New Research Project on Drinking Water Quality Management

Masahiro Fujiwara
Japan Water Research Center

1. Introduction

Currently, a considerable number of water purification plants in Japan are due for renewal within the next ten years. Also, when comparing the current water resource quality with that at the time of plant construction, the ratio of dam water (discharge/storage) to surface water relatively increased, and water quality has worsened due to development in the surrounding region. Furthermore, as is the case with cryptosporidium, there is a problem with pathogenic microorganisms that are resistant to chlorine disinfection. Meanwhile, in order to respond to consumer needs for safe and palatable water, contamination counter-measures against odor-causing compounds, including 2-MIB and geosmin, are vital to the water utilities.

The Japan Water Research Center (hereinafter JWRC) has employed the following kinds of methods in water technology research and development for about the past 20 years. Using Grant-in-Aid for Scientific Research from the Ministry of Health, Labour and Welfare, and research contributions from private companies as funds, the JWRC has carried out large-scale research projects through cooperation of private companies, water utilities and scholars. In these industry-utility-academia research and development projects, the research objective was to develop a technology that could actually be used in practice. A good example of the success of this research is membrane filtration technology. The researched and developed membrane filtration technology was put into practical use, and is now in use at many water purification plants around the country. The aforementioned industry-utility-academia research system is unique to Japan, and it is thought to be a method well suited to Japanese society.

2. History of research projects

As shown in Table-1, with regards to water purification technology, research started in 1991 with Pilot Plant for MF/UF Membrane (MAC21), then went on to Pilot Plant for NF Membrane (Advanced-MAC21). Next came R&D on High-Efficiency Water Purification Technology (ACT21). Following that there was R&D on Sustainable Water Purification Technology (***e-Water***), which finished the fiscal year before last, and now we have the 5th project, R&D on the Establishment of Advanced Water Purification Technology for Safe and Palatable Water (***e-Water II***). Pipeline technology research and development projects also began in 1996, and after finishing research on a water service system without receiving tank

Table-1 Research & Development Projects

Year	Project Name	Content
1991～1993	MAC21	Pilot Plant for MF / UF Membrane
1994～1996	Advanced-MAC21	Pilot Plant for NF Membrane
1997～2001	ACT21	R&D on High-efficiency Water Purification Technology
2002～2004	e-Water	R&D on Sustainable Water Purification Technology
	Epoch	R&D on Movement of Suspended Solid in Pipeline
2005～2007	e-Water II	R&D on the Establishment of Advanced Water Purification Technology
	New Epoch	R&D on Pipeline Diagnosis Technology

and an earthquake-resistant pipeline system, work began in 2002 on R&D on Movement of Suspended Solid in Pipeline (***Epoch***). R&D on Pipeline Diagnosis Technology (***New Epoch***) has been ongoing since 2005.

The development and diffusion of membrane water purification plants are a representation of the success originating from these research and development projects. Since the introduction of 7 plants (600m^3/d) around the country in 1993, the number of those plants has grown year by year and as of now (March 2006), the number has reached 550 plants with an accumulated plant capacity of 622,650m^3/d.

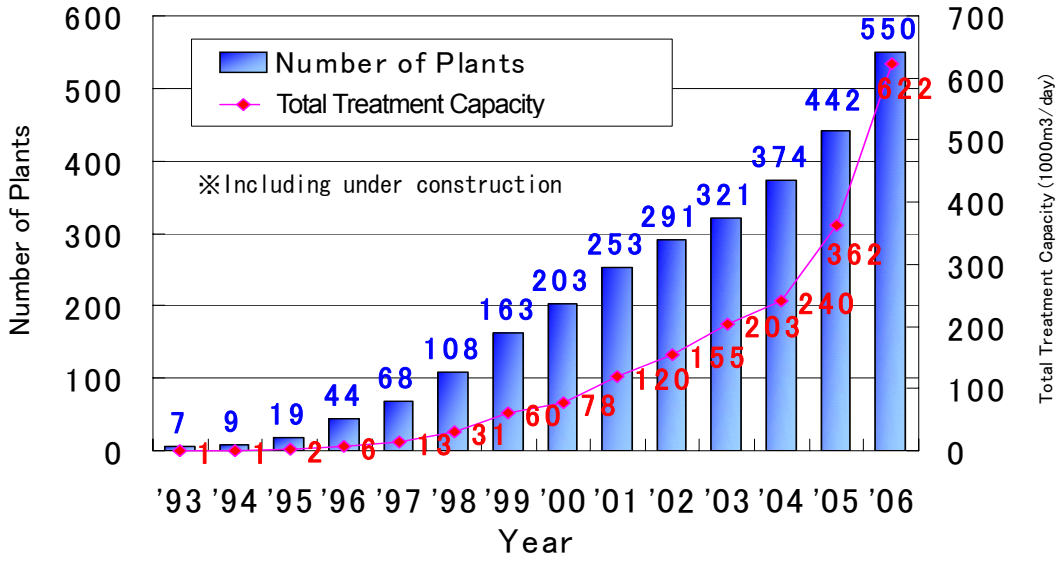

Figure-1 Membrane Water Purification Plants in Japan (researched by JWRC in 2006)

