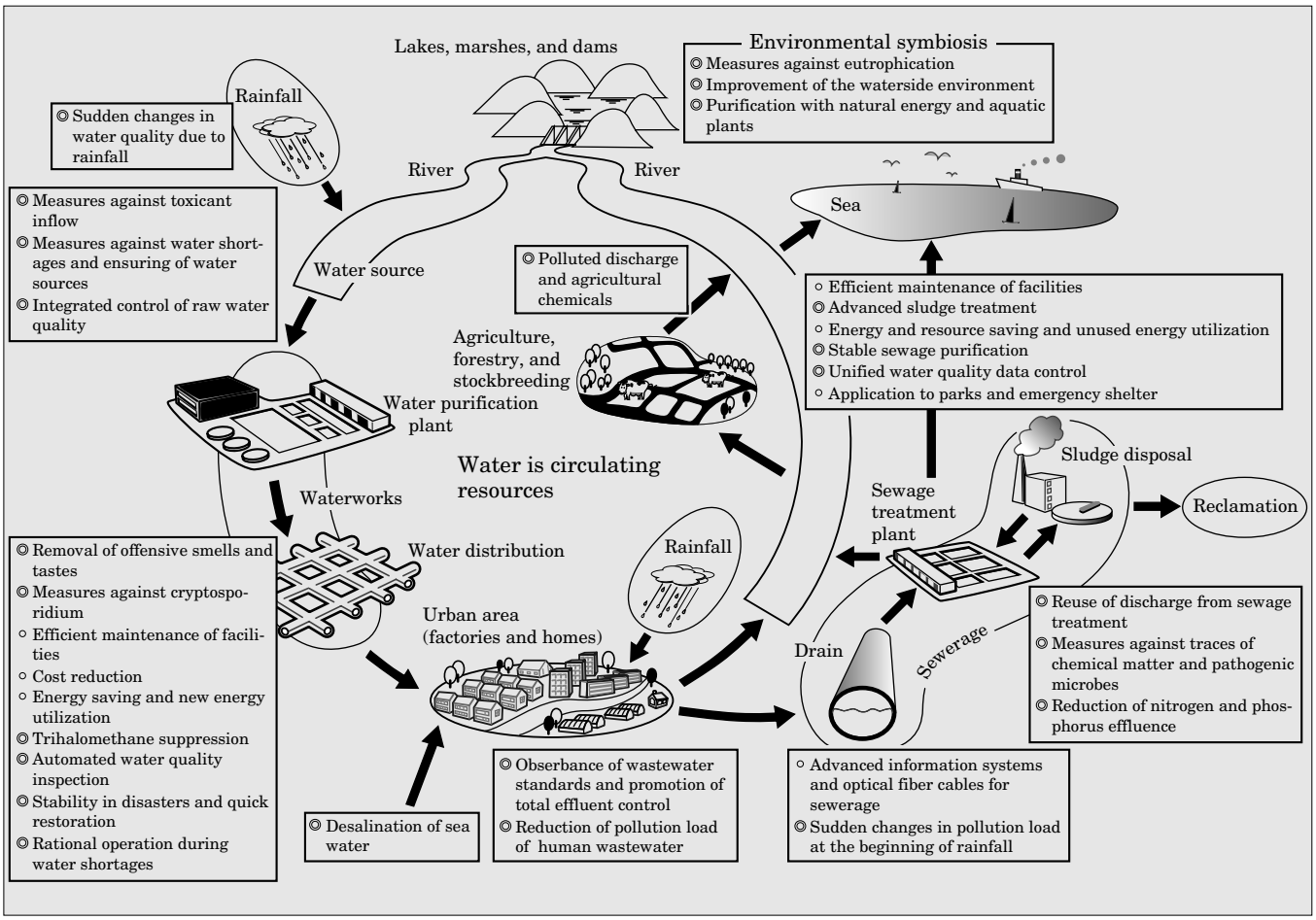
