保健医療科学　2022　Vol.71　No.1　p.55－65

Topics: Recent topics in public health in Japan 2022

＜ Review ＞

Recent contributions of the National Institute of Public Health to drinking water quality management in Japan

MIYOSHI Taro, MIURA Takayuki, ASAMI Mari

Area on Water Management, Department of Environmental Health, National Institute of Public Health

Abstract

Supplying drinking water with sufficient quality is essential for sustaining public health. The requirements on drinking water quality must be updated based on new evidence on chemical and biological risk factors. Providing accurate latest scientific knowledge required for such updates is one of the most important roles for the Area on Water Management (AWM), Department of Environmental Health, National Institute of Public Health (NIPH). In this article, the contributions of the NIPH to the drinking water quality management in Japan are reviewed. General aspects of drinking water quality management in Japan, including the history and the basic concept of the current drinking water quality standards (DWQSs), approaches for controlling pathogenic microorganisms, and activities for establishing water safety plans (WSPs) are overviewed. Recent water quality incidents and waterborne disease outbreaks are also explained. Then, the contributions of the AWM of NIPH to DWQSs are explained, with selected recent activities, i.e., setting allocation used in DWQSs based on exposure studies, a nationwide survey on water intake, selection of pesticides and other chemical substances to be included in DWQSs. Finally, the future perspectives on expected needs for our research and dissemination activities are provided."

Abbreviations

AWM, Area on Water Management
DWQSs, drinking water quality standards
HACCP, Hazard Analysis and Critical Control Points
MHLW, Ministry of Health, Labour and Welfare
NIPH, National Institute of Public Health
WHO, World Health Organization
WSPs, Water Safety Plans

keywords: drinking water supply, risk management, water quality standards, waterborne infectious disease, Health and Labour Sciences Research Grant

(accepted for publication, December 17, 2021)

I. Introduction

The population of Japan reached its peak of 128 million in 2008 and decreased to 125 million in 2021. In addition to the change in total population, the amount of tap water used has been decreasing since the late 1990s as water-saving devices and equipment (e.g., showerheads, faucet, toilet, and dishwashers) have become popular. Consequently, water suppliers in Japan have been facing a decrease of revenue. To strengthen the foundation of water suppliers to maintain good water supply facilities and excellent water quality, drinkable wherever in Japan, the Water Supply Act

---

Corresponding author: ASAMI Mari
2-3-6 Minami, Wako, Saitama 351-0197, Japan.
Tel: 048-458-6304, Fax: 048-458-6305
E-mail: asami.m.aa@niph.go.jp

was amended in October 2019.

The Area on Water Management (AWM), Department of Environmental Health, National Institute of Public Health (NIPH) has worked on the assessments and management of health risks related to drinking water quality, and some of the research activities have been financially supported by the Health and Labour Sciences Research Grants from the Ministry of Health, Labour and Welfare (MHLW), Japan. Health hazards involved in drinking water supply systems include pathogenic microorganisms, such as enteric viruses, opportunistic bacteria, and protozoa, and chemicals including pesticides, disinfection by-products, and bacterial endotoxins. Findings obtained through the research activities have been reflected in drinking water quality management (i.e., drinking water quality standards [DWQSs], guidelines for water treatment) in Japan.

In this review, current drinking water quality management in Japan is overviewed focusing on DWQSs, control of pathogenic microorganisms, and water safety plans (WSPs) [1]. Protozoan parasites, such as *Cryptosporidium* and *Giardia* that cause diarrhea, are the important pathogens for the microbiological safety of the drinking water supply as they are resistant to chlorine. Pathogen control in water supply facilities especially in small-sized ones facing the declining population remains a concern in Japan, and “the guidelines for *Cryptosporidium* and *Giardia* control in water supply” was amended on May 29, 2019. To understand the occurrence of health hazards in drinking water supply systems, information on water quality incidents and waterborne disease outbreaks in Japan are also reviewed. Furthermore, recent research findings of the AWM of NIPH that directly or indirectly contributed to the setting of DWQSs are explained.

II. Drinking water quality management in Japan

In this chapter, details of DWQSs in Japan are explained. The explanations related to the history of DWQSs, the basic concepts, control of pathogenic microorganisms, and WSPs are separately provided in the following sections. In the section of the basic concept, in addition to the ideas based on which the current DWQSs are established, the hierarchal structure of the current DWQSs is explained. The explanations on control of pathogenic microorganisms include the requirements in the management of water distribution systems in Japan and countermeasures for preventing waterborne diseases associated with chlorine-resistant microorganisms.

1. History of drinking water quality standard in Japan

In Japan, the first DWQS was established with 26 items in 1958. After the establishment of the DWQSs, successive revisions of the standard were performed taking into account the latest scientific knowledge and international trends such as revisions of the guidelines for drinking water quality of the World Health Organization (WHO). Minor revisions were made in 1960, 1966, and 1970 and then a significant revision was applied in 1992. Through the series of revisions, the number of items included in the standard increased from 26 to 46. After that, an additional revision was made in response to the revision of “Guidelines for Drinking-Water Quality” of the WHO in 2003 [2]. The details of this revision are provided in the next section.