3. Recent Research Results and Ongoing Research Projects

3.1 Research Project Organization and Scale

To facilitate its smooth implementation, the ongoing water purification research project has been organized into 4 committees such as The General Research Committee for integration of research contents. There are five research sub-committees under the committee for each specific research theme. The pipeline technology research project has been organized so that for each research theme, two research sub-committees are working under the Pipeline Research Committee.

With regards to the scale of the projects, the water purification technology project involves 32 private companies, 18 university scholars, and 25 water utilities and related organizations. The number of researchers exceeds 150. The pipeline technology project involves 14 private companies, 7 university scholars, and 16 water utilities. The total research budget is US $6,000,000, which comprises of direct expense only. (***e-Water II*** makes up US $5,000,000 and ***New Epoch*** makes up US $1,000,000.)

3.2 Water Purification Technology Research Contents

The fundamentals of the 3-year ***e-Water*** Project starting in 2002 were summarized and published as Guideline for introduction of large-scale membrane filtration facilities, Guideline for use of iron-based and

organic-polymer coagulants, Guideline for introduction of Ultraviolet-Rays (UV) disinfection, and Manual of integrated treatment for sludge from water purification plant and sewage treatment plant.

The ongoing 3-year ***e-Water II*** Project, which started in FY2005, is conducting a research on the following themes:.

(1) Research on a Suitable Purification System in Accordance with Raw Water Conditions

Raw water conditions nationwide are classified into groups based on water quality. They are then, through a water purification system implementing a combination of unit water purification processes, evaluated on such criteria as safety of treated water quality, sustainability and manageability, economical use of energy, a Life Cycle Assessment taking into account reduced environmental burden, drainage and sludge treatment process, and monitoring and instrumentation systems, and suitable water purification process guidelines are then investigated.

- The classification of treatment systems and the establishment of desirable treated water quality levels
- The study of coagulant dosage, mixing conditions and pretreatment methods with regard to the combination of membrane filtration treatment and iron-based coagulant (Plant experiment)
- Measurement, analysis and evaluation of raw water quality
- Evaluation of water quality and function in each purification process
- Establishment of Life Cycle Assessment (LCA) technique

Photo-1 Pilot Plant

(2) Research on Odor-Causing Compounds for Safe and Palatable Water

Traditionally, 2-MIB and geosmin have been stated as being the representative odorants. However, there are instances where even though these two substances have not been detected in the raw water, odors still occur after the purification treatment, or at the water taps. It may be that odor-causing compounds present in the raw water are denatured in the chlorine process, and then forms some sort of odorants.

Photo-2 Odor-Causing Compound Detection Equipment (VOC Monitoring System)

In order to supply safe and palatable water, we are carrying out research which will improve on safety and

comfort through such means as promptly detecting unknown odor-causing compounds, changing the method of water intake, and advancing the water purification process.

- Simulation by means of water quality prediction models
- Creation of hazard maps
- Examination of counter-measure technologies against odor-causing compounds (including 2-MIB, geosmin)
- Implementation of online observation experiments using VOC monitoring system

3.3 Pipeline Technology Research Contents

The 3-year ***Epoch*** Project, which started in FY2002, elucidated the condition of the movement of suspended solid in the pipeline. In addition, research was carried out on the effective usage of energy by small generator in the pipelines, and practical apparatus was developed.

Regarding the ongoing 3-year ***New Epoch*** Project, "R&D on Pipeline Diagnosis Technology", which started in 2005, the following themes are being researched.

(1) Research on Water Quality Deterioration in Decrepit Pipeline and Preventive Measures

Using the decrease and disappearance of residual chlorine as a main indicator, investigate methods to diagnose and evaluate the deterioration status of inside the pipes, and developing a pipeline function diagnosis technology in terms of water quality.