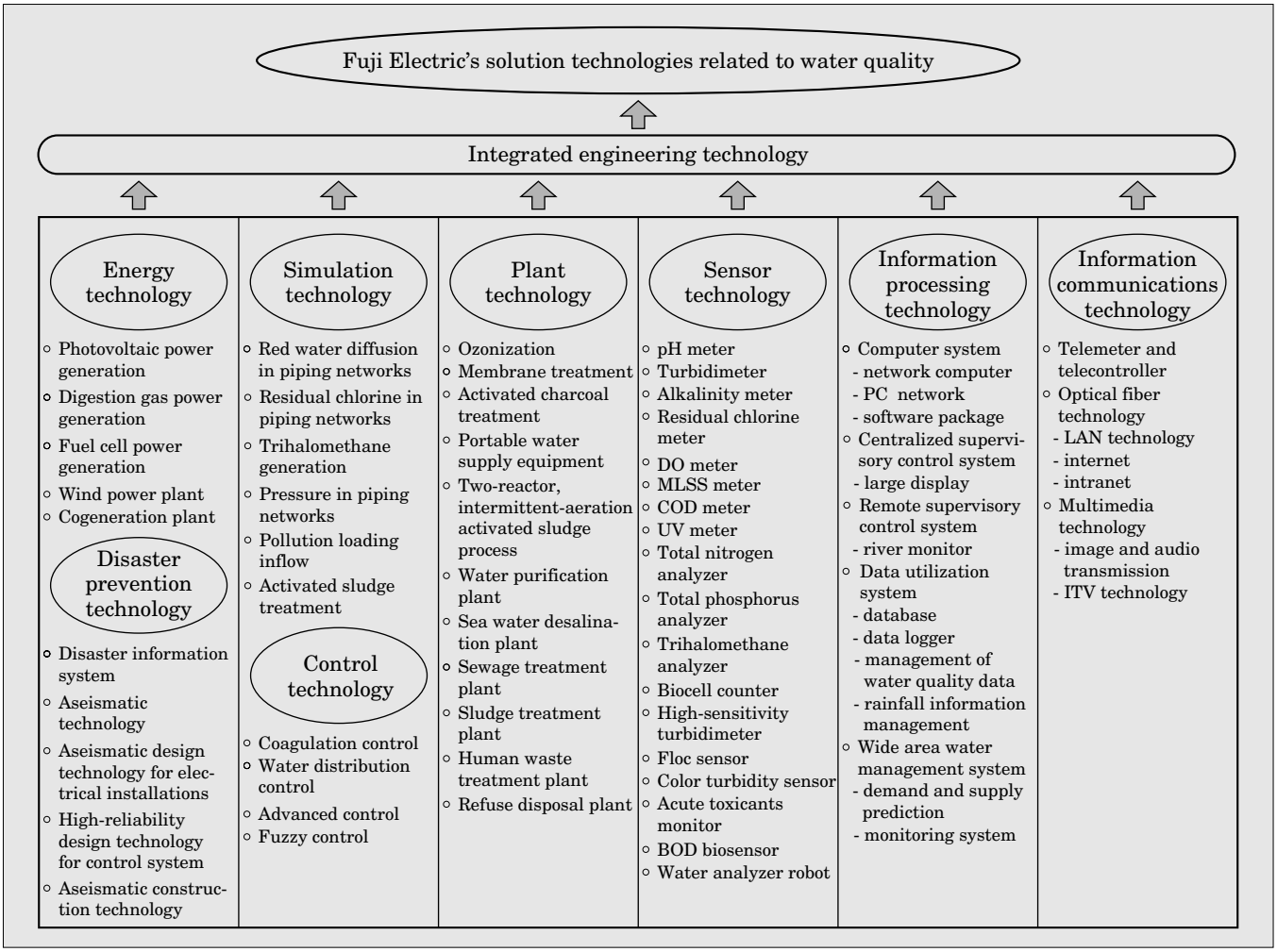