For appropriate revisions of DWQSs, providing the latest and accurate scientific knowledge is indispensable. Figure 1 shows the six major activities and examples provided by

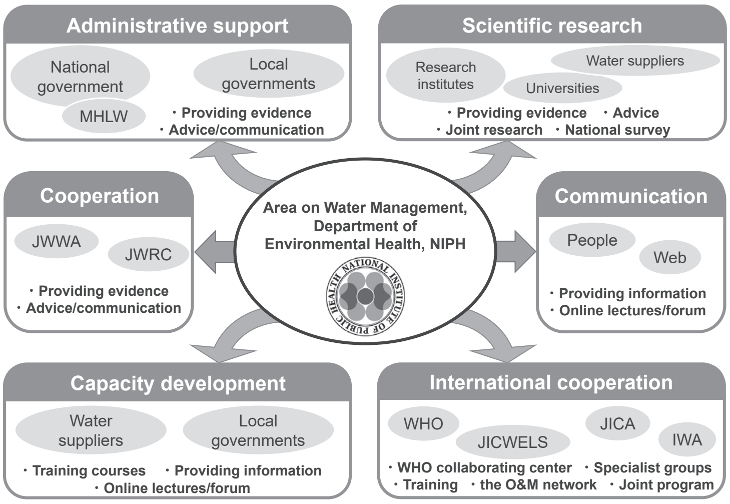

Figure 1 Six major activities of AWM, Department of Environmental Health, NIPH

the AWM, related to water safety. The research staff in the AWM jointly contributed to these aspects.

2. Basic concept of the current DWQSs

Before the major revision of DWQSs in 2003, the items included in the standard were limited to those that were detected and of health concern on a nationwide basis. Therefore, items that had been detected in specific regions or treatment processes were not included in the standard. Instead, administrative guidance had been set for these items. Such concepts were changed in the revision made in 2003. According to the MHLW, the revised DWQSs were based on the following basic concepts: “the standards are set for all items that have the possibility to cause an adverse effect on human health or living condition regardless of the specialty of the locality, types of water source, or purification methods, even if the detection level of these items is low on a national basis” and “water suppliers are obliged to carry out drinking water quality examination only for the basic items and may omit some of the non-basic items from analysis according to their local situation” (cited from the website of MHLW [1]).

For the latter point, water suppliers are requested to clarify the validity of the exclusion by preparing and publishing an “Annual Water Quality Examination Plan” prior to the examination.

Prior to the revision mentioned above, a special committee for water quality was formed. The research staff of AWM, NIPH were involved in this committee, indicating our obvious contribution to this revision.

As shown in Figure 2, the current DWQS in Japan has a hierarchal structure. The layer located on the top is DWQSs, which is legally regulated items. DWQSs are comprised of 51 items, in which 31 items are assigned to human health and 20 items are related to aesthetic aspects such as color, taste, and odor regarding water quality. The items listed in this category are selected from those detected in purified water with values above one-tenth of their standards: standard values or reference values on each item are determined based on a risk assessment.

The items in the middle layer are complementary items, i.e., the items with administrative target values. The items whose risk assessments are provisional at present are included in this category. In addition, the items detected at very low levels compared to their standard values are categorized here. Although the items listed in this category are not legally regulated, water suppliers are encouraged to monitor them to satisfy the targets for these items. The bottom category, items for further study, includes the items that require further considerations; their health risks or existence in purified water have yet to be totally elucidated. These items are not regulated at present. However, the targets for these items are possibly upgraded when health risks or existence in purified water are recognized. Therefore, accumulation of the further knowledge regarding these items are of great importance. The AWM of NIPH contributes on updating the current knowledge by performing surveys on the detection of emerging compounds and accumulating the latest information on the risk assessment for these items.

3. Control of pathogenic microorganisms

In Japan, a risk of waterborne infectious diseases is effectively controlled by high coverage of water supply (more than 98% in 2019) [3] and implementation of appropriate disinfection in drinking water treatment. On the other hand, even though the level of pathogenic microorganisms is efficiently decreased at drinking water treatment plants, bacterial regrowth and external contamination associated with negative pressure in pipes may be of concern when the

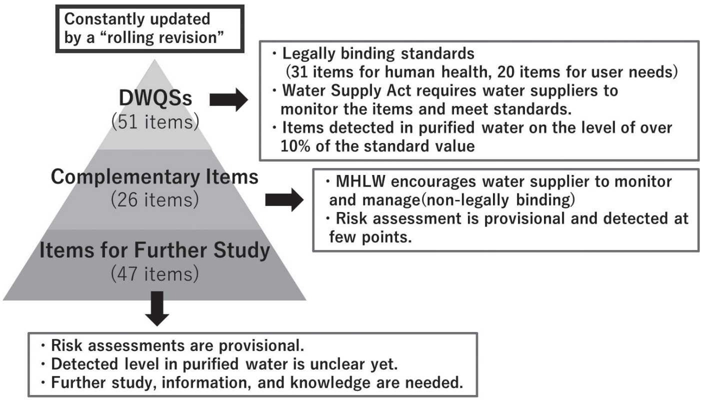

Figure 2 Scheme adopted in drinking water quality control in Japan (adopted from the website of MHLW [1])

management of water distribution system is inappropriate. For achieving appropriate management of water distribution system, the Water Supply Act in Japan regulates that residual chlorine concentration at the end of water distribution systems must be more than 0.1 mg/L for free chlorine (more than 0.4 mg/L for combined chlorine).