- Investigation of the relationship between water quality and decrease in residual chlorine
- Investigation of the relationship between pipeline material and decrease in residual chlorine
- Examination of actual water quality in decrepit pipelines
- Examination of water deterioration prevention by improving the Langelier's Index

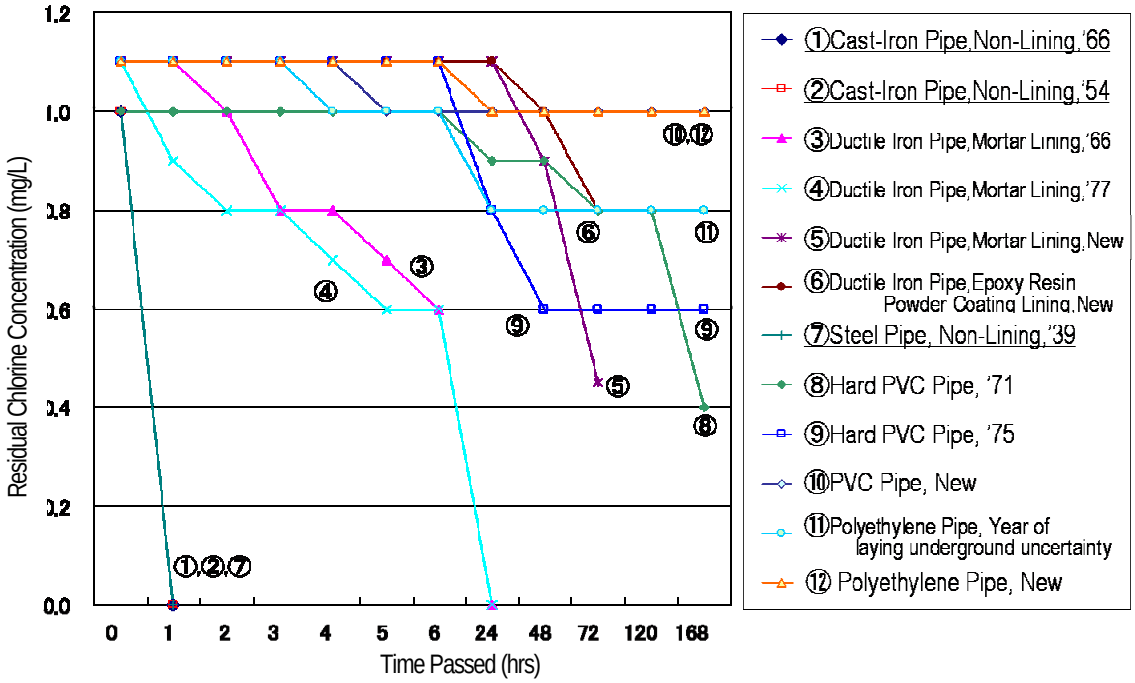

Figure-2 Changes over Time in Residual Chlorine Concentration

With regards to the investigation into the relationship between pipeline material and the decrease in residual chlorine, samples were taken from underground pipelines of various types that had been constructed in different years. These pipes were filled with water (residual chlorine concentration 1.0-1.2mg/l, pH7.0). The changes over time in residual chlorine concentration and various water qualities were measured. The results confirmed that the non-lining cast-iron pipe and the non-coated iron pipe showed a trend of decreased residual chlorine.

(2) Research on Diagnosis Technology of Decrepit Pipeline

By making use of statistical as well as physical methods, develop a new diagnostic technology to easily and efficiently determine the condition of underground pipeline, and consider its application to existing pipeline.

- Study of existing pipeline diagnosis technology
- Examination of diagnosis method of decrepit pipeline using statistical method
- Basic research towards No-Dig diagnosis

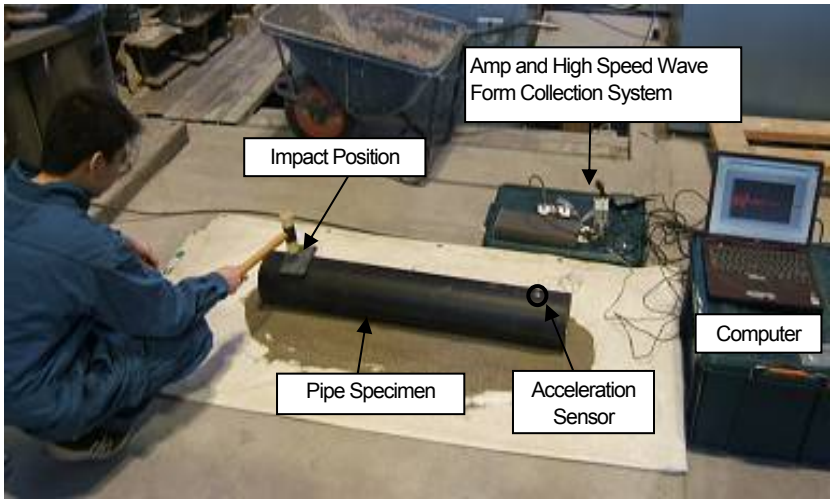

Photo-3 Impact-elastic wave method Experiment

4. Conclusion

The objective of the ongoing study is to create suitable water purification process selection guidelines for various raw water conditions, conducted research on counter-measures for odor-causing compounds in order to supply palatable water, and carry out research on pipeline diagnosis technology for systematic and efficient pipeline renewal, and deliver safe and palatable water. We intend to continue to endeavor to achieve our objectives, and utilize the knowledge gained from every participant to further our research.

