22. NEW TRENDS OF WATER TREATING TECHNOLOGY

~ On research for development of high-efficiency purification technology (ACT21) ~

Presenter

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ABSTRUCT

Research for development of high-efficiency purification technology (ACT21 –Advanced Aqua Clean Technology for 21st Century) is a large-scale R&D program which was implemented, with a subsidy from the Ministry of Health, Labor and Welfare, over a period of 5 years from the fiscal year 1997 to 2001. This project was started with a view to solving many different problems and tasks such as creating new technologies suitable to requirements of new age, while conforming to the policy target of cost reduction, in planning renewal of purification facilities, at this time when the water services in Japan marked a history of over 100 years and got into a period for renewal of facilities, a problem of water quality pollution by trace harmful chemical substances, cryptosporidium, etc., meeting people's needs for safe potable water, etc.

In this report, we will describe an outline of the research achievements of this project implemented over a period of 5 years.

1. Introduction

Japan Water Research Center (JWRC) implemented from the fiscal year 1991 to 1993, a project named MAC21(Membrane Aqua Century 21) that researches were made on application of membrane filtration technology to the field of water services.

Moreover, a project named MAC21 Advanced Treatment was implemented during the period from the fiscal year 1994 to 1996 and at that time, researches were made for expanding the scope of application of membrane filtration technology to advanced water treatment intended not only for removal of turbidity and disinfection but also for removal of insecticides and substances with foul smell.

After those research projects, high-efficiency purification development study was implemented for a period of 5 years from the fiscal year 1997 to 2001.

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The background of the above is as follows:
The water industry in Japan has a history of over 100 years since water supply was started in Yokohama City in 1887, and now the time has come for renewal of facilities, from a problem of deterioration of water facilities. In that case, the purification facilities, etc. are often planned to be supplemented with new functions, in other words, high-efficiency technologies have come to be looked for.
Here, high-efficiency technologies are interpreted as technologies with higher reliability of treatment, enabling reduction of equipment size or requiring a smaller surface area for installation, enabling more energy saving, capable of promoting labor saving in control, enabling simplification and cost reduction, and having higher pollutant removing performances, compared with conventional technologies

A research project was implemented, by globally evaluating such technologies and defining them as high-efficiency technologies.

2. The research system for the project.

This project was implemented by organizing on JWRC's initiative, a joint research system by the government, the academic circle and the private sector, with cooperation from Institute of Public Health, universities, water works and companies who are members of this Center, and other related associations, under the guidance of the Ministry of Health, Labor and Welfare.

This project was promoted by the following committee organization.

In the first place, Coordination Committee and Research Committee provide general guidance on the execution of this project.
Here, Coordination Committee is a committee for discussing matters regarding the project budget and operation, etc., while Research Committee discusses the contents of researches.

Under those Committees are established 7 Study Groups or Study Groups No. 1 to No. 7, for actually working on the 7 research themes as follows.

- Study Group No. 1: "Effective purification of water from lake, marsh and reservoir water sources"
- Study Group No. 2: "Effective purification of water from river and tributary water sources"
- Study Group No. 3: "Application of new membrane filtration technology"
- Study Group No. 4: "Development and practical use of alternative disinfection"

- Study Group No. 5: "Efficient disposal of drainage from water treatment plants"
- Study Group No. 6: Methods for diagnosis and improvement of water treatment facilities"
- Study Group No. 7: "Improvement of measuring and control instruments at treatment plants"