Apart from the appropriate management of pipeline mentioned above, problems associated with chlorine-resistant pathogens (e.g., *Cryptosporidium* and *Giardia*) are of great concern. In Japan, a large outbreak of cryptosporidiosis happened in Ogose town, Saitama Prefecture, in June 1996 [4]. More than 70% of residents suffered from severe diarrhea. As a result of the incidence mentioned above, “the guidelines for *Cryptosporidium* and *Giardia* control in water supply” was published in 2007. The research staff of the AWM of NIPH participated in the special committee establishing this guideline. Based on this guideline, water suppliers assess risk levels of potential contamination by *Cryptosporidium* at each water treatment plant taking the existences of indicator organisms in raw water and the types of raw water (i.e., surface water or groundwater) into consideration (Figure 3).

The unique feature of this guideline is that the risks associated with *Cryptosporidium* are controlled by regulating water treatment facilities; facility requirements in water treatment plants are defined for each risk level. For example, when the raw water is categorized as level 4 (i.e., raw water with high possibility of *Cryptosporidium* contamination), installation of the facility (or facilities) that enables to (a) produce treated water with turbidity of less than 0.1 degrees (calibrated using kaolin as a standard compound) or (b) filtration equipment followed by ultraviolet (UV) irradiation equipment. In the latter case, the requirements for UV irradiation equipment are capable of achieving more than 99.9% disinfection of *Cryptosporidium*, installation of UV intensity meter that enables constant monitoring of the UV strength, and installation of turbidity meter for constant monitoring of turbidity of water to be introduced in the UV irradiation equipment. The facilities required for risk levels 3 and 4 are presented in Figure 4.

4. Water safety plans

In 2004, WHO proposed the concept of WSPs in the Guidelines for Drinking-Water Quality 3rd edition [2]. This plan modified the Hazard Analysis and Critical Control Points (HACCP) approach, which is widely utilized in the food industry. The basic concepts of this plan are comprised of (a) determination of critical control points by evaluating risk levels of all hazards that potentially take place in all steps in the water supply system and (b) constant moni-

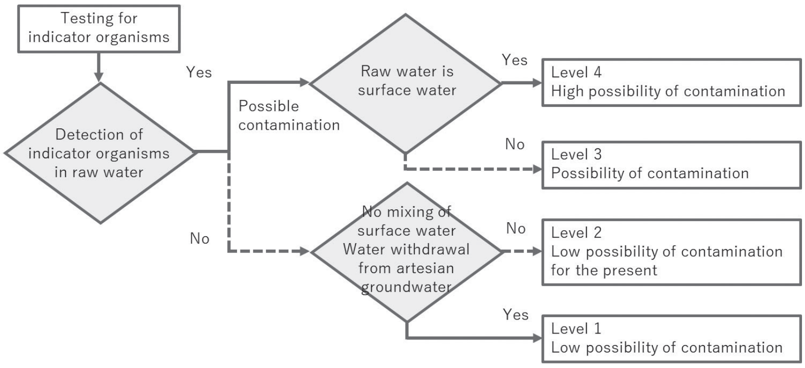

Figure 3 The flowchart in determining the risk level of *Cryptosporidium* contamination (adopted from the website of MHLW [1])

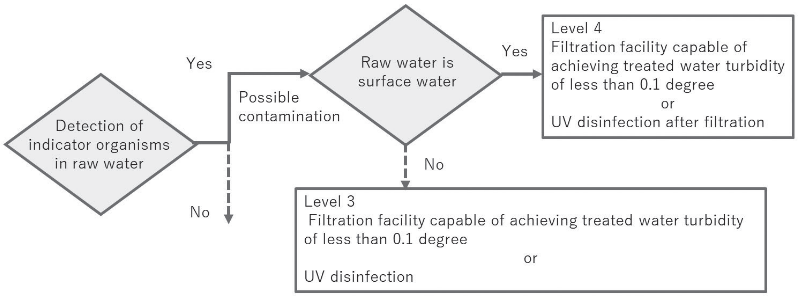

Figure 4 Facilities required for treating raw water with risk levels 3 and 4

toring of performances levels of all critical control points including not only tap water quality but also operational aspects of facilities.

In Japan, an official notification on the recommendation of developing WSPs to water suppliers was issued in 2008. At present, however, the developments of WSPs in Japanese water suppliers are ongoing, and only 4.4% of water suppliers have completed the development of WSPs in 2020 [4]. Many water suppliers in Japan still need further endeavor for developing WSPs. Water professionals in NIPH will continue to contribute to such consideration for facilitating the development of WSPs in Japanese water suppliers.

III. Recent water quality incidents and waterborne disease outbreaks in Japan

1. Water quality incidents

Although drinking water quality has been managed under the Water Supply Act as described above, water quality incidents occasionally occur. In Japan, water quality incidents that could lead to health hazards are reported to Water Supply Division of the MHLW [5]. Kishida et al. have reviewed the records of such water quality incidents that occurred during the three decades between 1983 and 2012 in Japan and analyzed their patterns of occurrence (Table 1) [6].

For each causative agent, which was categorized into “Microbes,” “Chemicals,” “Others,” and “No causative agents,” the number of incidents occurred and those with health hazards were investigated (Table 1). Turbidity and oils were the major causative agents that linked to the water quality incidents (117 and 66 incidents, respectively), but there were no incidents with health hazards during the three decades. In contrast, microbes such as pathogenic bacteria, protozoa, and viruses caused the incidents with a health hazard. Among the pathogenic microorganisms, *E. coli, Campylobacter, Cryptosporidium, Giardia,* and Norovirus are the important etiological agents that cause gastrointestinal diseases with symptoms of diarrhea, vomiting, fever, and abdominal pain. Chemicals, such as agricultural chemicals or pesticides, tetrachloroethylene, trichloroethylene, PCB, arsenic, cyanogen, bromate, and chlorate, were reported as the causative agents of several incidents; however, fortunately, there were no health-related incidents except one with organoarsenic.