2-8-1 Toranomon Minato-ku Tokyo 105-0001, Japan e-mail:fujiwara@jwrc-net.or.jp

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New Research Project on Drinking Water Quality Management

Masahiro FUJIWARA
President
The Japan Water Research Center

Japan-U.S. Governmental Conference on Drinking Water Quality Management and Wastewater control in 2007, Okinawa

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Outline

Tripartite Industry-Utilities-Academia R&D on Water Technology

- History of JWRC R&D Projects
- Research Budget
- Projects and its Results

  "e-Water" & *"e-Water II"* for Purification Technology

  "Epoch" & *"New Epoch"* for Pipeline Technology

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Previous Projects

JWRC has a 20-year experience with conducting large-scale research projects.

- Research subsidies from the Ministry of Health, Labour and Welfare
- Research contributions from private companies
- Objectives: Development of “practical technology”
- Successful Example: Membrane Filtration Technology with high efficiency

WHAT DOES JWRC DO?
JWRC, a non-profit public organization being established in1988, has contributed to the development of water-related technology in Japan by conducting information collection, research and development activities on the overall field of waterworks.

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Large Scale R&Ds

Term	Project Name	Themes
1991– 93	MAC21	Pilot Plant for MF / UF Membrane
1994– 96	Advanced-MAC21	Pilot Plant for NF Membrane
1997– 2001	ACT21	R&D on High-efficiency Purification Technology
2002– 04	*e-Water*	R&D on Sustainable Purification Technology
	Epoch	R&D on Movement of SS in Pipelines
2005– 07	*e-Water II*	R&D on Establishment of Advanced Purification Technology
	New Epoch	R&D on Pipeline Diagnosis Technology

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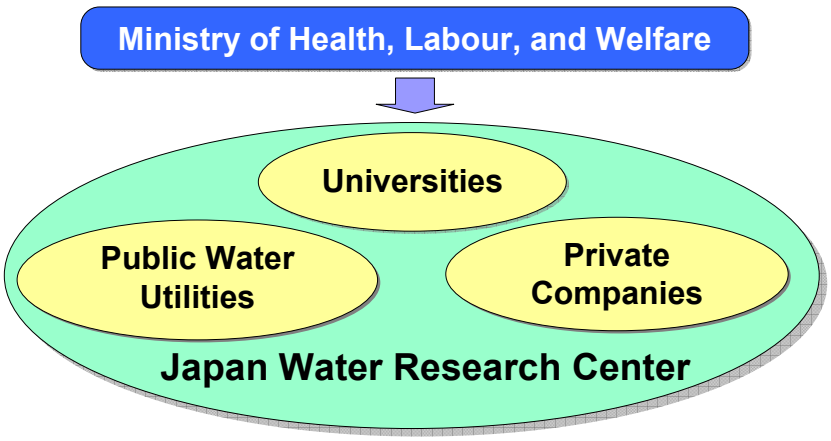
Organization



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"e-Water" Pilot Plant

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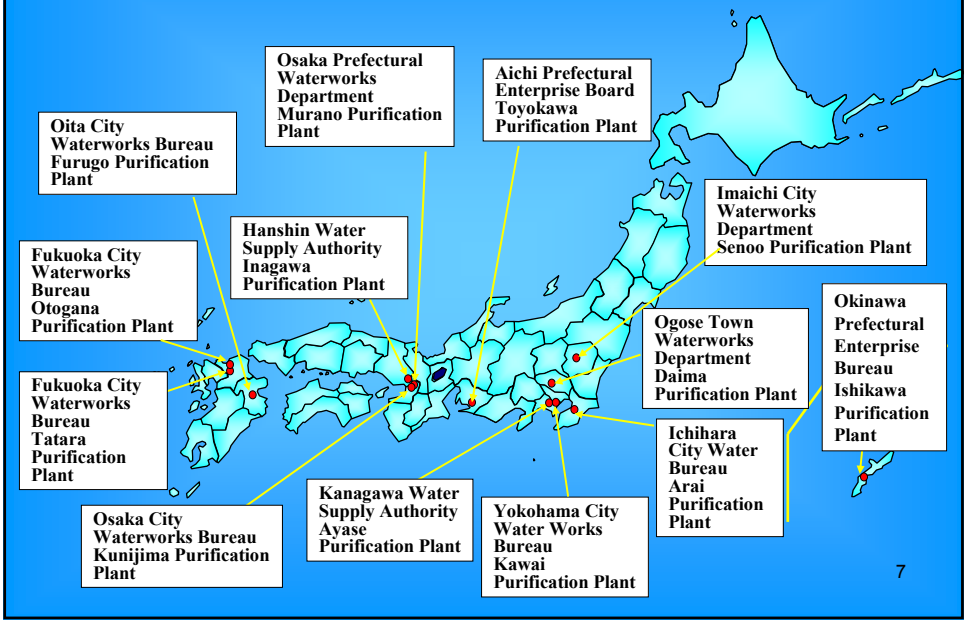
"e-Water" Experimental Fields