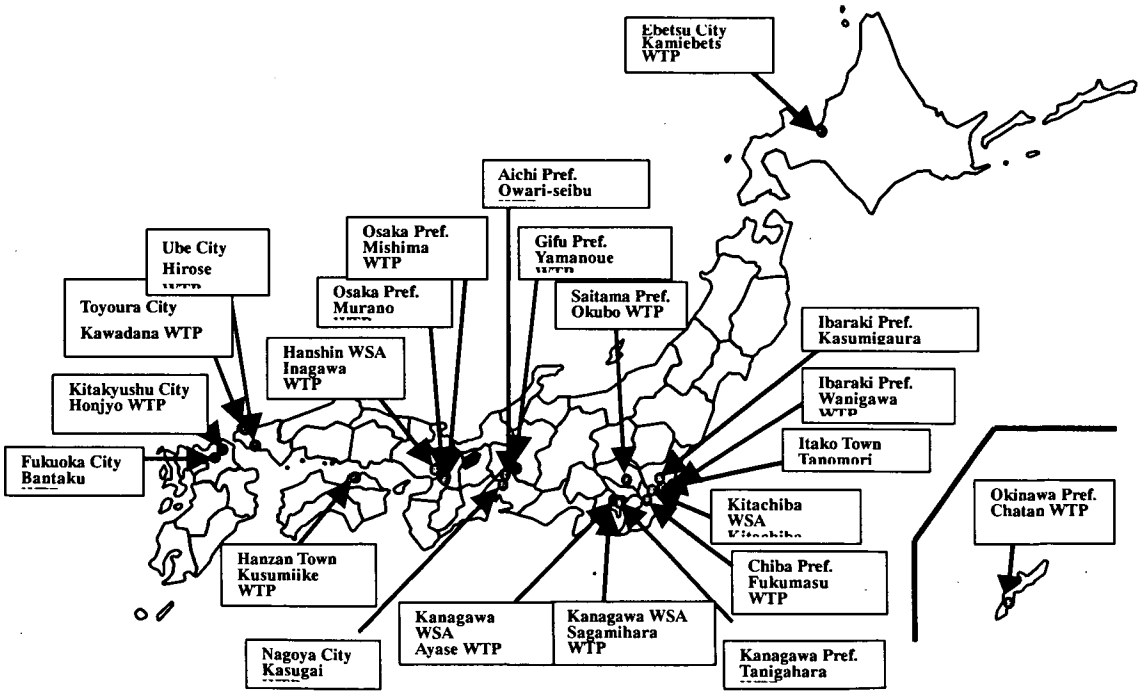
In addition, we established Research Project Committee to take charge of exchange of information among companies, Working Group for studying new coagulant, Literature & Extract Committee, Results Summarizing Committee for summarizing results of studies by the respective Study Groups, and Working Group for preparing technical data.

As modes of implementation of the studies, the studies were conducted in the form of either joint study, individual study or basic study.

A joint study is a study made jointly by all related organizations participating in this project.

An individual study is a study made by the water works or private enterprise belonging to the respective Study Groups No. 1 to No. 7, based on the research policy stipulated by the respective Study Groups.

Experiment Sites



A basic study is a study made by researchers of university, etc. belonging to the respective Study Groups, for the purpose of establishing foundation technology on the research subject to be taken charge by the Group concerned.

As for places of experiments, the experiments were conducted at 22 purification plants all over Japan from Hokkaido in the north to Kyushu and Okinawa in the south. (Refer to the map above)

3. The contents of study of the 7 research themes and achievements.

1) "Effective purification of water from lake, marsh and reservoir water sources" made by Study Group No. 1.

For treating raw water from lakes and marshes by conventional coagulation/sedimentation and rapid filtration method, there are a variety of problems to be solved.

The first problem is fluctuations of raw water quality.
In the case of raw water from lakes and marshes, there are increase of algae due to eutrophication in particular, and rise of pH resulting from it, and they cause various problems in the treatment, such as prevention of coagulation, clogging of filter, etc.

Moreover, there is a problem of cryptosporidium these days.
To prevent leakage of cryptosporidium, it is necessary to treat the water until the turbidity becomes extremely low.
The turbidity of treated water is provisionally stipulated as approximately 0.01 NTU, as target value for preventing leakage of cryptosporidium.

It is therefore necessary to establish technologies enabling stable and effective treatment for protection against such problems, so study was made using test plant for the following items.

A. Examination of the type of coagulant
   At present, aluminum based coagulants are widely used in Japan. On our side, we studied possibility of application of iron based and organic high polymer based coagulants.

B. Examination of filtration rate
   We also studied possibility of realizing rapid filtration at 300 m/day or over, for the purpose of achieving high efficiency.

In addition, composition of filter layer and washing method of filter sand

were also studied.

This test plant, which is located in Fukumasu Purification Plant in Chiba Prefecture, works with a treating system of conventional filtration by coagulation/sedimentation, with a treating capacity of approximately 1,000 m^3/day.

This experiment was conducted as a joint study.