Among the 140 incidents with health hazards, underlying causes were identified for approximately 80 incidents [6]. Inadequate disinfection in water treatment processes was the major underlying causes for the health-related incidents (48 incidents), followed by source water contamination with sewage or human feces (23 incidents) and rainfall (8 incidents). In water treatment processes, inadequate flocculation and sedimentation were also associated with four incidents, and sewage infiltration to pipes was the major underlying cause of six incidents in the distribution network.

During the period between 2013 and 2021, there was one health-related incident caused by groundwater contamination with oil in Kumamoto Prefecture in September 2014, resulting in two cases of illness with vomiting and diarrhea [7]. Although no health problem has been reported, there have been one to three incidents with violation of DWQS

Table 1 Causative agents of water quality incidents (1983–2012)

Category	Causative agent		No. of incidents	No. of incidents with health hazard
Microbes	Bacteria	*E. coli*	58	58
		Campylobacter	25	25
		Shigella	8	8
		Yersinia	5	5
		Salmonella	4	4
		Aeromonas	4	4
		Others (*Leptospira* etc.)	5	4
	Protozoa	*Cryptosporidium*	26	6
		Giardia	14	2
	Virus	Norovirus	6	6
		Rotavirus	1	1
	Others (fungi, etc.)		2	0
	Unknown (indicator bacteria (+))		10	5
	Unknown		3	3
	Subtotal		**171**	**131**
Others	Turbidity		117	0
	Sewage or industrial water		21	2
	Odor and taste		8	0
	Insufficient residual chlorine		7	0
	Chromaticity		3	0
	pH, etc.		5	0
	Subtotal		**161**	**2**
No causative agents	Incursion, breaking		5	0
	Attempted poisoning		3	0
	Operation by a prowler		1	0
	Subtotal		**9**	**0**
Chemicals	Oils		66	0
	Agrichemicals/pesticides		16	0
	Organic compound	Tetrachloroethylene	12	0
		Trichloroethylene	11	0
		Phenols	9	0
		Dioxins	6	0
		Toluene	6	1
		1,4-dioxane	5	0
		Carbon tetrachloride	5	0
		Benzene	4	0
		PCB, etc.	21	0
	Inorganic substances	Arsenic	26	1
		Cyanogen	12	0
		Nitric/nitrous acid	8	1
		Mercury	7	0
		Manganese	6	0
		Chromium	5	0
		Uranium	3	0
		Aluminum	3	0
		Fluorine, etc.	6	0
	Disinfectants/ DBPs/ impurities	Bromate	12	0
		Chlorate	10	0
		Sodium hypochlorite	5	2
		Formaldehyde, etc.	4	0
	Others (water treatment chemicals etc.)		8	2
	Subtotal		**276**	**7**
	Total		**617**	**140**

[a] Adapted from Kishida et al. (2015) [6]. *E. coli: Escherichia coli* ; PCB: poly chlorinated biphenyl; DBPs: disinfection by-products.

values of geosmin (<0.00001 mg/L) and/or 2-methylisoborneol (2-MIB, <0.00001 mg/L), which cause mold odor, every year between 2013 and 2019 [8]. To accumulate knowledge for the measures against taste and odor problems caused by algae, the AWM of NIPH has worked on the ecology of algae including the development of monitoring methods and treatment technologies such as activated carbon and coagulation.

2. Waterborne disease outbreaks

To understand the occurrence of recent waterborne disease outbreaks in Japan, we organized information on the outbreaks that occurred between 2003 and 2019 (Table 2). Most of outbreaks have been reported to the Water Supply Division of MHLW [8], and literature surveys were conducted to identify the types of water supply, source waters, causative agents, and the number of cases [9,10].

Although there have been no waterborne disease outbreaks reported in the municipal drinking water supply systems that supply water to a population of >5000 individuals since the largest waterborne disease outbreak caused by *Cryptosporidium* in 1996, a total of 23 outbreaks occurred in the small drinking water supplies that supply water to a population of <5000 individuals between 2003 and 2019 (Table 2). Among the 23 outbreaks, seven outbreaks occurred in water supply systems from private wells, four outbreaks in the small water supply that supply water to a population of 101–5000 individuals, and four outbreaks in the small water supply that served to a population less than 100 individuals. Fifteen out of 23 outbreaks (65%) occurred in water supply systems using groundwater from wells or springs. *Campylobacter* spp. were the major causative agents identified in eight outbreaks followed by norovirus (six outbreaks) and pathogenic *E. coli* (five outbreaks).

As source water is often contaminated with pathogenic microorganisms, inadequate disinfection (i.e., malfunctions in chlorine treatment) results in waterborne disease outbreaks. Assessment of the microbiol contamination of source waters and appropriate management of microbiological safety of water supply systems are required to further reduce the waterborne disease outbreaks. To assess the source water contamination with pathogenic viruses, the AWM of NIPH has conducted surveys under Health and Labour Sciences Research Grants from the MHLW, Japan [11,12].

