Revision of Drinking Water Quality Standards in Japan

日本の水道水質基準の改正について

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Revision of Drinking Water Quality Standards and QA/QC for Drinking Water Quality Analysis in Japan

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1. Introduction

Since first enacted in 1958 based on the Waterworks Law, Drinking Water Quality Standards (DWQSs) have undergone a series of amendments to comply with the scientific knowledge accumulated as time passes. Among those amendments, the one conducted in 1992 was especially significant. It increased the standard items from 26 to 46 in order to substantially reinforce and enhance drinking water quality management.

Approximately 10 years have passed since the amendment in 1992, and problems with new disinfection byproducts, such as trihalomethane (THM), and bromic and haroacetic acids, and chlorine-resistant pathogenic microorganism, such as *Cryptosporidium*, have arisen. Recently, the World Health Organization (WHO) has started preparation for a fully-fledged revision of the Guidelines for Drinking Water Quality for the first time in 10 years.

In July 2002, in order to respond to such situational changes surrounding water quality management, the Ministry of Health, Labour and Welfare (MHLW) consulted the Health Science Council about revision of DWQSs. Following a response from the Council of April 2003, the MHLW laid down a new set of standards in May 2003, which went into effect on April 1, 2004.

The report by the Health Science Council suggested a credibility assurance system to be introduced to drinking water quality analysis, which is conducted to ensure the ultimate safety of drinking water. In responding to this suggestion, the MHLW specified the legal obligation of institutions that carry out drinking water quality analysis based on the Waterworks Law in order to initiate a credibility assurance system.

2. Revision of Drinking Water Quality Standards

2.1. Fundamental principles

Traditionally, the Drinking Water Quality Standards (DWQSs) of Japan were set for

substances and items that are commonly seen throughout the nation as the source of the problem. For problems that are seen only locally or in specific methods for water purification, governmental instructions were made as a form of administrative guidance through notification.

In the revision of DWQSs, such principles were reconsidered, and the new standards were established based on the two fundamental principles described below.

1) Standards are set for all substances (or items) that have the possibility of having an adverse effect on the protection of health and/or livelihood of people depending on the locality, type of untreated water, or purification method, even when the detection level of the substance (or item) is low on a national basis.

2) Water suppliers are obliged to carry out drinking water quality analysis only for the basic items and may exempt some of the non-basic items from analysis according to the situation.

Although a decision to simplify the drinking water quality analysis items is made at the discretion of the water suppliers, this decision must be appropriate and transparent because drinking water quality analysis are a vital factor in drinking water quality management. Thus, a new system was introduced to require water suppliers to prepare a water quality analysis plan that indicates the boundaries for analysis and publish the plan for water consumers prior to the analysis.

2.2. Revision of Drinking Water Quality Standards

a. Drinking Water Quality Standards (50 items)

The DWQSs were established under a policy to include as many items as possible even if they are associated only with regional or personal issues. Specifically, it was decided that the DWQSs would include “items that are detected or can possibly be detected in purified water at a level of 10% or higher of the assessment value (excluding items that happen to show a high level due to a singular value).” When calculating the assessment values, the method used for the existing standards was applied in principle.

The items subject to the standards were reviewed in accordance with the new definition, and new items were specified. As a result, the number of items subject to the DWQSs increased from 46 to 50 (Table 1).

- New items added to the standards (13 items) -

1) *Escherichia coli*, 2) Boron, 3) 1,4-Dioxane, 4) Bromate, 5) Chloroacetic acid, 6) Dichloroacetic acid, 7) Trichloroacetic acid, 8) Formaldehyde, 9) Aluminum, 10) Geosmin, 11) Nonionic surface active agents, 12) 2-Methylisobormeol(2MIB), 13) Total organic carbon (TOC)

- Items removed from the DWQSs (9 items) -

1) Total coliforms , 2）1,2-Dichloroethane, 3) 1,3-Dichloropropene, 4) Simazine, 5) Tiuram, 6) Thiobencarb, 7) 1,1,2-Tricholoroethane, 8) 1,1,1-Trichloroethane 9) Potassium permanganate consumption

It is notable that a disinfection byproduct (haloacetic acid) and taste and odor-causing substances (geosmin and 2-methylisoborneol) were added to the list; *Escherichia coli* was added while coliform bacteria in general were removed; potassium permanganate consumption as an index for organic substances was removed; and total organic carbon (TOC) was added.