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"Epoch" Experimental Pipeline Facility

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Budget and Researchers (2005- 07)

- **Total Budget for Direct Expense Only: US$6 million**
  - US$5 million for *"e-Water II"* (Purification Technology)
  - US$1 million for *"New Epoch"* (Pipeline Technology)
- **Participating Organizations**
  - *"e-Water II"*: 32 Private Companies
    18 Scholars
    25 Water Utilities (incl. Related Organizations)
  - *"New Epoch"*: 14 Private Companies
    7 Scholars
    16 Water Utilities
- **Number of Researchers**: approx. 200

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Necessity and Background

Purification Facility

Challenges

- Large Number of Decrepit Facilities
- Strengthen Water Quality Standards
- Water Resource Quality → Change
  Water Resource Trends: From River Surface Water to Water from Dam Reservoirs
  Cryptosporidium
  Odor-Causing Compound

Research Target

Development of Advanced and Efficient Purification Technology

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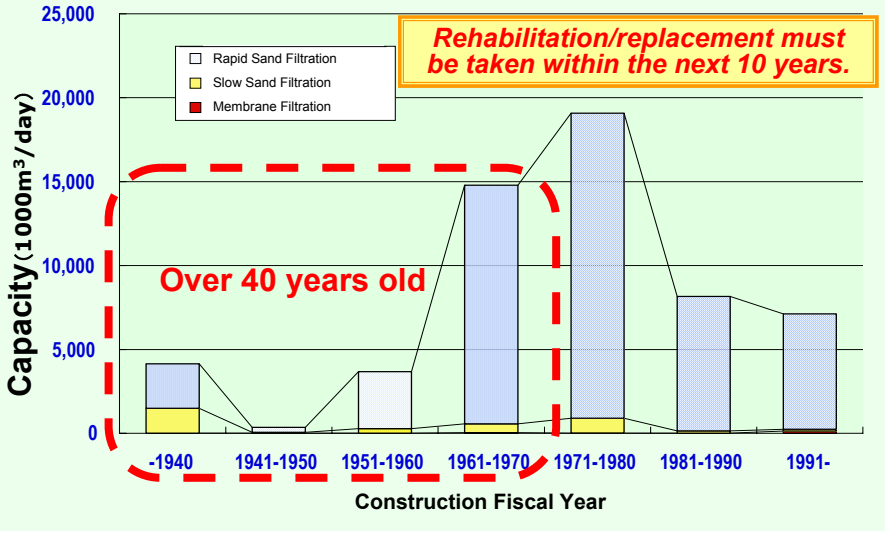
Purification Plant Construction Fiscal Year (categorized by treatment type)



Reference: "Waterworks Vision Basic Data"

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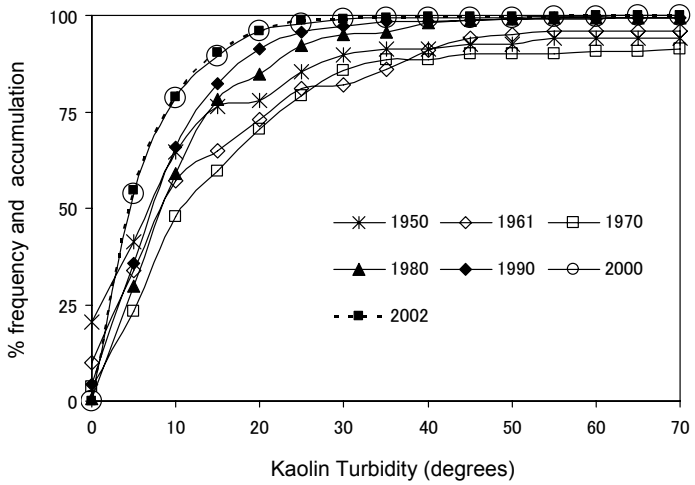
Changes in Turbidity of Raw Water



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Necessity and Background

Pipeline Facility

Challenges

- Large Number of Decrepit Pipelines
  - → Water Quality Deterioration in Pipelines
    Increased Water Leakage
    Vulnerable to Earthquake

Research Target

- Pipeline Diagnosis Technology
- Countermeasures for Pipeline Water Quality Deterioration

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Outcomes

- ***"e-Water"*** (2002- 04)
  - Guidelines on the introduction of membrane filtration facilities based on experiments conducted in large-scale plants
  - Guidelines on the introduction of iron-based and organic polymer coagulants
  - Guidelines on the introduction of Ultraviolet-Ray (UV) Disinfection
  - Manual of integrated treatment for sludge from purification plants and sewage treatment plants.