The main points which became clear as a result of this experiment are the following:

- Ferric chloride which is an iron based coagulant is sufficiently fit for practical use, because its treating performance is about equivalent or slightly inferior, compared with polyaluminum chloride which is an aluminum based coagulant.
- In the case where an iron based coagulant is used in combination with a high-polymer coagulant, for rapid filtration, the stability improves compared with the case of independent use of an iron based coagulant.
- As for rapid filtration, it was indicated that filtration at a rate of 300 m/day is realizable, except for the season during which the water temperature drops and the season when the amount of algae in the raw water increases.

2) "Effective purification of water from river and tributary water sources" studied by Study Group No. 2.

The tasks or countermeasures to be solved or taken for raw water from river and tributary water sources are basically the same as those in the case of raw water from lake, marsh and reservoir water sources, as far as the problems of fluctuations of raw water quality or cryptosporidium are concerned.
However, the raw water from river and tributary water sources is characterized by large fluctuations of water temperature and sudden change of water quality due to precipitation or melting of snow.

Study Group No. 2 also studied treatment made by combination of a conventional treating system with membrane filtration process, from the viewpoint of improvement of efficiency.

The test plant, which is located in Murano Purification Plant in Osaka Prefecture, also works with a treating system of conventional filtration by coagulation/sedimentation, with a treating capacity of approximately 2,000 m^3/day.

This experiment was also conducted as a joint study.

The main points which became clear as a result of this experiment are the following:

- Adding a high-polymer coagulant to ferric chloride, it can make a treatment equivalent to that by polyaluminum chloride.
- As filtration rate, a rate of 350 m/d can be achieved during a period of high water temperature and a rate of 250 m/d during a period of low water temperature, under the standard conditions of 48-hour continuous filtration and turbidity of treated water of 0.1 degree (approximately 0.01NTU)or under.
- As for combination of membrane filtration process with conventional treating system, we found that good water quality can be obtained with a high flux (flow rate) of membrane filtration.

In addition, there are other experiments for improvement of efficiency conducted as individual studies by Study Group No. 1 and Study Group No. 2 as follows:

- Development of efficient underdrain system.
- Study of counter-current dissolved air flotation/filtration process.
- Coarse filtration using fiber filter medium.
- Acti-Flow process. This process adds sand to the water treatment as a coagulation process. This sand settles dirt suspended particles and bacteria.
- Combination with efficient biological treatment.

Also in each of those experiments of new technology, more efficient treatment could be made compared with the conventional treating system.

3) "Application of new membrane filtration technology" studied by Study Group No. 3.

Membrane filtration technology is believed to be the purification technology which will constitute the main stream in the 21st century.

On the other hand, we may also mention the following points as problems to be solved for its application to new fields:

- Problem of stability of operation, for enabling long-term operation by controlling fouling of membrane.
- Realization of high flux (flow rate).
- Technology enabling not only removal of turbidity and disinfection but also removal of soluble matters such as organic matters, substances with foul smell, etc.
- Application to large-scale purification plants also forms a subject of

study for the future, because membrane filtration facilities are adopted mainly in small-scale purification plants in Japan today. (Introducing situation as of June, 2002: 280 places, about 137 thousand m^3/day)

On those points, we made the following studies:

A. We studied reduction of substances causing fouling with pretreatment and, as study for removing soluble matters, studied application of coagulation/sedimentation and fiber filtration, biological activated carbon, pre-ozone treatment, etc.

B. As study of membrane filtration process itself, we developed vibration type membrane separator and membrane materials such as ozone resistant membrane, ceramic membrane, polyvinylidene fluoride membrane, etc. and studied stability of operation of NF membrane, etc.

Those studies expanded possibility of application of membrane filtration technology to new fields.

4) "Development and practical use of alternative disinfection" studied by Study Group No. 4.

At present, chlorination is legally obligated for potable water supply in Japan for the advantages of accurate treating effect and residual property, etc.
In recent years, however, a problem of disinfection by-product such as trihalomethane, etc. was actualized, with the progress of pollution by organic matters of water sources for potable water supply.
Moreover, for protection against chlorine resistant pathogens such as cryptosporidium, etc., putting to practical use of disinfection technology using substitute disinfectant for chlorine has become an important task.

For that reason, we studied disinfecting effect, method of application, equipment specifications, cost, etc., on chlorine dioxide, chloramine, UV, and ozone which are substitute disinfectants, combination of a plural number of disinfectants, and physical removal of pathogens, from the viewpoints of the following.