Among the biological standard items, *Escherichia coli* was newly adopted as an index for fecal pollution, which is the major cause of water-borne infectious diseases. Although *E. coli* has been known to be the best index for this purpose, the total coliforms had been used as a standard item in the old system due to technical limitations on measuring *E. coli*. As effective measuring techniques for *E. coli* have been developed, the bacterium was added to the list of standard items to increase the accuracy of the fecal pollution index. During the discussion to select the items, the heterotrophic bacterial (HPC) was considered as a candidate in addition to the general bacteria. The HPC was not adopted this time, however, due to the insufficient amount of essential data available in Japan.

Potassium permanganate consumption has long been used as an index for organic substance levels. It is pointed out, however, that the measurement of this substance has many flaws; the method cannot clearly identify the exact substance that is actually measured and non-organic substances are also included in the measurement, for example. In contrast, in the measurement of total organic carbon (TOC), the specific item measured (the amount of carbon that makes up the organic substances in this case) is clearly known. In addition, a proper measuring instrument (TOC analyzer) is available for highly accurate measurement. Because of these advantages, the TOC was adopted as the standard item instead of potassium permanganate consumption. However, a grace period was given until March 2005 before the TOC becomes an obligatory item for standards. This is to facilitate the shift in measuring items by water suppliers who have been using potassium permanganate consumption as an index for the management of purification treatment processes.

In addition to the substances and items listed above, the “items not listed in the DWQSs, but can possibly be detected in purified water at the level of 10% or higher of the standard value in some cases” are now categorized as “Complementary Items to Set the Targets for Water Quality Management.” Also, the “items on which necessary information and knowledge should be collected” are now categorized as “Items for Further Studies.”

b. Complementary items to set the targets for water quality management (27 items):

Items in this category do not need to be included in the standards because of the low detection levels or provisional evidence of toxicity. This category includes items normally detected in the natural environment and items that have the potential to be detected in drinking water because of their use in large quantities. This is a category that will draw the attention of the people/parties concerned with supplying water (Table 2). Although inclusion in this category does not necessitate a water quality analysis, analysis is recommended in line with the DWQSs for the sake of data collection and accumulation of knowledge.

c. Items for Further Study (40 items)

The items in this category were excluded from the list of the DWQSs or Complementary Items to Set the Targets for Water Quality Management. They include items whose toxicities have not yet been determined, or where concentrations in drinking water are not clear. Further studies are necessary to accumulate information and knowledge on these items (Table 3).

d. Pesticides

There were no specific pesticides to be classified in the DWQSs at the time of the revision in 2003. However, since pesticides in drinking water have a high public interest factor, they were classified as Complementary Items to Set the Targets for Water Quality Management as “pesticides”. MHLW decided to introduce evaluation by the total pesticide level. In evaluating by the total pesticide level, currently, 101 items were listed as “pesticides” based on their detection and consumption levels in Japan. Water suppliers must ensure that consumers feel their water supply is safe by monitoring the total pesticide level with due consideration given to the usage period and the conditions in the area around the water source.

- The Total Pesticide Level -

The target level is set for each of the 101 pesticides. The sum of the ratio of the measurement value (DV_i) to the target value (GV_i), where i is a specific pesticide, should

not be greater than 1.

$$DI = \sum_i \frac{DV_i}{GV_i} \leq 1$$

DI: Value of measurement standard
DV_i: Measurement value of pesticide i
GV_i: Target value of pesticide i

2.3 Water quality analysis plan

A new principle was adopted in the this revision of DWQSs. The traditional idea that "DWQSs consider only those items that are the cause of nationwide problems; items that are the cause of local problems are dealt with by administrative guidance through notification" was changed to embody the principle of setting a legal standard for all items that may cause a problem even if they are seen only locally. At the same time, the imposition of water quality analysis on water suppliers is limited to basic items and other items may be omitted under certain circumstances. This would reduce some of the rather heavy burden of water quality analysis for water suppliers and allow them to implement analysis that better suits the regional situations in a more rational form. Although the decision to simplify the water quality analysis items is made at the discretion of the water suppliers, this decision must be appropriate and transparent because water quality analysis is a vital factor in water quality management. Thus, a new system was introduced that requires water suppliers to prepare and publish a water quality analysis plan each year prior to the analysis.

- Items that must be included in the water quality analysis plan -

1) Fundamental policy of water quality analysis.
2) Items on which the water quality analysis is performed, location of water sampling, frequency of analysis, and reason for performing the water quality analysis.
3) Items for which the water quality analysis is omitted and the reason for omission.
4) Information related to temporary water quality analysis.
5) Specifics of commission when a water quality analysis is entrusted to another organization.
6) Special considerations that must be observed at the time of water quality analysis.