- ***"Epoch"*** (2002- 04)
  - Identify the movement of suspended solids in pipelines
  - Propose a removal system for suspended solids in pipelines
  - Develop a hydraulic generator system

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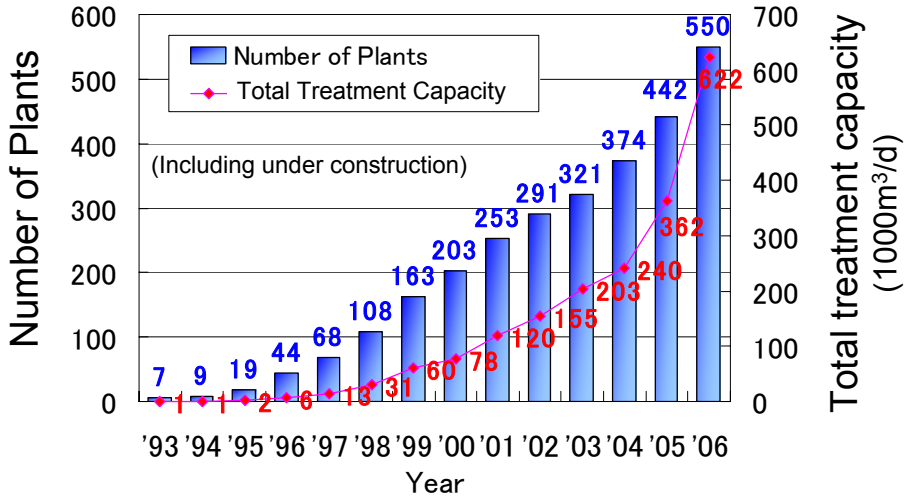
Membrane Filtration Plants in Japan



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UF Membrane Filtration Unit (10,000m³/day)

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Monitoring of Suspended Solids at a Pipe Branch

T-Pipe : φ150 × φ100 Sand

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Ongoing Projects

- **Purification Technology**
  "e-Water II" (2005- 07)
- **Pipeline Technology**
  "New Epoch" (2005- 07)

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"e-Water II" Project
Research Themes

Establishment of advanced purification technology for safe and palatable water

Theme 1
Suitable purification system in accordance with raw water conditions

Theme 2
Effective measures against odor-causing compounds aiming at safe and palatable water

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"e-Water II": Theme 1

- Type classification of treatment systems and level establishment of desirable purified water quality
- Measurement, analysis and evaluation of raw water quality
  Evaluation of water quality and function in each purification process
- Establishment of Life Cycle Assessment (LCA)

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Experimental Plant

Membrane Filtration

Coagulation-Sedimentation

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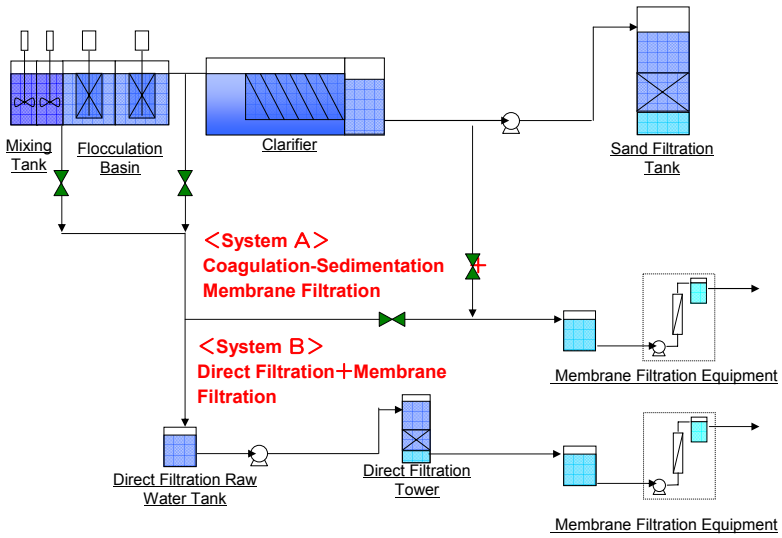
Experimental Plant Flow Diagram



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Plant Experimentation

Control system: Coagulation → Flocculation → Sedimentation → Sand Filtration

System A: Coagulation → Flocculation → Sedimentation → Membrane Filtration

System B: Coagulation → Direct Filtration → Membrane Filtration

To determine optimum coagulation conditions, coagulation dosage, mixing intensity and others are being studied.

