大 韓 衛 生 學 會 誌
KOREAN. J. SANITAT
Vol.1, No. 1, 1～29(1986)

The Significance of Drinking Water Quality Standards in Developed Countries in Relation to Environmental Health

yun－syng Cho

Department of Environmental Health Research
National Environmental Protection Institute

Abstract

The guidelines and regulations that have revised by World Health Organization, the United States of America, Canada and Japan were reviewed for standards relevant to health of the people. The substances and parameters were discussed. Various standards were presented and recent changes in policies were relighted with their scientific information.

World Health Organization estimates that 500 million(1) diarrheal episodes occur each year in children under five in Asia, Africa, and Latin America. Three to four percent of these end in death. These illnesses are the result of proverty, ignorance, mulnutrition, and poor environmental sanitation, particularly inadequate water supply and excreta disposal.

In connection with drinking water, the United Nations inaugurated the International Water Supply and Sanitation Decade (1981 – 1990), with the goal of readily accessible, safe, reliable, and adequate community water supplies and sanitation by the year 1990.

The primary purpose of drinking water standards are for the protection of public health. Any water intended for human consumption should not contain any disease-causing organisms, excessive amounts of toxic substances or radioactive substances. Aesthetic considerations may also provide a basis for drinking water standads since the water should be pleasant to drink. Temperature, taste, odour, turbidity and colour are all important in achieving waters which are aethetically acceptable and pleasant to drink.

Less than 50 years ago, epidemics of waterborne diseases were a major public health menace in the developing countries. Modern methods of water purification –

particularly chlorination – have been remarkably effective in reducing instances of cholera, typhoid, dysentery, and paratyphoid. Waterborne diseases still occur with unnecessary frequency, but major epidemics have been all but eliminated in this century..

In recent years, however, public health professionals have become incresingly concerned about contaminants in water supplies. These include inorganic chemicals such as nitrate, arsenic, and lead, as well as toxic organic chemicals which have been produced in ever-growing volumes. Certain pesticides also have been produced in ever-growing volumes. Certain pesticides also have been added to the list of contaminants that have found their way into drinking water in some places. Some of these pollutants are harmful even in small amounts, and can be extremely difficult to remove once they have contaminated a water supply.

To assist with those problems, World Health Organization and the developed countries revised the guidelines(2) or regulations related to drinking water quality standards. European countries apply WHO guidelines with EEC standards, while, most of other developing countries prepared their own standards or criteria taking into consideration of WHO recommendations.

Some countries, of which Great Britain has been one,(7) have preferred not to adopt madatory standards, on the grounds that no standards can be framed to take adequate account of the many local factors which affect the suitability of given types of water for their intended uses.

METHOD OF LITERATURE REVIEW

A search of the major bibliographic system was performed by the National Environmental Protection Institute library. The search process also included the International Referal System for Source of Environmental Information.(8)

From each report or document the reviewer abstracted information for any development through comparison between recent and previous standards which established by WHO and the developed countries such as, USA, Canada and Japan.

WHO Guidelines

In 1984, World Health Organization revised the guidelines for the International and the European standards for drinking water quality. The guidelines are intended to supersede previous standards which have been in existance for over a decade. These recommendations are also intended for use by countries as a basis for the development of standards.

Basis of guidline values;

In developing guideline values revised by WHO, the objective is to define a quality of water that can be safety consumed by everyone throughout their lifetime. These guidelines represent an informed judgement based upon several factors, including;

- scientific criteria, defining dose-response relationships for substances,
- analytical data on the frequency of occurr-

ence and concentrations of substances commonly found in drinking water, and

– the potencial application of suitable control techniques to remove or reduce the concentration of substances in drinking water.

Inorganic chemicals;

In the previous standards published in 1971,[3] the substances included arsenic, cadmium, lead, mercury, selenium, fluoride and nitrate while, the guidelines of 1984, newly added chromium and there were minor adjustment of values.

Organic chemicals;

The guidelines 1984, newly established 18 organic substances, mainly pesticides. In the previous standards of 1971, WHO recommended the observations organic contamination referred only to pesticides and polycyclic aromatic consituents in the European standards. During last decade the increase in knowledge relating to water contamination by organic substances has necessitated the consideration of a much broder range of such contaminants. More than 2000 chemical contaminants of all kinds have been found in water, about 750 of which have been identified in drinking water. Of these, more than 600 are organic substances, including many that are pharmacologically active, several that are recognized carcinogens or carcino promoters, and a number that have been shown to be mutagenic.

The pesticides are major change of guideline values compared to previous one. Of these compounds, chlorinated hydrocarbons and their derivatives occur frequently in water supplies and some pesticides of these group are still used for purposes such as vector control which have been shown to produce tumours in animals. These guideline values are derived from the acceptable daily intake (ADI) values set over the years by FAO/WHO Joint Expert Meetings on Pesticide Residues with the assumption that not more than 1% of the ADI would be derived from drinking water.

Guideline values have been recommended for a number of organic and inorganic substances, that are carcinogens or suspected carcinogens based upon a linear, multi-stage extapolation model. The guideline values quoted in this document are based upon the selection of an acceptable risk of less than 1 additional case of cancer per 100,000 population assuming a daily consumption of 2 litres of drinking water by a 70 kg man.