Fig.2 Scheme of Fuji Electric's solution technologies related to water quality



are shown in Fig. 1.

Amidst the growing trends toward the improvement and preservation of the water environment, Fuji Electric is tackling the problems of the water environment with various solution technologies used in energy, plant, process, and EIC (electric control, instrumentation, computer) system engineering.

We are researching clean energy (such as photovoltaic, digestion gas, and fuel cell power generation), new and advanced treatment and sewage disposal processes, an analysis and process simulation technique by using computers and a line of optimum EIC systems. In order to perform on-line water quality control to meet the increase in water quality problems, Fuji Electric has developed various sensors using the fundamental technologies of physics, chemistry, optics, and biology.

The scheme of Fuji Electric's solution technologies related to water quality is shown in Fig. 2.

This paper describes major problems in the water environment and the trends of Fuji Electric's solution technologies related to water quality.

2. Solution Technologies Related to Water Quality

Recently, the water quality of rivers, lakes and marshes for city water sources has been a problem. In 1996, there were no less than 300 cases of water quality problems which included toxicant effluence and unlawful waste abandonment in first-class rivers. Action was demanded on all fronts. In some urban districts in Japan, sewage treatment plants or factory drainage outlets are situated upstream of waterworks. Therefore, safety control of water quality sources is the most important priority of the water service.

Fuji Electric has developed an acute toxicants monitor that can continuously, sensitively, and automatically monitor the pollution of river, lake and marsh water used as raw water. We have also developed a river water management system that supports the river management staff when faced with water quality problems. The acute toxicants monitor, the key to the system, incorporates nitrifying bacteria

sensitive to toxicants. They are immobilized in a microbial membrane and then fit to a dissolved oxygen electrode. It can sense the activity of nitrifying bacteria from the change in dissolved oxygen consumption, thus detecting toxicants that are mixed in with the river water.

Generally, the presence of toxicants is often measured by observing the behavior of fish. However, this type of measurement has a disadvantage-impreciseness due to differences between individual fish. Features of the acute toxicants monitor include a detection sensitivity of approximately 10 times that of the fish measurement, instantaneous reaction, and a function of sample water storage at the time of toxicant reaction. The monitor can quickly and positively detect toxicants. A wide area toxicant monitoring system can be established by positioning the acute toxicants monitor at multiple points, such as specified plants on the river, irrigation channels, and sewage treatment plant discharge outlets, and then linking them with information communications, computers, and problem management software. This system has been introduced into at least 10 domestic waterworks and rivers with deteriorated water quality in the metropolitan area. In March 1997, Fuji Electric and the Public Works Research Institute of the Ministry of Construction, a joint developer, received the Water Environment Institute prize for this technology.

This system conforms to the River Act, soon to be amended to include regulations for environmental preservation.

The symptoms of mass infection caused by cryptosporidium that broke out in the Kanto district in 1996 is believed to have been caused by city water. The Ministry of Welfare and Health issued guidelines for tentative measures against cryptosporidium, and discussions on improvement of the control method for the water purification process began.

Fuji Electric has marketed a high-sensitivity turbidimeter capable of on-line measurement of 0.1 degrees turbidity at the outlet of a filter basin as described in the guidelines for tentative measures. The turbidimeter adopts a forward scattering particle counter method and can measure very low turbidity of 0.001 degrees and particles that are 0.5 μm or larger, which a conventional transmission or surface scattering method cannot measure.

Fuji Electric has developed a floc sensor and controller which can realize low-turbidity operation of a water purification process and optimum chemical injection control to suppress the excessive injection of coagulant. This control system uses the size of the microflocs measured in the mixing tank as feedback signals and controls the amount of chemical injection to maintain the size of the flocs. This results in a floc formation with high sedimentation and minimized chemical injection. The optimum quantity of chemical injection is considered to be an effective measure against cryptosporidium and Alzheimer's disease, which is suspected to be caused by excessive injection of an aluminum coagulant. The control system is already operating in several waterworks and is effective in removing suspended solids at the stage preceeding intermediate chlorination to reduce side products by disinfection.

In the field of advanced treatment technology for water purification, Fuji Electric has developed a high efficiency, high performance ozonizer using glass lined pipes and a two-sided cooling system. The ozonizer powerfully decomposes offensive smells and tastes and trihalomethane precursors in raw water, contributing to a safe and good tasting water supply. In parallel with the development of this equipment, Fuji Electric is promoting studies on fundamental technology and simulation technology for advanced treatment processes such as physical and chemical theories and a high efficiency ozone reaction treatment technique (joint research with Tokai and Hiroshima Universities).

In the field of water supply, physical water distribution control technologies, such as terminal pressure uniformity, grouping service terminals, and measures against water leakage, have been studied and introduced. Recently, control technologies for water quality to supply safe and good tasting water have also been added. As a solution to the control of service water quality and through joint research with the Japan Waterworks Association, Fuji Electric has marketed a service water quality monitor which can detect the slight coloration of service water. Conventional water quality monitors measure only a yellow coloration. The new monitor can measure on-line several types of coloration including red (iron rust), yellow (humus), black (manganese) and white (air). It has a higher sensitivity than a visual inspection. With this monitor, the measurement of color, turbidity, and residual chlorine can be automated and greatly reduce the inspection load carried by the water service. For example, there was a case in which the monitor detected residual matter flowing through the pipe to the faucets as a slight coloration when the water supply was restored. Thus, the monitor's strength lies in the inspection of service water after pipe work and recognizing any damages in piping after a disaster.