- Establishment of pathogen control system.
- Establishment of individual disinfection technologies.
- Establishment of disinfection system also applicable to water supply and distribution systems.
- Protective measures against newly produced and/or revived microbes.
- Positioning of oxidizing in purification of water as disinfection system.

To be concrete, we conducted studies as follows:

- A study regarding putting to practical use of ultraviolet ray, chlorine dioxide, chloramine and ozone.
- A study on the method for removing cryptosporidium in waste water by filter washing.
- A study regarding disinfection with sodium hypochlorite generated at high concentration.
- A study on technology for removing microbes leaking out from granular activated carbon filter, etc.

By collecting the achievements of this Study Group No. 4, we prepared a practical document entitled "Manual regarding putting to practical use of substitute disinfectant".

We believe this manual will help promote putting to practical use of disinfectants other than those by chlorination.

5) "Efficient disposal of drainage from water treatment plants" studied by Study Group No. 5.

As current problems in waste water treatment at purification plants in Japan, we may enumerate as follows:

- Increase of volume of sludge due to increase of volume of coagulant used in purification, and difficulty of waste water treatment due to poor condensability.
- Limited capacity in the place of disposal.
- Necessity of methods for treatment & disposal taking account of energy saving and material circulation, etc.

For that reason, this group conducted the following studies:

- Research on the quality of returned water.
- Development of condensing & treating technology by membrane filtration.
- Protective measures against cryptosporidium in waste water treatment.
- Study of waste water treating system introducing new energy.

Those studies led to development of an efficient treating technology with load-reduction for environment.

6) "Methods for diagnosis and improvement of water treatment facilities" studied by Study Group No. 6.

Study Group No. 6 set a target of presenting methods for diagnosis of functions and improvement which are practical and easy to understand, by

making a general study on the renewal and improvement of purification facilities constituting the background of this project.

As changes in the social situation surrounding the water industry today, we may mention increase of demands for renewal and requests for diversification and sophistication of water services, improvement of business efficiency, reduction of environmental load, etc.

We therefore studied ideal way for managing functions of purification facilities, at the same time, considering the fact that those wide variety of tasks and targets vary depending on the situation and conditions at the respective water utilities, we collected cases of diagnosis widely, not only on functional diagnosis of water facilities based on arguments from the viewpoint of engineering, but also on water business as a whole including finance, and prepared a "Collection of cases of diagnosis and evaluation of water business".

Furthermore, we also prepared a "Collection of data on purification facilities", for the purpose of supplying information on purification facilities useful for improvement of efficiency to make up for depression of functions of purification facilities.

Those "Collection of cases" and "Collection of data" make it possible for the respective water utilities to select optimal methods of diagnosis and evaluation.

7) "Improvement of measuring and control instruments at treatment plants" studied by Study Group No. 7.

As for measuring & control technologies in recent times, a variety of equipment and systems are developed with electronic control in particular as nucleus, and introduced in a wide variety of technical fields.

Various technological reforms using electronic equipment are being made also in water purification plants. However, measuring & control technologies are introduced in a way to be added to purification technology in many cases and, for that reason, it also produces some negative effects such as troublesome maintenance control, complication of management and control systems, cost increase, etc.

To solve such problems, Study Group No. 7 intended to promote labor saving in management, high reliability, stability, and reduction in size of facilities, by utilizing latest measuring & control technologies.

To be concrete, new measuring & control technologies have been developed, through evaluation of basic performances of low-concentration turbidimeter and study regarding continuous measurement of chlorine dioxide and chlorous acid ion.

Moreover, as study for the entire Study Group No. 7, a study was made on the building of a water facilities operation system fully utilizing information technology.

4. Conclusion

The 5-year study for development of high-efficiency purification technology was completed, and a meeting for announcing its achievements was held in this July. Those achievements are planned to be published by the end of the current fiscal year under the title of "New Purification Technologies".

About the influences which those achievements may eventually have on the water services in Japan, we are considering as follows:

The degree of freedom in the design of water facilities greatly expanded and much of the restrictions on introduction of new technologies were abolished, with the enforcement in 2000 of "Ordinance stipulating technical standards of water supply facilities (water supply facility standards)", the contents of which became performance standards. As a result, the chance for putting to practical use of the research achievements of ACT21 became very large and, in fact, we have already received inquiries accompanying concrete facility plans from several water utilities.

We expect that selection of new technologies will be made also in the future, and wish to continue working with new projects, on problems which remained unsolved in ACT21.