Table 1 and Table 2 are the summaries of chemicals which closely related to disease and health of the people and other constituents may give rise to trouble.[11]

Sampling;

The frequency of sampling should depend on source-water quality, the number of watersources, the past frequency of unsatisfactory samples, the adequacy of treatment and capacity of the treatment plant, the size and complexity of the distribution system, the practice of disinfection, and the size of the population served. However, decisions on

Table 1. Chemical and other sources present in water supply which closely related to health;

Source	Disease or syndrome	Remarks
Metals	Toxicoses	Intake of metals in drinking water, food, and air from both natural sources and human activities. These include arsenic, cadmium, copper, chromium, lead, mercury, selenium, vanadium, zinc, can be important on a local basis, e.g., arsenic in parts of Argentina.
Organic chemicals	Toxicoses · Cancers Mutations · Birth defects	Intake of certain chemicals, esp. Certain synthetic organic chemicals, including some pesticides. Also some trihalomethane by products of chlorination are suspect carcinogens.
Radionuclides	Cancers	Natural and man-made radioactivity.
	Cardiovascular disease	Some epidemiological evidence indicates an inverse correlation of cardiovascular diseases with hardness of drinking water.
Other	Fluorosis	Damage to teeth and bones resulting from long-term ingestion of high concentrations of naturally occuring fluorides.
	Methemoglobinemia	Serious, sometimes fatal poisoning of infants following ingestion of well waters containing nitrates(NO_3) at concentrations higher than 45
	Endemic goiter	Iodine-deficient water or containing goitrogen.
	Asbestosis & Mesothelioma	Asbestos in lungs known to cause cancer. Fate in gastrointestinal tract unknown.
	Hypertension	Sodium-restricted diets necessary for parts of population.

Table 2. Constituents in water which, if present in excessive amount may give rise to trouble.

Substance	Nature of trouble which may arise
Phenolic compounds	Taste, particularly in chlorinated water
Fluoride (as F)	Fluorosis
Nitrate (as NO_3)	Danger of infantile methemoglobinemia if the water is consumed by infants
Iron (total as Fe)	Taste; discoloration; deposits and growthof of iron bacteria; turbidity
Manganese (as Mn)	Taste; discoloration; deposit in pipes; turbidity
Zinc (as Zn)	Astringent taste; opalescence and sandlike deposits
Magnesium (as Mg)	Hardness, taste
Sulfate (as SO_4)	Gastrointestinal irritation when combined with magnesium or sodium
Hydrogen sulfide (as H2S)	Taste and odor
Chloride (as Cl)	Taste; corrosion in hotwater system
Anionic detergents	Taste and foaming
Ammonia (as NH_4)	Growth of organizms, danger of corrosion in pipes difficulties in chlorination
Free carbon dioxide (as CO_2)	Damage to pipes, danger of bringing toxic metals into solution
Total hardness	Excessive scale formation danger of dissolving heavy metals if the level of hardness is below the recommended limit

sampling frequency should be taken by national authorities.

The following minimum sampling frequencies are recommended by WHO;

Population served	minimum number of samples
less than 5000	1 sample per month
5000-100,000	1 sample per 5000 population/month
more than 100,000	1 sample per 100,000 population/month

In Ontario, Canada, the minimum number of bacteriological sample collection from a distribution system determined from the following table: (17)

Population served	Minimum number of samples per month	Minimum frequency sampling
UP to 100,000	8+1 per 1,000 population	Weekly
Over 100,000	100+1 per 10,000 population	Several times per week

Table 3 presents a summary and comparison of WHO drinking water quality standards between old and new.

Table 3. Comparison of WHO drinking water quality standards of 1971 and 1984

Substance		1971	1984
1. Inorganic;			
arsenic	mg/l	0.05	0.05
cadmium	〃	0.01	0.005
chromium	〃	–	0.05
cyanide	〃	0.05	0.1
fluoride	〃	0.8 – 1.7	1.5
lead	〃	0.1	0.05
mercury	〃	0.001	0.001
nitrate	〃	40	10
selenium	〃	0.01	0.01
2. Organic;			
aldrin and dieldrin	mg/l		0.00003
benzene			0.01
benzo(a) pyrene			0.00001
carbon tetrachloride			0.003
chlordane			0.0003
chloroform			0.03
2,4-D			0.1
D D T			0.001
1,2-dichloroethane			0.01
1,1-dichloroethene			0.0003
heptachlor + heptachlor epoxide			0.0001
hexachlorobenzene			0.00001
lindane			0.003
methoxychlor			0.03
pentachlorophenol			0.01
tetrachloroethene			0.01
trichloroethene			0.03
2,4,6-trichlorophenol			0.01
3. Aesthetic quality;			
aluminium	mg/l		0.2
calcium		200	
chloride		600	250
colour	TCU	50	15
copper	mg/l	1.5	1.0
forming agent	〃	1.0	0.2
hardness		500	500
iron		1.0	0.3
manganese		0.5	0.1
odour		inoffensive	inoffensive

pH		6.5 – 9.2	6.5 – 8.5
phenols	mg/l	0.002	–
sodium		–	200
sulfate		400	400
total dissolved solids	mg/l	1500	1000
turbidity	NTU	25	5
zinc	mg/l	15	5

4. Radioactive;

gross alpha activity	pCi/l	3	Bq/l 0.1
gross beta activity	〃	30	〃 1

5. Microbiological quality;

1971	1984
(1) Throughout any year, 95% of samples should not contain any coliform organisms in 100 ml.	(1) No sample should contain faecal coliforms in 100 ml.
(2) No sample should contain E. coli in 100 ml.	(2) Throughout the year in 95% of samples should not contain any coliform organisms in 100 ml. (in the case of large supplies when sufficient samples are examined).
(3) No sample should contain more than 10 coliform organisms per 100 ml.	(3) Coliform organisms should not exceed 3 in 100 ml of any occasional sample but not in consecutive samples.
(4) Coliform organisms should not be detectable in 100 ml of any two conceuctive samples.	