2.4. Rolling Revision of Drinking Water Quality Standards

The Guidelines for Drinking Water Quality of WHO discontinued the system where revision of the guidelines was made on a regular basis. Instead, a new system was adopted where the guidelines are reviewed and revised consecutively in responding to the availability

of the latest scientific knowledge. The Ministry of Health, Labour and Welfare (MHLW) decided to follow suit and adopted the rolling revision system. The MHLW has established a committee of experts who will discuss the issues on the review of drinking water quality standards.

3. Quality assurance and control of drinking water quality analysis

3.1. Drinking water quality analysis system in Japan

The Waterworks Law of Japan limits the analysis organizations for drinking water supplied by water suppliers to the following three types of organizations.

1) Analysis organizations of the water suppliers
2) Analysis organizations of the local public
3) Analysis organizations* registered by the Minister of Health, Labour and Welfare

* In order to be registered as an analysis organization by the Minister of Health, Labour and Welfare, the organization must meet the standards laid down by the Waterworks Law.

3.2 The current situation of drinking water quality analysis

Water quality analysis is carried out to ensure the conformity of the water quality with the standards and to confirm the safety of the water supplied. The drinking water quality analysis, therefore, evaluates the whole water management system carried out by the water supplier.

When measuring the items listed in the DWQSs, a wide range of accurate measurements are required at a level from mg/L to ng/L. This requires highly advanced facilities and equipment as well as skilled engineers.

However, the results of the control survey, which has been carried out by MHLW every year since fiscal 2000, have proven that the accuracy of measurement of the organizations that conduct water quality analysis is not always satisfactory.

To maintain the quality of drinking water, a guarantee of safety is indispensable. The situation described above is a critical matter from the viewpoint of the risk management of drinking water quality.

3.3 Introduction of accuracy and credibility assurance system in water quality analysis

In order to solve the problem described above, a report by the Health Science Council proposed a credibility assurance system to be introduced for water quality analysis. In responding to this proposal, the MHLW consulted ISO9001 and ISO17025 and laid down the registration standards in the Waterworks Law as a measure of credibility assurance for the water quality analysis organizations registered by the Minister of Health, Labour and Welfare.

Specifically, the following scheme was established as a national framework to ensure the accurate results of analysis.

a. Organizational scheme for water quality analysis (Figure 1)

i. The water quality analysis division and credibility assurance division must be established independently of each other.
ii. The water quality analysis division must designate a manager who supervises all inspectors.
iii. The credibility assurance division must be specialized in the operational management of water quality analysis and maintenance of accuracy.

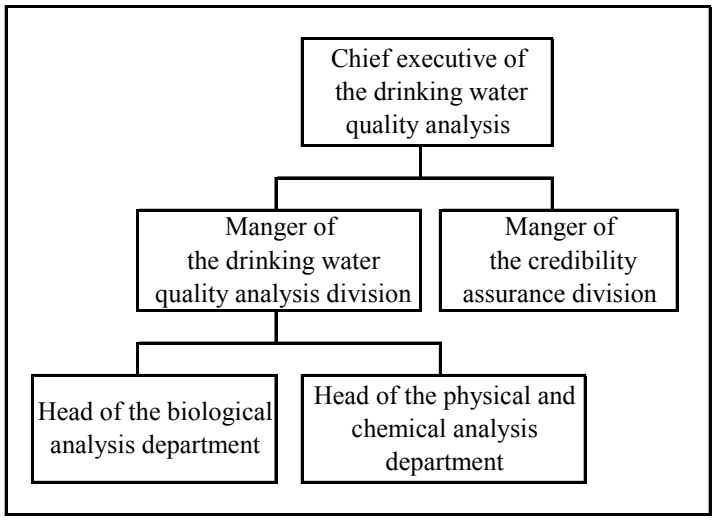

Figure 1. Organizational scheme for water quality analysis

iv. The credibility assurance division must designate a manager who is in charge of the whole operation of the division.
v. The credibility assurance division must inspect the water quality analysis division.

- The tasks of the manager of the water quality analysis division -
1) To supervise the water quality analysis division.
2) To confirm that the analysis procedures are carried out in compliance with the standards manual and to take necessary measures if compliance cannot be confirmed.
3) To implement corrective measures.
4) To perform other tasks as needed.

- The tasks of the manager of the credibility assurance division -
1) To carry out periodical internal audits.
2) To handle the paperwork that is necessary to carry out accuracy management analysis.