IV. Contributions of the NIPH to DWQSs

The AWM of NIPH has played a major role in the revision of Japanese DWQSs, particularly in basic research such as surveys on drinking water quality and risk management. It has conducted basic research such as surveys on drinking water quality, daily water intake, and treatability of chemicals. These results have contributed to the formulation of standards and their conditions as risk management, based on WHO drinking water quality guidelines [13], overseas

Table 2 Recent waterborne disease outbreaks in Japan [a]

Year	Prefecture	Type of water supply	Source water	Causative agent	No. of cases
2003	Niigata	Private well	Shallow well	Norovirus GI and GII	151
	Ishikawa	Private well	Well	Norovirus GII	76
	Chiba	Receiving tank	Public water supply	Rotavirus A	47
	Oita	Private well	Well	Enterohemorrhagic *E. coli*	3
	Ehime	Specified (>100 individuals)	Deep well	*Campylobacter jejuni/coli*	69
2004	Hiroshima	Private well	Shallow well	Unknown (total coliforms (+))	15
	Nagano	Private well	Shallow well	Norovirus GII	65
	Ishikawa	Small (101–5000 individuals)	Surface water	*Campylobacter* sp.	52
2005	Akita	Small (101–5000 individuals)	Shallow well/spring	Norovirus GII	29
	Yamanashi	Small (101–5000 individuals)	Surface water	*Campylobacter jejuni*	76
	Oita	Specified (>100 individuals)	Subsoil water	*Plesiomonas shigelloides*	190
	Oita	Private 50–100 individuals	Spring	*E. coli* O168	273
	Nagano	Private 50–100 individuals	Spring	*E. coli* O55	43
2006	Fukushima	Private 30–100 individuals	Spring	*Campylobacter jejuni*	71
	Miyagi	Private well	Well	*Clostridium botulinum*	1
2010	Chiba	Receiving tank	Public water supply	*Giardia*	39
2011	Nagano	Specified (>100 individuals)	Surface water	*E. coli* O121	37
	Yamagata	Specified (>100 individuals)	Spring	*E. coli* O157	2
2012	Toyama	Small (101–5000 individuals)	Spring	*Yersinia enterocolitica* O8	4
2013	Osaka	Receiving tank	Public water supply	Norovirus GI, *Campylobacter jejuni*	6
2017	Yamanashi	Private well	Shallow well	*Campylobacter* sp.	18
2019	Hyogo	Receiving tank	Public water supply	Norovirus GI and GII	35
	Nagano	Small (≤100 individuals)	Spring water	*Campylobacter jejuni*	41

[a] Information was gathered and organized from MHLW (2020) [8], Yamada and Akiba (2007) [9], and Miura (2021) [10].

regulatory framework, and domestic studies, in addition to analytical methods and treatment technologies. NIPH plays important roles in the accomplishment of scientific research, producing reports and papers and laying statements at the council meetings. Now we can obtain the reports, papers, and all talks related to the discussion at the council meetings [14]. We hereby demonstrate the direct and indirect relationships between the DWQSs and research results.

1. Basis for setting water quality standards

Since the establishment of the Food Safety Commission in 2003, toxicity evaluation in risk assessment has been conducted independently by the Food Safety Commission. In response to the results, the MHLW, as a risk management organization, examines the use and detection conditions of the substances, contribution rate to water supply, controllability both in source water and treatment systems, analytical methods, and overseas conditions based on the values, and finally determines water quality standard values when necessary.

The values of the national drinking water quality standards on chemicals are determined from toxicity and allocation of the substance. The “allocation” is the percentage of intake allocated to tap water among the total intakes. Toxicological assessment is based on the Food Safety Commission’s assessment results, normally expressed as the value, such as TDI, tolerable daily intake. Using the value, the standard value is introduced using a standard bodyweight of 50 kg and water ingestion of 2 L.

Reference value = [Tolerable daily intake (TDI) (mg/kg/d)] × [allocation (%)] × [standard body weight 50 kg] / [water intake 2 L]

2. Setting the allocation -- necessity of the exposure study

The allocation value is a numerical value that determines how much of the intake is via tap water. Currently, 10% is generally used as a conventional rule in setting water quality standards in Japan, and 20% is used as the default value for disinfection by-products. Currently, this default value is used in principle in the successive revision of water quality standards for tap water, but if actual intake data are available, or if the contribution of other exposure pathways through the water supply is significant, a larger quota is used. The following are some examples of the use of quotas other than the default value.

For chlorate, the quota was set at 80% because it is contained in sodium hypochlorite solution, which is a major disinfectant, and quality control and refrigerated storage of sodium hypochlorite solution were promoted. When this allocation was determined, the AWM of NIPH conducted a national survey in drinking water and disinfectants [15] and a survey on chlorate and perchlorate, in foods and water to introduce their contribution rates [16]. In particular for chlorate, they showed that the contribution rate, i.e., intake of chloric acid from tap water containing the portion used for cooking rice, exceeded about 50% of the total intake, although it was lower than the TDI than the overall intake (Figure 5).