U.S. National Interim Primary Drinking Water Regulations

In 1975, under the Safe Drinking Water Act, EPA adopted National Interim Primary Drinking Water Regulations. The regulations specify maximum levels for several organic and inorganic contaminants, microbiological contaminants, and turbidity. Regulations radionuclides in drinking water were added in 1976[4] while, trihalomethanes were established in 1979.[5] All those contaminants are enforceable by EPA or the states which have accepted primary responsibility.

EPA established National Secondary Drinking Water Regulations in 1979. These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. The regulations are not federally enforceable but are intended as guidelines for the states. The states may establish higher or lower levels which may be appropriate dependent upon local conditions such as unavilability of alternate source waters or other compelling factors, provided that public health and welfare are not adversely affected.

The maximum contaminant levels of

substances are as follows;[6)]

Fluoride;

Temperature	MCL
12–0 and below	2.4
12.1 to 14.6	2.2
14.7 to 17.6	2.0
17.7 to 21.4	1.8
21.5 to 26.2	1.6
26.3 to 32.5	1.4

Organic;

– Chlorinated hydrocarbons;	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
– Chlorophenoxys;	
2,4-D	0.1
2,4,5-TP Silvex	0.01
– Total trihalomethanes	

Gross alpha particle radioactivity;

Combined radium-226 and radium-228 5 pCi/l

Gross alpha particle activity (including radium-226 but excluding raon and uranium) 15 pCi/l

Beta and photon; 4 millirem/y

Biological contaminants;

The maximum contaminant levels for Coliform bacteria, applicable to community water systems are given below.

When the membrane filter technique is used, the number of coliform bacteria shall not exceed any of the following;[(6)]

1. One/100 ml as the arithmetic mean of all samples examined per month. – or –

Secondary maximum contaminant levels;

Contaminant	MCL
Chloride	250 mg/l
Colour	15 CU
Copper	1.0 mg/l
Corrosivity	noncorrosive
Forming agents	0.5 mg/l
Iron	0.3
Manganes	0.05
Odour	3.0 threshold odour number
pH	6.5 – 8.5
Sulfate	250 mg/l
Total Dissolved Solids	500
Zinc	5.0

2. Four/100 ml in more than one sample when 20 or more are specified per month.
3. Four/100 ml in more than five percent of the samples when 20 or more are specified per month.

When using multiple-tube fermentation test; (10 ml portions)

1. Coliform should not be present in more than 10 percent of the portions per month,
2. Not more than one sample may have three or more portions positive when less than 20 samples are examined per month, or
3. Not more than 5 percent the sampels may have three or more portions positive when 20 or more samples are examined per month.

Total trihalomethanes control;

Total trihalomethanes including chloroform, dichlorobromomethane, dibromochloromethane, and bromoform occur in drinking water as a result of the interaction of chlorine, applied for disinfection and other purposes, with naturally occuring organic substances in raw water.

U.S. EPA identified the following as the best technology, treatment techniques or other means generally available for achieving compliance with the maximum contaminant level for total trihalomethanes.

1. Use of chloramines as an alternate or supplemental disinfectant or oxidant.
2. Use of chlorine dioxide as an alternate or supplemental disinfectant or oxidant.
3. Improved existing clarification for THM precursor reduction.
4. Moving the point of chlorination to reduce TTHM formation and, where necessary, substituting for the use of chlorine as a pre-oxidant chloramines, chlorine dioxide or potassium permanganate.
5. Use of powdered activated carbon for THM precursor or TTHM reduction seasonally or intermittently at dosages not to exceed 10 mg/l on an annual average basis.

In the determination of total trihalomethanes in raw and drinking water, U.S. EPA approved one of the following methods;

- The analysis of trihalomethanes in drinking waters by the Purge and Trap Method 501.1, EMSL, EPA Cincinnati, Ohio
- The analysis of trihalomethanes in drinking water by Liqui/Liquid Extraction, Method 501.2, EMSL, EPA Cincinnati, Ohio

According to EPA source, analysis using gas chromatography mass spectrometry (GC/MS) have shown that there was no evidence of interference in the determination of trihalomethanes.

Analysis of Trihalomethanes in drinking water by liquid/liquid extraction;

1. Scope

1.1 This method (1,2) is applicable only to the determination of four trihalomethanes. i.e., chloroform, bromomodichloromethane, chlorodibromomethane, and bromoform in finished drinking water, drinking water during intermediate stages of treatment, and the raw source water.

1.2 For componds other than the above methioned trihalomethanes, or for other sample sources, the analyst must demonstrate the usefulness of the the method by collecting precision and accuracy dataon actual samples as described in (3) and provide qualitative confirmation of results by Gas Chromatography/Mass Spectrometry (GC/MS) (4).

1.3 Qualitative analyses using GC/MS or the purge and trap method (5) must be performed to characterize each raw source water if peaks appear as interferences in the raw source analysis.

1.4 The method has been been shown to be useful for the trihalomethanes over a concentration range from approximately 0.5 to 200ug/l. Actual detection limits are highly dependent upon the characteristics of the gas chromatographic system used.

2. Summary

2.1 Ten milliliters of sample are extracted one time with 2 ml of solvent. Three ul of the extract are then injected into a gas chromatography equipped with a linearized electron capture detector for separation and analysis.