3) To report the results of the internal audits and accuracy management analysis to the manager of the water quality analysis division.
4) To perform other tasks as needed.

b. Preparation of written manuals

i. Standard manuals that specify the procedures for water quality analysis must be prepared.
ii. Regulations for operational management and accuracy assurance of water quality analysis must be prepared.
iii. The overall process of water quality analysis must be carried out in conformity with the documents listed above.
iv. The documents listed above must be prepared in the process of documentation, analysis, and authorization.

- Types of Standard Operation Papers -
1) Procedures for water quality analysis
2) Handling of samples
3) Handling of reagents
4) Maintenance of machinery and equipment

- Types of regulations -
1) Authorization, responsibility, and interrelation of each division in the organization
2) Management of documents
3) Management of records
4) Education and training
5) Non-compliance of procedures and corrective measures
6) Procedures for internal audits
7) Procedures for implementation and planning of accuracy management
8) Procedures for trust of drinking water quality analysis
9) Procedure for publication of drinking water quality analysis reports
10) Procedures for procurement of goods
11) Others

4. Conclusion

The drinking water system has taken root as part of the country's infrastructure and is playing a vital role in maintaining the functioning of society. However, it is true that there are growing concerns among the public over the safety of water supply systems due to the contamination of the source. There is also a sense of distrust in the quality and taste of

drinking water.

There is a vital and urgent agenda for concerned parties to dispel many of these concerns and distrust to maintain the availability of safe water. The Ministry of Health, Labour and Welfare is determined to make its efforts to improve the credibility of the quality of drinking water, and to make this acceptable to the public.

Table 1. Drinking Water Quality Standards

No.	Items	Standard Value
1	Standard Plate Count	100 per 1 ml
2	*E. coli*	Not to be detected
3	Cadmium	0.01mg/L
4	Mercury	0.0005mg/L
5	Selenium	0.01mg/L
6	Lead	0.01mg/L
7	Arsenic	0.01mg/L
8	Chromium (VI)	0.05mg/L
9	Cyanide ion and Cyanogens chloride	0.01mg/L as Cyanide
10	Nitrate and Nitrite	10mg/L as Nitrogen
11	Fluoride	0.8mg/L
12	Boron	1.0mg/L
13	Carbon tetrachloride	0.002mg/L
14	1,4-dioxane	0.05mg/L
15	1,1-Dichloroethylene	0.02mg/L
16	*cis*- 1,2-Dichloroethylene	0.04mg/L
17	Dichloromethane	0.02mg/L
18	Tetrachloroethylene	0.01mg/L
19	Trichloroethylene	0.03mg/L
20	Benzene	0.01mg/L
21	Chloroacetic acid	0.02mg/L
22	Chloroform	0.06mg/L
23	Dichloroacetic acid	0.04mg/L
24	Dibromochloromethane	0.1mg/L
25	Bromate	0.01mg/L
26	Total trihalomethanes (Total of Chloroform, Dibromochloromethane, Bromodichloromethane and Bromoform)	0.1mg/L
27	Trichloroacetic acid	0.2mg/L
28	Bromodichloromethane	0.03mg/L
29	Bromoform	0.09mg/L
30	Formaldehyde	0.08mg/L
31	Zinc	1.0mg/L
32	Aluminium	0.2mg/L
33	Iron	0.3mg/L
34	Copper	1.0mg/L
35	Sodium	200mg/L
36	Manganese	0.05mg/L
37	Chloride ion	200mg/L
38	Calcium, Magnesium (Hardness)	300mg/L
39	Total residue	500mg/L
40	Anionic surface active agent	0.2mg/L
41	(4S, 4aS, 8aR)-Octahydro-4,8a-Dimethylenaphtalene-4a(2H)-ol (Alias: Geosmin)	0.00001mg/L (Note 1)
42	1,2,7,7 - Tetramethylbicyclo[2,2,1]Heptane-2-ol (Alias: 2-Methylisobolneol)	0.00001mg/L (Note 1)
43	Nonionic surface active agent	0.02mg/L
44	Phenols	0.005mg/L in terms of Phenol
45	Organic substances (Total Organic Carbon) (Note 2)	5mg/L (Note 2)
46	pH Value	5.8 ~ 8.6
47	Taste	Not abnormal
48	Odor	Not abnormal
49	Color	5 degree
50	Turbidity	2 degree

Note 1) The number “0.00001mg/L” means “0.00002mg/L” until March 31, 2007 in the columns 41 and 42 which refers to the water supplied by the water system already installed at the time of the enforcement of this

Note 2) The column 45 stating “Organic substances (the amount of Total Organic Carbon)” means “Organic substances (consumption of Potassium Permanganate)” and “5mg/L” means “10mg/L” until March 31, 2005.