3. Nationwide data for water intake

The AWM of NIPH and Hokkaido University conducted a national study to reveal actual water intakes from tap water and other types of drinks [17]. We conducted a nationwide Internet questionnaire survey. Tap water intake negatively correlated with bottled water and soft drink intakes. The index, Potential Tap Water Intake (pTWI), was proposed in our study, calculated by adding soft drinks and bottled water to tap water intake. The estimated mean intake rate of drinking water was lower than 2 L/d; for example, mean tap water intake and pTWI were 1,287 and 1,653 mL/d, respectively. Two liters per day corresponds to the 88th percentile of tap water intake. Consequently we can say we covered

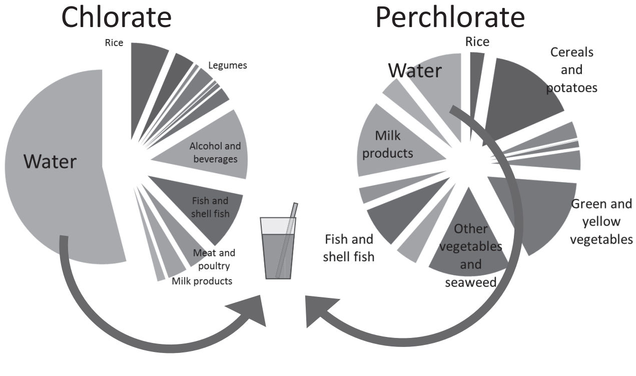

Figure 5 Total intake study of chlorate and perchlorate

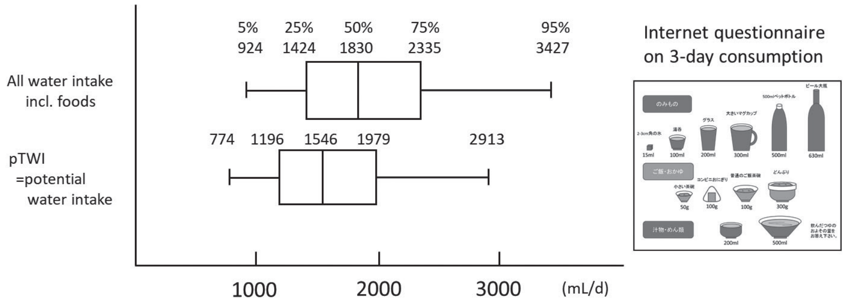

Figure 6 Box plot of pTWI, tap water intake and categories included in pTWI. Whiskers show 1st and 99th percentiles (based on Ohno et al. [17])

the intake of the majority of the population in Japan, although the intake rate distributed widely (Figure 6).

4. Selection of pesticides

Since two-thirds of water supply systems in Japan uses surface water as drinking water source, water contamination is an important issue for ensuring the safety and reliability of tap water. Pesticides, especially used in paddy areas, that may enter river water and are found in drinking water are of people's concern about chemical contamination of tap water. Sales of pesticides frequently change depending on market trends. Sales trends were analyzed from 1963 to 2016, and it was found that herbicides of soluble properties are increasing in these decades, i.e., the average log-Kow of herbicides has decreased from the 1970s to the present, due to the strong trend toward the application of hydrophilic herbicides, such as glyphosate [18]. The complementary items for pesticides are set using the total pesticide evaluation method, i.e., the sum of the ratios of the individual assessment values and detection values for each pesticide is set to be less than one. In selecting the pesticides with high detection potential, the amount shipped, and the value obtained by dividing the shipped amount by the the ADI was considered, and a selection index was developed [19]. Water suppliers are required to refer to the list of target pesticides and can select the pesticides to be measured from the list according to the actual conditions of each water source basin. This national framework was introduced in WHO report supported by NIPH members [20].

5. Other chemical substances

As for other chemical substances, consideration will be given to those that are frequently detected or have high detection concentrations, such as those listed as complementary items or items for further study. In addition, chemical substances that have been detected frequently in studies conducted overseas or by other ministries, chemical substances that are used in large quantities or discharged into the environment, and substances that have caused water quality accidents are monitored and added as necessary. Detection of some substances in the environment as a water source, the concentrations in purified water may be close to the provisional evaluation values [21].

We have conducted the national survey and data analysis on perchlorate [22], NDMA [23], radioactive substances [24], disinfection by-products [25, 26], inorganic substances [27], and currently organic fluorine substances, for instance. Toxicity assessments are conducted from a scientific point of view, but sometimes extremely strict assessment values are derived from the actual intake/exposure amounts and control measures. For example, in Japan, perchlorate is rarely detected at high concentrations in purified water because the source is limited; therefore, efforts have been made to reduce perchlorate in source water while asking the factories to reduce it despite setting standards and regulating perchlorate [22]. The AWM of NIPH played a substantial role in finding information and providing evidence to the government. We also have proposed many treatment options to control water quality. Two-step chlorination is proposed to control disinfection by-products [28], for example.

V. Conclusions and future perspectives

As described above, risk assessments and management in setting DWQSs have become more rational based on scientific evidence. The AWM of NIPH has conducted surveys to assess the risks posed by pathogenic microorganisms and chemicals in drinking water supply systems and has proposed the risk management strategies through papers, academic conferences, committees of national and local governments. The AWM has also provided training courses for personnel in water-related sections and environmental health sections of local governments. In addition, providing good evidence from international perspectives is fulfilled by publishing translation of WHO documents as shown in Figure 7 [29].