2.2 The extraction and analysis time is 10 to 50 minutes per sample depending upon the analytical conditions chosen.

EPA is seeking various ways of controlling a group of chemicals known as volitile synthetic organic chemicals(VOCs) frequently found in drinking water supplies, especially ground water. EPA currently is considering controls on up to 14 volatile organics, but other, similar compounds also may be of concern to the agency.

Water treatment methods effective in controlling volatile organics include aeration and filtering through granular activated carbon. The choice choice of cleanup method would be left up to the water utilities.

Preliminary EPA estimates indicate that the cost of controlling these or organics in larger drinking water systems (10,000 or greater population) could add roughly $1 or $2 to customers' monthly water bills.[16]

The Guidelines for Canadian drinking water quality 1978

This guidelines are replacement for the Canadian drinking water standards and objectives 1968. It is recognized, however, that local circumstances may necessiate modification of some of the recommended values. The limits described herein should therefore not be regarded as legally enforceable standards unless promulgated as such by the appropriate provincial or federal agency.

Purpose and scope;

Water for drinking, bulinary, and other domestic uses should be safe, palatable and aesthetically appealing. It should be free from pathozenic organisms, hazardous chemical and radioactive substances, and objectionable colour odour, and taste. Other aspects, such as corrosivity, tendency to form inclustations and excessive soap consumption due to hardness are also important in determining domestic water supply.

Limits are specified on the basis of two considerations, namely, health and aethetics, as follows;

Health; These limits apply to certain substances that are known or suspected to have adverse health effects.

Aesthetics; These limits apply to certain substances or conditions, the presence of which inexcess of these limits in water does not present a risk to human health, but may render the water unpalatable or otherwise unacceptable to the consumer.

In the case of physical and chemical characteristics, two types of limit have been established;

- Maximum acceptable;
  Drinking water that contain in concentrations greateer than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.
- Objective;
  This level is interpreted as the ultimate quality goal for both health and aesthetic purposes.

The chemical characteristics of water are divided into four section; fluoride, other parameters related to health, parameters related to aesthetic and other considerations, and non-specific parameters.

Fluoride;

The maximum acceptable concentration for fluoride in drinking water is 1.5 mg/l. Fluoride levels in excess of this limit produce dental fluorosis, a condition characterized by mottling of tooth enamel. The presence of small amounts of fluoride in drinking water leads to substantial reduction of dental caris, particularly among children.

Chemical substances related to health;

This category comprises those inorganic and organic chemical substances that may be a hazard to the health of man if present above certain concentrations in drinking water. In general, the specified maximum acceptable concentrations have been derived by assessing the possibility of adverse effects after prolonged exposure. Because the intake of these substances from other sources (such as milk, food, or air) may be difficult to avoid, it is desirable to control that fraction of intake associated with drinking water. The total environmental exposure of man to the specific toxicant has therefore been taken into consideration in arriving at a specific limit. Maximum acceptable and objective concentrations for these substances are listed in Table 5.(9)

Pesticides;

The maximum acceptable and objective concentrations of various pesticides are given in Table. 6. When more than one of these

Table 5. Recommended Limits for Chemical Substances Related to Health

Substances	Maximum Acceptable Concentration mg/l	Objective concentration mg/l
Inorganic		
Arsenic	0.05 mg/l	< 0.005
Barium	1.0	< 0.1
Boron	5.0	< 0.01
Cadium	0.005	< 0.001
Chromium	0.05	< 0.0002
Cyanide (free)	0.2	< 0.002
Lead	0.05	< 0.001
Mercury	0.001	< 0.0002
Nitrate (as N)	10.0	< 0.001
Nitrite (as N)	1.0	< 0.001
Selenium	0.01	< 0.002
Silver	0.05	< 0.005
Sulphate	500	< 150
Uranium	0.02	< 0.001
Organic;		
Nitrilotriacetic Acid (NTA)	0.05	< 0.0002
Pesticides (Total)	0.1	–
Trihalomethanes	0.35	< 0.0005

pesticides are present the sum of their concentrations should not exceed 0.1 mg/l. With the exception of the maximum concentration for toxaphene, which is based on aesthetic criteria, these limits have been established on the basis of health considerations.

Maximum acceptable concentrations have been derived for those pesticides for which acceptable daily intake values have been published by the WHO or the U.S. Environmental Protection Agency. Daily consumption of 2 litres of water containing the maximum acceptable concentration of a specific pesticide would result in the ingestion of not more than 20 percent of the A.D.I. for that pesticide.

It is recognized that the list of pesticides in Table 6 is not comprehensive and constitutes only a small fraction of the number of such substances available in Canada. Local circumstances may, however, require the extensive use of a pesticide for which guidelines have not been established.

Coliform organisms;

In Canada, three methods are currently in use for the multiple-tube-fermentation (most probable number or MPN) and membrane filter techniques may be found in the current edition of Standards Methods for the Examination of Water and Wastewater.