Table 2. Complementary Items to Set the Targets for Water Quality Management

No	Item	Target Value
0-01	Antimony	0.015
0-02	Uranium	0.002P
0-03	Nickel	0.01P
0-04	Nitrite-Nitrogen	0.05P
0-05	1,2-dichloroethane	0.004
0-06	*trans*-1,2-dichloroethylene	0.04
0-07	1,1,2-Trichloroethane	0.006
0-08	Toluene	0.2
0-09	Diethylexyl phtalate	0.1
0-10	Chlorite	0.6
0-11	Chlorate	0.6
0-12	Chlorine dioxide	0.6
0-13	Dichloroacetonitrile	0.04P
0-14	Chlorale hydrate	0.03P
0-15	Pesticides (Note1)	1
0-16	Chlorine residue	1
0-17	Hardness（Ca, Mg）	10-100
0-18	Manganese	0.01
0-19	Free carbon dioxide	20
0-20	1, 1, 1-Trichloloethane	0.3
0-21	Methyl-t-butylether（MTBE）	0.02
0-22	Organic substance（Potassium permanganate consumption）	10(3)
0-23	Threshold Odor Number	3TON
0-24	Residue on evaporation	30-200
0-25	Turbidity	1 degree
0-26	pH Value	Approx. 7.5
0-27	Causticity（Langelier's Index）	-1～0

Note1) The total of "each measurement value / each target value" should not be more than 1. 101 items are listed for "pesticides".

Note) Target value is not set for Heterotrophic Plate Count, however, it is recommended to carry out water examination toward the future standardization.

（Unit：mg/L（※O-23,25,26,27 are excluded））

Table 3. Items for Further Study

No	Item	Target Value
I-01	Silver	－
I-02	Valium	0.7
I-03	Bismuth	－
I-04	Molybdenum	0.07
I-05	Acrylamide	0.0005
I-06	Acrylic acid	－
I-07	17-β-Estradiol	0.00008P
I-08	Ethynyl-Estradiol	0.00002P
I-09	Ethylenediaminetetraacetic acid（EDTA）	0.5
I-10	Epichlorohydrin	0.0004P
I-11	Chloroethene	0.002
I-12	Vinyl Acetate	－
I-13	2,4-Deaminotoluene	－
I-14	2,6-Deaminotoluene	－
I-15	N,N-Dimethylaniline	－
I-16	Stylene	0.02
I-17	Dioxin, etc	1pgTEQ/L（P）
I-18	Triethylenetetramine	
I-19	Nonylphenol	0.3P
I-20	Bisphenol A	0.1P
I-21	Hytrazine	－
I-22	1,2-Butadiene	－
I-23	1,3-Butadiene	－
I-24	Dibutyl phtalate	0.2P
I-25	Dybutyl benzyl phtalate	0.5P
I-26	Microcystin－ＬＲ	0.0008P
I-27	Organotin compounds	0.0006P(TBTO)
I-28	Bromochloroacetic acid	－
I-29	Bromodichloroacetic acid	－
I-30	Dibromochloroacetic acid	－
I-31	Bromoacetic acid	－
I-32	Dibromoacetic acid	－
I-33	Tribromoacetic acid	－
I-34	Trichloroacetnitrile	－
I-35	Bromochloroacetnitrile	－
I-36	Dibromoacetnitrile	0.06
I-37	Acetaldehyde	－
I-38	ＭＸ	0.001
I-39	Chloropicrin	－
I-40	Xylene	0.4

（Unit：mg/L（※I-17 are excluded）

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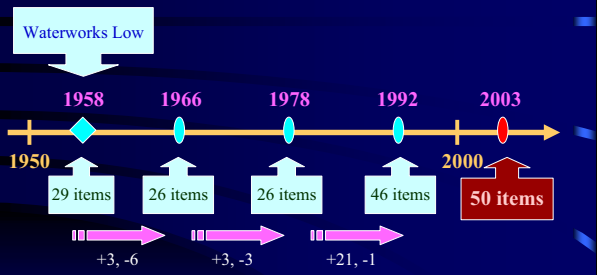
History of DWQSs in Japan



Background of Revision in 2003

Ten years have passed
since the revision in 1992, · · ·

- new disinfection byproducts
- chlorine-resistant pathogenic microorganism
- continuous pollution of water sources
- revision of the WHO GDWQs

Flow of Revision in 2003

July, 2002 : MHLW consulted the Health Science Council about revision of DWQSs.