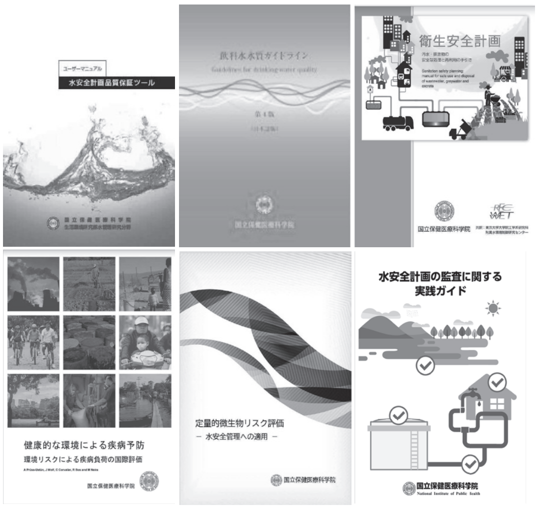

Figure 7 Publications on translation of WHO documents [29]

In general, when people hear the explanation of the basis for the standard values, people may concern about water safety. However, in reality, concentrations close to the standard values are very rarely detected, and in many cases, water quality control is carried out with sufficient margin on a daily basis. On the other hand, setting too stringent standards may be too costly or may lead to unbalanced measures. Management of environmental risks to achieve Sustainable Development Goals is also an important side of the worldwide issues [30]. It is necessary to explore the best available way of the standards pursuing the original purpose, that is, to protect people's health, conducting risk-benefit assessments for society, which are constantly changing.

Acknowledgments

This work was partly supported by the Health and Labour Sciences Research Grants (grant numbers H25-Kenki-Ippan-007 and H28-Kenki-Ippan-005) from MHLW, and JPMEERF18S11720(S-17). The views expressed in this article are those of the authors, but do not necessarily reflect the position of the supporting agency and the entities with which the authors are affiliated; therefore, no official endorsement should be inferred. The authors declare no actual or potential competing financial interests.

References

[1] MHLW. Water Supply in Japan. 4. Water Quality. https://www.mhlw.go.jp/english/policy/health/water_supply/4.html (accessed 2021-12-10)

[2] WHO. Guidelines for drinking-water quality, 3rd ed. Geneva. 2004.

[3] Yamamoto N, Urabe K, Takaoka M, Nakazawa K, Gotoh A, Haga M, et al. Outbreak of cryptosporidiosis after contamination of the public water supply in Saitama Prefecture, Japan, in 1996. Kansenshogaku Zasshi. 2000;74:518-526.

[4] 厚生労働省．令和２年３月末時点での上水道事業及び水道用水供給事業の水安全計画の策定状況．https://www.mhlw.go.jp/content/10900000/000750663.pdf (accessed 2021-12-10)
MHLW. Current status of development of water safety plans in water suppliers at the end of March, 2020. https://www.mhlw.go.jp/content/10900000/000750663.pdf (in Japanese)(accessed 2021-12-10)

[5] 厚生労働省．飲料水健康危機管理実施要領（平成９年３月，平成25年10月一部改定）. 2013. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/topics/bukyoku/kenkou/suido/kikikanri/inryo.html (accessed 2021-12-10)
MHLW. The operating procedure on health crisis management of drinking water. 2013. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/topics/bukyoku/kenkou/suido/kikikanri/inryo.html (in Japanese)(accessed 2021-12-10)

[6] 岸田直裕，松本悠，山田俊郎，浅見真理，秋葉道宏．我が国における過去30年間の飲料水を介した健康危機事例の解析（1983～2012年）．保健医療科学. 2015;64(2):70-80.
Kishida N, Matsumoto Y, Yamada T, Asami M, Akiba M. Analysis of health-related incidents associated with drinking water in Japan in the last three decades (1983-2012). J Natl Inst Public Health. 2015;64(2):70-80. (in Japanese)

[7] 厚生労働省．水質汚染事故等の発生状況．平成26年水道水質関連事故事例. 2014. https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000072229.pdf (accessed 2021-12-10)
MHLW. Occurrence of water quality incidents. Case example of water-quality-related incidents. 2014. https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000072229.pdf (in Japanese)(accessed 2021-12-10)

[8] 厚生労働省．水質汚染事故等の発生状況．健康影響の発生した水質汚染事故（令和２年10月現在）. 2020. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/topics/bukyoku/kenkou/suido/kikikanri/03.html (accessed 2021-12-10)
MHLW. Occurrence of drinking water contamination incidents. Water quality incidents with health hazard. As of October 2020. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/topics/bukyoku/kenkou/suido/kikikanri/03.html (in Japanese)(accessed 2021-12-10)

[9] 山田俊郎，秋葉道宏．最近10年間の水を介した健康被害事例．保健医療科学. 2007;56(1):16-23.
Yamada T, Akiba M. Waterborne health hazard cases in the

last 10 years. J Natl Inst Public Health. 2007;56(1):16-23. (in Japanese)

[10] 三浦尚之．地下水の微生物汚染とリスク管理．公衆衛生. 2021;85(2):78-82.
Miura T. Microbial contamination in groundwater and risk management. The Journal of Public Health Practice. 2021;85(2):78-82. (in Japanese)

[11] Miura T, Gima A, Akiba M. Detection of norovirus and rotavirus present in suspended and dissolved forms in drinking water sources. Food Environ Virol. 2019;11(1):9-19.

[12] Miura T, Takino H, Gima A, Haramoto E, Akiba M. Recovery of nucleic acids of enteric viruses and host-specific *Bacteroidales* from groundwater by using an adsorption-direct extraction method. Appl Environ Microbiol. 2021;87(18):e0071021.

[13] WHO. Guidelines for drinking-water quality, 4th ed. Geneva: WHO; 2011.
国立保健医療科学院．飲料水水質ガイドライン第４版（日本語版）. 2012.