A third procedure, the presence-absence test, is essentially a modification of the multiple-tube-fermentation test in which only one analysis bottle per sample is used. It

Table 6. Recommended Limits for Pesticides

Pesticide*	Maximum Acceptable Concentration mg/l	Objective Concentration mg/l
Aldrin + Dieldrin	0.0007	$< 5 \times 10^{-8}$
Carbaryl	0.07	$\leq 5 \times 10^{-4}$
Chlordane (Total Isomers)	0.007	$\leq 5 \times 10^{-7}$
DDT (Total Isomers)	0.03	$\leq 5 \times 10^{-8}$
Diazinon	0.014	$\leq 1 \times 10^{-6}$
Endrin	0.0002	$\leq 5 \times 10^{-8}$
Heptachlor + Heptachlor Epoxide	0.003	$\leq 5 \times 10^{-8}$
Lindane	0.004	$\leq 1 \times 10^{-7}$
Methoxychlor	0.1	$\leq 5 \times 10^{-8}$
Methyl Parathion	0.007	$\leq 1 \times 10^{-6}$
Parathion	0.035	$\leq 1 \times 10^{-6}$
Toxaphene	0.005	$\leq 5 \times 10^{-8}$
2,4-D	0.1	$\leq 1 \times 10^{-3}$
2,4,5-TP	0.01	$\leq 1 \times 10^{-3}$
Total Pesticides**	0.1	–

* The limits on each pesticide refer to the sum of all forms present.

** The "total pesticides" limit applies to water in which more than one of the above pesticides is present, in which case, the sum of their concentrations should not exceed 0.1 mg/l.

offers a sensitive, economical, and efficient means of analysis municipal water supplies when a series of samples from one system has been collected. However, because it is not quantitative, samples giving a positive result will require an MF or MPN analysis to determine numbers of organisms.

The following maximum acceptable level is recommended;

1. no sample should contain more than 10 total coliform organisms per 100 ml, and
2. not more than 10 percent of the samples taken in a 30-day period should show the presence of coliform organisms; and
3. not more than 2 consecutive samples from the same site should show the presence of coliform organisms; and
4. none of the coliform organisms detected should be fecal coliforms.

Radionuclides;

Man's exposure to radiation results from external sources such as cosmic and terrestrial radiation and internal sources such as radionuclides taken into the body with food, water, inhaled air and particulate matter. With respect to drinking water the important factors to consider are the type of radiation associated with the radionuclides that may be present in water supplies, their distribution to body organs and tissues after ingestion, and the radiation doses delivered over the lifetime of the individual.

There are more than 200 radionuclides, some of which occur naturally and others which originate from activities of amn such as energy production and nuclear weapons testing. The radionuclides currently of greatest interest from a health viewpoint are tritium, strontium-90, iodine-131, cesium-137 and radium-226. Of these, tritium and radium-226 are naturally occuring, but their levels may be enhanced above background due to operations associated with the nuclear fuel cycle. Tritium is introduced by its release from nucleapower gernerating facilities; radium-226 levels may be elevated in water bodies that drain areas in which uranium mining and milling are conducted.

The guidelines for the radiological characteristics of water are based on the dose-response relationships as recommended by the International Commission on Radiological Protection in publication 26. Two types of limits have been derived;

Table 7. Recommended Limits for Radionuclides in Drinking Water

Radionuclides	Maximum Acceptable Concentration Bq/l	Target Concentration Bq/l
Cesium-137	50	5
Iodine-131	10	1
Radium-226	1	0.1
Strontium-90	10	1
Tritium	40,000	4,000

Maximum acceptable concentrations which correspond to 1% of the ICRP recommended annual occupational dose equivalent limit for occupational exposure. Target concentrations which correspond to 0.1% of this dose equivalent limit or 1/10 of the maximum acceptable concentration.

Parameters related to aesthetic and other consideration;

This category comprises certain chemical substances that are of no immediate health significance but which could, if present in excessive amounts, interfere with the intended domestic uses of the finished water. These chemicals may be aesthetically objectionable, interfere with water-treatment processes and distribution, or stain fixtures and plumbing.

Table 8. Recommended Limits for Substances Related to Aesthetic and Other Considerations

Contaminant	Maximum Acceptable Concentration mg/l	Objective Concentration mg/l
Chloride	250	< 250
Copper	1.0	< 1.0
Iron	0.3	< 0.05
Manganese	0.05	< 0.01
Phenols	0.002	< 0.002
Sulphide (as H_2S)	0.05	< 0.05
Zinc	5.0	< 5.0

Japanese water quality standards

The ministrial ordinance of the drinking water quality standards under the Waterworks Law in Japan was revised in August 1978. The new standards refers to 27 water quality items, and also presents administrative guidelines for one item.

Establishment of the standards was based on the following three principles.

- Safety and fitness for use of supplied water
- Appropriateness of the selection of items
- Appropriateness of the examination method

These three principles contain the following practical details.

- Information of effect on human health and on use of water supply in daily life (toxicological data, etc.)
- Distribution patterns of substances in natural environment.
- Actual condition of river and lake water pollution.
- Technical possibility of removing the appropriate substances with water treatment.
- The present status of technical level of water examination systems.

Water quality standards for drinking water in Japan are as follows;[10]