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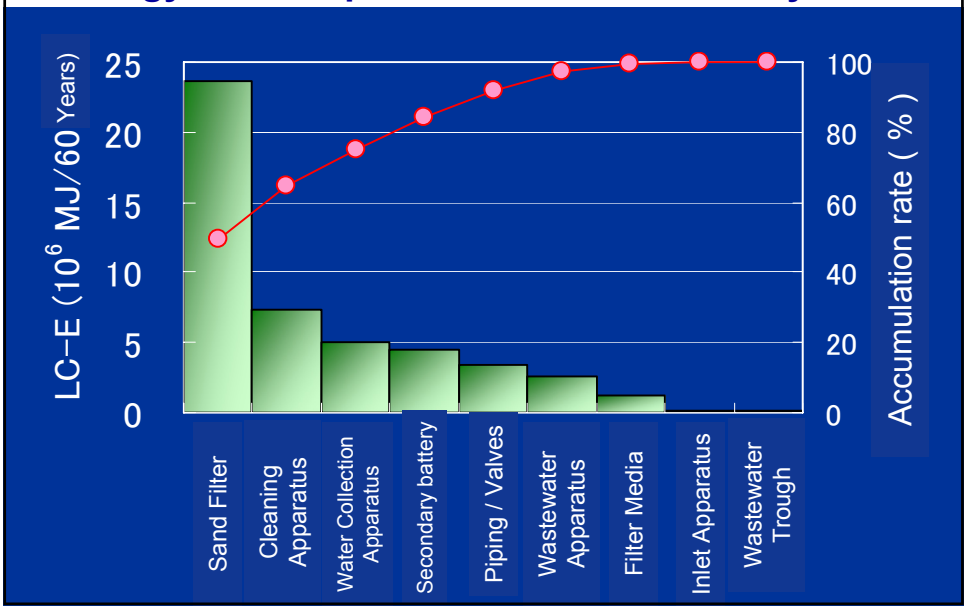
An example of LCA study

Energy Consumption at Sand Filtration System



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"e-Water II": Theme 2

- Simulation by means of water quality prediction models
- Creation of hazard maps
- Implementation of online observation experiments using a VOC monitoring system

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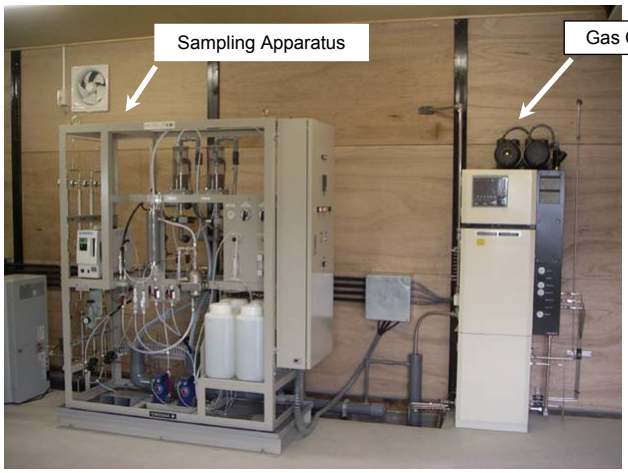
Odor-Causing Compounds Detection Equipment (VOC Monitoring System)



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"New Epoch": Research Theme

- Research on water quality deterioration in decrepit pipelines and preventive measures
- Research on diagnosis technology for decrepit pipelines

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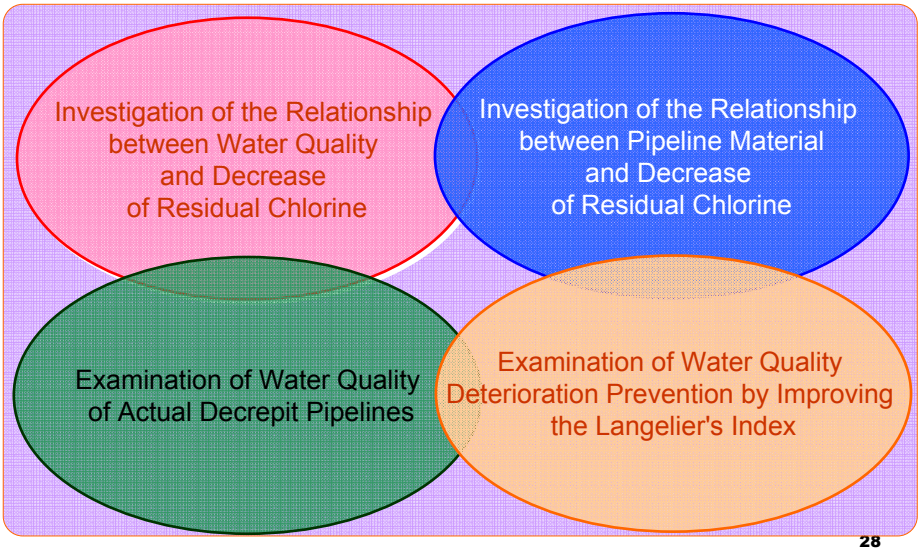
Research on Water Quality Deterioration in Decrepit Pipelines and Preventive Measures