[14] 厚生労働省．水質基準逐次改正検討会．https://www.mhlw.go.jp/stf/shingi/other-kenkou_128627.html (accessed 2021-12-10)
MHLW. Committee on the revision of national drinking water quality standard. https://www.mhlw.go.jp/stf/shingi/other-kenkou_128627.html (in Japanese)(accessed 2021-12-10)

[15] Asami M, Kosaka K, Kunikane S. Bromate, chlorate, chlorite and perchlorate in sodium hypochlorite solution used in water supply. J Water Supply: Research and Technology AQUA. 2009;58(2):107-115.

[16] Asami M, Yoshida N, Kosaka K, Ohno K, Matsui Y. Contribution of tap water to chlorate and perchlorate intake: a market basket study. Science of the Total Environment. 2013;463:199-208.

[17] Ohno K, Asami M, Matsui Y. Is the default of 2 liters for daily per-capita water consumption appropriate? A nationwide survey reveals water intake in Japan, J Water Health. 2018;16(4):562-573.

[18] Kamata M, Matsui Y, Asami M. National trends in pesticides in drinking water and water sources in Japan. Sci Total Environ. 2020;744:140930.

[19] Narita K, Matsui Y, Iwao K, Kamata M, Matsushita T, Shirasaki N. Selecting pesticides for inclusion in drinking water quality guidelines on the basis of detection probability and ranking. Environ Int. 2014;63:114-120.

[20] Bevan R, Fawell J. Contributed by Asami M, et al. Chemical Mixtures in Source Water and Drinking-Water. WHO, 2017, Geneva. ISBN 978-92-4-151237-4. https://apps.who.int/iris/bitstream/handle/10665/255543/9789241512374-eng.pdf (accessed 2021-12-10)

[21] NIPH. Detection of some substances in the environment. https://www.niph.go.jp/soshiki/suido/pdf/h28chemDB/NIPH-chemDB_2016JWWAannualconf.pdf (accessed 2021-12-10)

[22] Kosaka K, Asami M, Matsuoka Y, Kamoshita M, Kunikane S. Occurrence of perchlorate in drinking water sources of metropolitan area in Japan. Water Res. 2007;41(15):3474-3482.

[23] Asami M, Oya M, Kosaka K. A nationwide survey of NDMA in raw and drinking water in Japan. Sci Total Environ. 2009;407:3540-3545.

[24] Kosaka K, Asami M, Kobashigawa N, Ohkubo K, Terada H, Kishida N, et al. Removal of radioactive iodine and cesium in water purification processes after an explosion at a nuclear power plant due to the Great East Japan Earthquake. Water Res. 2012;46(14):4397-4404.

[25] Kosaka K, Ohkubo K, Akiba M. Occurrence and formation of haloacetamides from chlorination at water purification plants across Japan. Water Res. 2016;106:470-476.

[26] Nakai T, Hishida Y, Asami M, Ohkubo K, Akiba M. Formation of 2,6-dichloro-1,4-benzoquinone from aromatic compounds after chlorination. Water Res. 2017;110:48-55.

[27] Asami M, Furuhashi Y, Nakamura Y, Sasaki Y, Adachi Y, Maeda N, et al. A field survey on elution of lead and nickel from taps used in homes and analysis of product test results, Science of the Total Environment. Sci Total Environ. 2021;771:144979(1-7).

[28] Kosaka K, Kobashigawa N, Nakamura R, Asami M, Echigo S, Akiba M. Control of trichloramine formation by two-step chlorination in water purification processes. Water Science & Technology: Water Supply. 2014;14:650-666.

[29] NIPH. List of WHO publications translated into Japanese by the Area on Water Management, Department of Environmental Health, NIPH. https://www.niph.go.jp/publications/ (accessed 2021-12-10)

[30] Asami M. Spectrum of environmental risk assessment, management and communication. In: Nakajima T, Nakamura K, Nohara K, Kondo A, edited. Overcoming environmental risks to achieve sustainable development goals. Singapore; Springer Nature Singapore: 2022. Chapter 19, p.157-176.

＜総説＞

我が国の水道水質管理における国立保健医療科学院の近年の貢献

三好太郎，三浦尚之，浅見真理

国立保健医療科学院生活環境研究部水管理研究領域

抄録

安全な水道水の供給は公衆衛生の維持において必須である．水道水質に対する要求は新規の有害化学物質やリスク要因が認知されるに伴い更新される．そのような更新に際し，正確で最新の科学的知見を提示することは国立保健医療科学院・生活環境研究部・水管理研究領域における最重要事項の一つである．本稿では，我が国の水道水質管理における当院のこれまでの貢献を総括する．我が国における水道水質管理の概略を水質基準の歴史，現在の水質基準の基本的な考え方，病原微生物制御の方策，及び水安全計画策定に向けた取り組みの観点から説明する．また，近年生じた水質汚染事故並びに水系感染症集団発生事例を概説する．さらに，当院の貢献をいくつかの具体事例を挙げながら詳細に説明する．具体事例としては，近年当院で取り扱った水道水質基準策定時に活用する各種成分の摂取における水道水の寄与率の設定，水道水の飲水量に関する全国調査，並びに水道水質基準において規制対象とする農薬やその他化学物質の選定に係る検討の成果を報告する．以上の経緯を踏まえ，当院に期待される今後の研究面及び研修面における活動内容について展望を述べる．

キーワード：水道システム，リスク管理，水質基準，水系感染症，厚生労働科学研究費