Table 9. Japanese Drinking Water Quality Standards

A requirement prescribed in Article 4, Paragraph 1, Item 1. (Not to be affected by any pathogenic organism nor to contain any organism or substance which gives ground for suspicion of being affected by pathogenic organism)	Nitrate and Nitrite nitrogen Chloride Organic substances (as potessium permanganate consumption) Standard plate count Coliform group	Max. 10 mg/l Max. 200 mg/l Max. 10 mg/l (colony counts per ml at 37°C) Max. 100 Not to be detected (volume of the sample in 50 ml)
A requirement prescribed in Article 4, Paragraph 1, Item 2. (Not to contain cyanide, mercury and other poisonous substances)	Cyanide Mercury Organic phosphate	Not to be detected* Not to be detected Not to be detected
A requirement prescribed in Article 4, Paragraph 1, Item 3. (Not to contain copper, iron, fluorine, phenols and other substances in excess of their allowable quantities)	Copper Iron Manganese Zinc Lead Chromium (hexavalent) Cadmium Arsenic Fluoride Calcium, Magnesium (hardness) Total residue Phenols Anion surfactant	Max. 10 mg/l Max. 0.3 mg/l Max. 0.3 mg/l Max. 1.0 mg/l Max. 0.1 mg/l Max. 0.05 mg/l Max. 0.01 mg/l Max. 0.05 mg/l Max. 0.8 mg/l Max. 300 mg/l Max. 500 mg/l Max. 0.005 mg/l as phenol Max. 0.5 mg/l
A requirement prescribed in Article 4, Paragraph 1, Item 4. (Not to assume abnormal acidity or alkalinity)	Hydrogen ion concentration (pH)	From max. 8.6 to min. 5.8 as pH value
A requirement prescribed in Article 4, Paragraph 1, Item 5. (Not to give an offensivesmell, except the smell caused by sterilization)	Odor Taste	Not to be abnormal Not to be abnormal
A requirement-prescribed in Article 4, Paragraph 1, Item 6. (To be almost colorless and transparent in appearance)	Color Turbidity	Max. 5 degree Max. 2 degree

* Minimum detectable quality; Cyanide 0.01 mg/l, Mercury 0.0005mg/l, Organic phospate 0.1 mg/l.

Control level of trihalomethane;

The Ministry of Health and Welfare established a Control Level of total trihalomethanes of 0.10 mg/l in drinking water in March, 1981. This level is the same value as the maximum contaminant level of U.S.A.

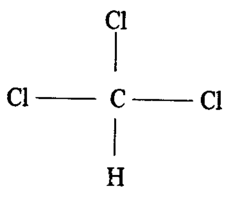
Regardless of the population served, this level is applied for all water works. Each community water works must estimate mean values of potassium permanganate consumption and colour during the past five years.

A considerable value of consumption, above 12 mg/l, is found of potassium permanganate water works using surface water, and that value of colour is more than 20 grades higher than river bed water or underground water, therefore the water works must begin monitoring trihalomethane in drinking water.

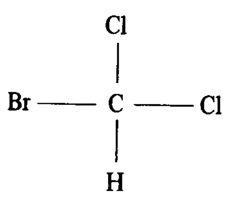
- When the raw water quality of waterworks is not satisfactory, total trihalomethanes must be tested more than four times a year.
- When total trihalomethane is up to 0.10 mg/l, it must be tested once a year.

The structural formulas of the four trihalomethanes commonly associated with chlorination are as follows;

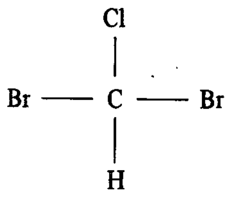
Cl



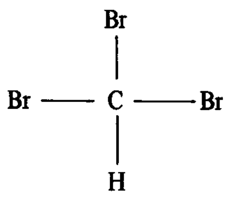
Chloroform



Bromo dichloromethane



Dibromochloro-methane



Bromoform

DISCUSSION

The guideline values which were recomended by WHO included 46 substances for the protection of public health covering inorganic, organic, aesthetic and other consideration, radioactive, and microbiological contaminants.

The U.S.A. established 35 miximum contaminant levels including the primary and secondary regulations while, Canada adopted 48 miximum acceptable concentration togetther with objective concentration. On the other hands, Japan regulated 27 items and also added administrative guideline for one contaminant.

Table 10. summarizes the drinking water quality standards in developed countries.

Inorganic;

Compared to drinking water quality standards between WHO and three countries, there was'nt any big differences in total substances and values, except few trace metals.

Figure 1. presents the comparison of major trace metals between WHO and developed countries.

Natural sources;

Interdisciplinary programs are necessary to establish causal relationships between the distribution of trace metals in the environment and health and disease. Toxic amounts of arsenic and selenium, for instance, have been found in domestic waters of certain region where source rocks contain anomanous amounts of these elements, in those areas, toxic effects have been noted in human populations (Oregon and Wyoming)(12)

Lead, zinc and cadium in toxic amounts may occur in vegetables grown on mucks in areas where rocks contain large amounts of these elements. Conversely, deficiencies of several elements have been linked with health. These include selenium, zinc, copper, and chromium.

Table 10. Comparison of Drinking Water Quality Standards in Developed Countries

1. Inorganic

Substance	Unit	USA (1979)	WHO (1984)	Canada (1978)	Japan (1981)
arsenic	mg/l	0.05	0.05	0.05	0.05
barium	〃	1.0		1.0	
boron	〃			5.0	
cadmium	〃	0.01	0.005	0.005	0.01
chromium (total)	〃	0.05	0.05	0.05	0.05 (Hexavalent)
cyanide	〃		0.1	0.2	0.01
fluoride	〃	1.4-2.4	1.5	1.5	0.8
lead	〃	0.05	0.05	0.05	0.1
mercury	〃	0.002	0.001	0.001	0.0005
nitrate	〃	10.00	10.00	10.00	
nitrate and nitrite	〃				10.00
nitrite	〃				1.0
selenium	〃	0.01	0.01	0.01	
silver	〃	0.05		0.05	
uranium	〃			0.02	
2. Organic					
aldrin and dieldrin	mg/l		0.00003	0.0007	
benzene	〃		0.01		
benzo(a)pyrene	〃		0.00001		
carbaryl	〃			0.07	
carbon tetrachloride	〃		0.003		
chlordane	〃		0.0003	0.007	
chloroform	〃		0.03		
2,4-D	〃	100	0.1		
DDT	〃		0.001	0.03	
diazinon	〃	0.1	0.1	0.014	