In the field of sewerage, Fuji Electric has developed a BOD biosensor which can measure a BOD (biochemical oxygen demand) value within 20 minutes instead of five days by previous measurement. The principle of measurement of the BOD biosensor is that it has trichosporon, an omnivorous yeast, immobilized in a membrane. Its dissolved oxygen electrode detects the process in which the trichosporon digests organic matter from organism decomposition in sample water and simultaneously consumes oxygen dissolved in the water.

Recently, attempts have been made to quickly measure organic loading in water flowing into sewers

with the BOD biosensor and utilize the data to control the volume of aeration and the extraction of sludge. A wide application of the BOD biosensors to sewage treatment plants is expected. The BOD value is an important organic pollution index for river water, and the BOD biosensor will increase in importance for monitoring water-environmental pollution and for continuous BOD monitors for wastewater discharge.

In the field of sewage treatment technology, Fuji Electric developed a two-reactor, intermittent-aeration activated sludge process (sold as a plant) that is effective in removing nitrogen and phosphorus found in sewage. The process has been successful in controlling the inflow of eutrophication matter into the water environment.

3. Future Prospects

To improve the water environment and water treatment, the administration has announced policies for a safe and good tasting water supply, construction of waterworks resistant to water shortages and earthquakes, preservation of the basin water environment, and prevention of closed water area pollution. In accordance with these policies, Fuji Electric's goal is the solution of the remaining problems of the water environment and offers broad solution technologies ranging from discrete to system products.

For effective measures against the eutrophication of closed water areas such as lakes and marshes, Fuji Electric is developing a system to improve lake and marsh water quality using flexible, film-shaped amorphous solar cells. In this system, a float with solar cells moored on the water supplies power to agitators, which circulate the river and marsh water and contributes to the maintenance of a sound ecosystem.

Even when an area's lifeline is toppled by a large earthquake or typhoon, the drinking water supply should have the highest priority. Quick restoration of the water supply facility is required. For this purpose, safety inspection of a substitute for the service water source with a portable acute toxicants monitor, ensuring satellite communications independent of ground systems, and command of dependable facilities with built-in battery systems are important.

Fuji Electric will concentrate an its sensor and information system technologies to obtain these goals.

When methods for improving the water environment and effective methods of water treatment are investigated, an accurate grasp of water quality conditions is fundamental. Fuji Electric possesses this fundamental understanding of the behavior of water quality constituents through its research and development of water quality sensors. We will further strive for the development of optimum water treatment equipment, control systems, and plant management techniques. On-line water quality sensors are indispensable to the automation of facilities to reduce operator burden and maintain reliable operation. We will also promote improvement of their performance and the development of new products.

Recently, public attention has been focused on the detection of toxicants and pathogenic substances mixed in raw water and inflow wastewater. One such topic was the detection of colon bacilli in raw water. In 1996, diseases caused by the O-157 colon bacilli and cryptosporidia, a pathogenic microbe, received national attention. In particular, direct detection of the cryptosporidium is difficult, and therefore, measurement of the number of colon bacillus groups as an index to infer pollution is necessary. The detection of colon bacillus requires two or more days using the official analytical method, and the shortening of measuring time is the goal of monitor development.

In sewerage, a reduction in the eutrophication of the water environment by denitrification and phosphorus removal in water treatment plans is promoted. Recently, however, in some treatment plans, denitrification was reduced by an obstruction to bionitrification. Harmful matter discharged by a chemical plant was suspected to be the cause. In the future, acute toxicants monitoring systems will be used in sewerage.

4. Conclusion

In this paper, some of the solution technologies relating to water quality which Fuji Electric is striving to develop were described. These include sensor, plant, control, and information processing technologies to solve the problems of the water environment. Solution technologies for the water environment will further develop and Fuji Electric will adopt the results to speed up the improvement of the water environment.

On the occasion of this special issue, we thank the parties involved with the water environment, waterworks, and sewerage. We would appreciate any further guidance and support.