April, 2003 : The Council submitted a report.

May, 2003 : MHLW laid down a new set of standards.

April 1, 2004 : New DWQSs went into effect.

Targets of DWQSs

In former DWQSs system,
- DWQSs : only for items commonly seen throughout the nation
- An administrative for other items

Revision of DWQSs on 2 principles

Fundamental Principles (1)

• Standards are set for all substances (or items) that have the possibility of having an adverse effect on the protection of human health or living condition for people.

Total revision of DWQSs system

Fundamental Principles (2)

• DWQSs include
- Basic items
(requisite for drinking water quality analysis)
- Non-basic items
(to be omitted according to the situation)

Water suppliers are require to prepare a 'Water Quality Analysis Plan'.

New DWQSs system in Japan

• DWQSs items (50 items)
• Complementary items (27 items)
- including Pesticides (101 items)
• Items for further study (40 items)
• Introduction of Rolling Revision System

DWQSs Items (50 items)

- Items classified as DWQSs :
  - (possibly be) detected in purified water at a level of 10% or higher of the assessment value

50 items were set up.
(13 added, 9 removed)

New items added to the standards (13 items)

1) *Escherichia coli*
2) Boron
3) 1,4-Dioxane
4) Bromate
5) Chloroacetic acid
6) Dichloroacetic acid
7) Trichloroacetic acid
8) Formaldehyde
9) Aluminum
10) Geosmin
11) Nonionic surface active agents
12) 2-Methylisobormeol (2MIB)
13) Total organic carbon (TOC)

Items removed from the DWQSs (9 items)

1) Total Coliforms
2) 1,2-Dichloroethane
3) 1,3-Dichloropropene
4) Simazine
5) Tiuram
6) Thiobencarb
7) 1,1,2-Tricholoroethane
8) 1,1,1-Trichloroethane
9) Potassium permanganate consumption

Complementary items (27 items)

- Not listed in the DWQSs
- Targets for water quality management to be noticed
- Include item that :
  - detected in the natural environment.
  - may be detected in drinking water because of their use in large quantities.

Pesticides

- No pesticides are included in new DWQSs.
- However, many people have an interest in pesticides.

- Classify into the Complementary items.
- Introduction of evaluation by the total pesticide level .

The Total Pesticide Level

$$DI = \sum_i \frac{DV_i}{GV_i} \leq 1$$

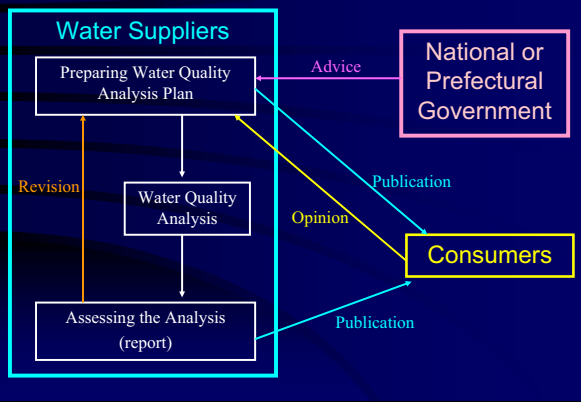
DI : Value of measurement standard
DV_i: Detected value of pesticide *i*
GV_i: Target value of pesticide *i*

Items for Further Study (40 items)

- Include item that :
  - Toxicities have not yet been determined.
  - Concentrations in drinking water are not clear, because there is no data.

Further studies are necessary to accumulate information and knowledge on these items.

Scheme of Water Quality Analysis Plan



Outline of Water Quality Analysis Plan

1) Fundamental policy of water quality analysis.
2) Items on which the water quality analysis is performed, location of water sampling, frequency of analysis, and reason for performing the water quality analysis.
3) Items for which the water quality analysis is omitted and the reason for omission.
4) Information related to temporary water quality analysis.
5) Specifics of commission when a water quality analysis is entrusted to another organization.
6) Special considerations that must be observed at the time of water quality analysis.

Conclusion

- MHLW decided to introduce the Rolling Revision system for revision of DWQSs, like WHO.
- These systems introduced newly will contribute to improve our system of drinking water quality management.

Thank you.

The longest water pipe bridge in Japan (L = 1,100 meter)