1,2-dichloroethane	〃		0.01		
1,1-dichloroethane	〃		0.0003		
endrin	〃	0.0002		0.0002	
heptachlor + heptachlorepoxide	〃		0.0001	0.003	
hexachlorobenzene	〃		0.00001		
lindane	〃	0.004	0.003	0.004	
methoxychlor	〃	0.1	0.03	0.1	
methyl parathion	〃			0.007	
nitrilotriacetic acid	〃			0.05	
organic phosphate	〃				0.10
parathion	〃			0.035	
pentachlorophenol	〃		0.01		
tetrachloroethene	〃		0.01		
toxaphene	〃	0.005		0.005	
trichloroethene	〃		0.03		
2,4,6-trichlorophenol	〃		0.01		
2,4,5-TP	〃	0.01		0.01	
total pesticides	〃			100	
total trihalomethanes	〃	0.10		0.35	0.10

3. Aesthetic quality and other consideration

aluminium	mg/l		0.2		
chloride	〃	250	250	250	200
colour	TCU	15	15	15	5 degree
copper	mg/l	1.0	1.0	1.0	10
corrosivity		noncorrosive			
hardness	mg/l		500		500
hydrogen sulfide				0.05	
iorming agent	mg/l	0.5			0.5
iron	〃	0.3	0.3	0.3	0.3
manganese	〃	0.05	0.1	0.5	0.3
odour		3 threshold	inoffensive		not to be abnormal
potassium permanganate consumed					10
pH		6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
phenols	mg/l			0.002	0.005
sodium	〃		200		
sulfate		250	400	500	
taste			inoffensive		not to be abnormal
temperature	°C			15	
total dissolved solids	mg/l	500	1000	500	500
turbidity	NTU	TU 1-5	5	5	2 silica degree
zinc	mg/l	5.0	5.0	5.0	1.0

4. Radioactive

Substance	Unit	WHO	USA	Canaca	Japan
cesium - 137	Bq/l			50	
combined radium-226 and radium 228	PCi/l				
gross alpha activity	Bq/L		0.1		
gross beta activity	"		1		
gross alpha particle activity (including radium-228 but excluding radon & uranium)	PCi/l	15			
gross beta particle and photon	millirem/ year	4			
iodine - 131	Bq/l			10	
radium - 226	"			1	
strontium - 90	"			10	
tritium	"			40,000	

5. Bacteriological quality

WHO 1984	USA 1977	Canada 1978	Japan 1981
1) No sample should contain faecal coliforms in 100 ml. 2) Throughout the year in 95% of samples should not contain any coliform organisms in 100 ml. (in the case of large supplies when sufficient samples are examined). 3) Coliform organisms should not exceed 3 in 100 ml of any occasional sample but not in consecutive samples.	1) When using membrane filter test: – 1 colony/100 ml for average of all monthly samples. – or – – 4 colonies/100 ml in more than one sample if less than 20 samples are collected per month. – or – – 4 colonies/100 ml in more than 5 per cent of the sample if 20 or more samples are collected per monthly. 2) When using multiple-tube fermentation test: (10 ml portions) – Coliform should not be present in more than 10 percent of the portions per month, – Not more than one sample may have three or more portions	1) No sample should contain more than 10 total coliform organisms per 100 ml and 2) Not more than 10 per cent of the samples taken in a 30 day period should show the presence of coliform organisms; and 3) Not more than 2 consecutive samples form the same site should show the presence of coliform organisms;	1) Total coliforms at 37°C not to be detectable in 50 ml. 2) Standard plate count (total bacteria) at 37°C 100.

	positive when less than 20 samples are examined per month, or – Not more than 5 per cent the samples may have three or more portions positive when 20 or more samples are examined per month.	and 4) None of the coliform organisms detected should be fecal coliform.