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Examples of Specimen Pipes

Cast-Iron Pipe,Non-Lining,'54

Steel Pipe, Non-Lining,'39

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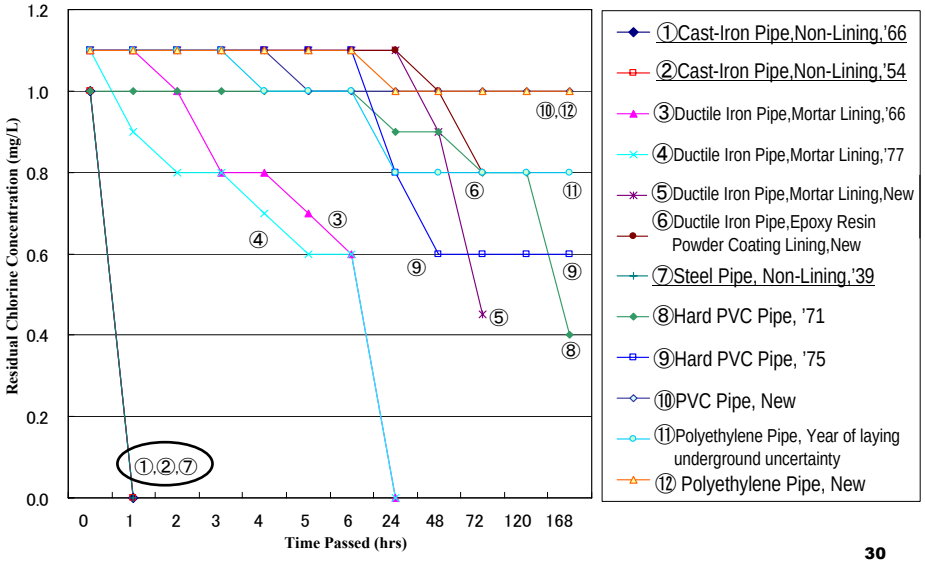
Relationship Between Pipeline Material and Decrease in Residual Chlorine

Changes Over Time in Residual Chlorine Concentration



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Research on Diagnosis Technology of Decrepit Pipeline

Basic Research towards No-Dig Diagnosis

- Impact Elastic Waves
- Sound Waves
- Electromagnetic Waves

Examination of Diagnosis Method of Decrepit Pipeline Using Statistical Method

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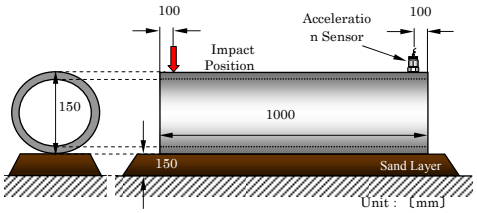
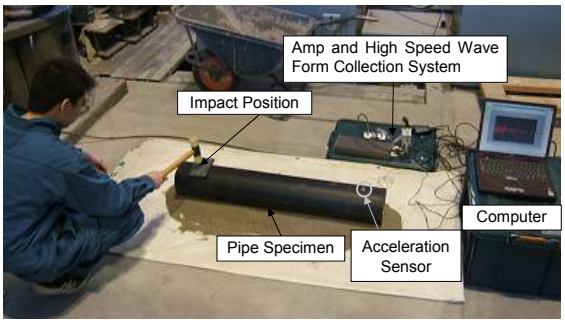
Basic Research towards No-Dig Diagnosis

Impact Elastic Wave Method



Relationship of Position between a Pipe Specimen (1m Pipe) and Impact and Vibration



Measurement Conditions

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Presentations of Results

The 7th International Symposium on Water Supply Technology (Yokohama, Nov 22-24, 2006)

e-WaterII & New Epoch **Seminar**
(Tokyo, Oct 24, 2006)

The 57th JWWA Water Research Conference
(Nagasaki, May 24-26, 2006)

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Publication

Report & Manual on "***Epoch"***

Guidelines & Technical Data on ***"e-Water"***

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