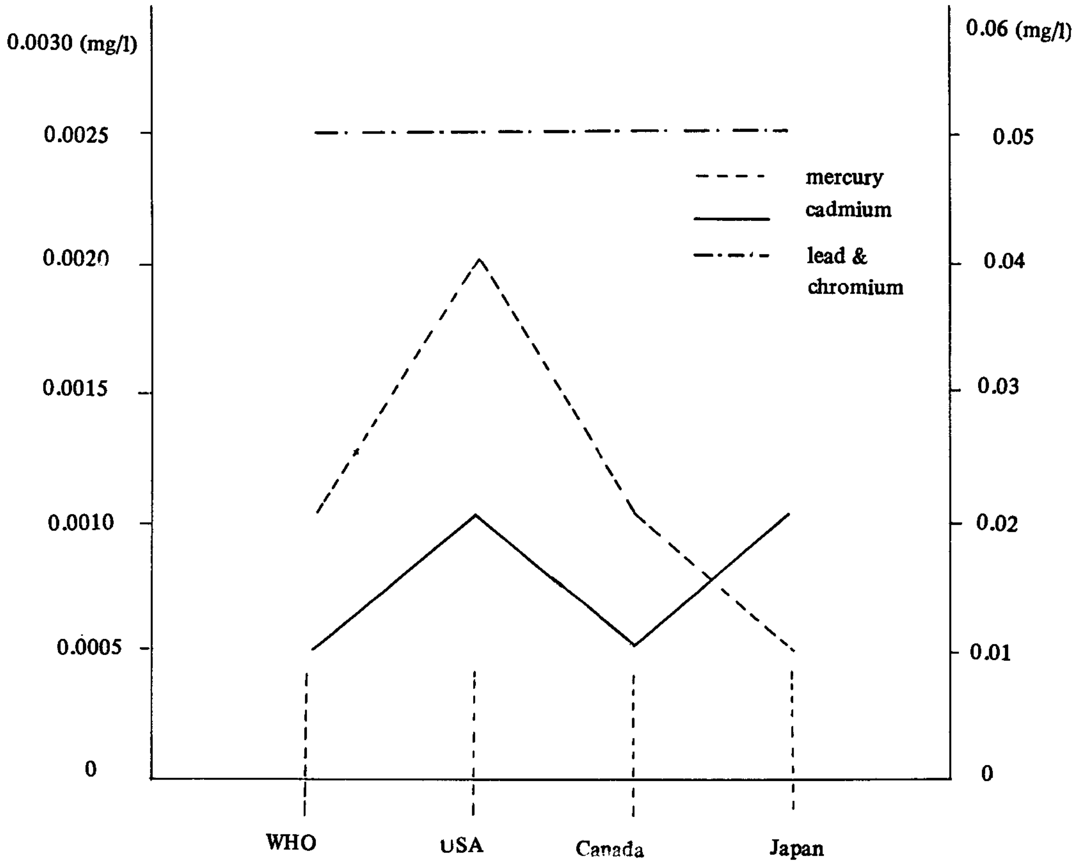


Figure 1. Comparison of trace metals between WHO and three

Water-borne microbiological Diseases;

Basically, these are diseases in which the pathogens are in the water and, when ingested at a sufficient dose, infect the drinker. The majority of these pathogens reach the water through contamination with human excreta and ultimately enter the body through the mouth, hence, the term "fecaloral transmission.

The number of coliform organisms in human feces and in sewage is very great. The daily per capita excretion of this group varies from 125 to 150 billion in winter and is close to 400 billion is summer. [13]

Since human feces are the primary source of pathogenic enteric organisms, the presence in water of coliform offers significant evidence of the potential presence of such pathogens. The test for organisms of the coliform group is sufficiently simple of performance. That's why the group of organisms are known as a satisfactory bacteriological indicator of contamination of water.

Human carcinogen;

There are approximately 25 chemicals[18] for which convincing epidemiologic evidence exists linking exposure to the development of carcinogenic responses. These studies adequately in animal have also produced carcinogenic responsis. The carcinogens of chemicals to humans and animals showed in Table 11.

Groundwater becoming acidified;

Sulphur deposition leads to the acidification of groundwater. So far, in Sweden, acidification has been found in the groundwater reservoirs that are relatively close to the surface, but just as with surface water, the acidification is gradually penetrating deeper into the ground and spreading to larger areas, with increasingly serious effects on groundwater. Acidification like this increases the mobility of metals, which are leached out of the ground and end up in the groundwater. Acid groundwater can suffer additional metallic contamination from corroded water pipes.

Cadmium is one the heavy metals that are beginning to "migrate". If groundwater with increased cadmium concentrations in used as drinking water, then the population, which is already heavily burdened with cadmium, gets another unwelment increment of cadmium, albeit a relatively small one.[19]

Giardiasis outbreak;

Giardiasis is a significant public health hazard which can be transmitted through drinking water supplies. The disease, caused by the parasite Giardia lamblia is characterized by weight loss, weakness, diarrhea, nausea, and abdominal cramps. This intestinal disorder was originally thought to affect primarily backpackers and other outdoor enthusiasts who drank from mountain streams contaminated by infected animals. In recent years, however, the incidence of giardiasis in more urban areas has sharply increased.

In November 1982 the Washoe County District Health Department, Nevada, detected an increase in the incidence of giardiasis in the area. By December there were 340 cases [20] reported in the areas.

EPA recommended ways to modify the water treatment. The number of causes dropped significantly. For the long term, a new filtration system will virtually eliminate the risk of future waterborne giardiasis outbreak.

The ionic form in which a metal occurs in water and soils is extremely important in terms of its availability to plants, animals, and man. For instance, selenium as selenate, hexavalent chromium, and methylated mercury are much more toxic than other forms of these elements.

Man-made sources;

Concentrations of natural trace metals in the environment are increased by man's activities, such as fertilizer practices, automobiles, mining, smelting, and power plants. In areas where the natural levels of essential trace metals are low, the addition of fertilizer which includes these elements or the discharge of effluents from power plants may aid in raising the concentrations toward optimum; in areas where the natural concentrations of particular elements are high, additions of these elements by industrial contamination may result in toxic concentrations in domestic water or produce. In order to assess the effect of man's activities in a particular area, optimum concentrations for each metal in domestic water, soils and produce must be established and the expected uptake by the various species of plants in a particular geochemical environment determined.

Phosphate fertilizers contain as contaminates small amounts of nickel, cadmium, chromium, arsenic, fluorine, uranium, and vanadium. The fact that phosphate ores are accompanied by relatively large quantities of naturally occurring radionuclides. (primarily uranium and radium).

Mining, milling, and smelting contribute considerably greater amounts of inorganic elements to the environment than either naturally occurring mineral deposits in the geologic substrate or the combustion of coal. When mineral deposits are exposed through mining, the ore becomes oxidized and is more available for uptake. During smelting, large tonnages of accessory metals are released either as particulate matter or volatiles to the atmosphere and to nearby soils and drainage systems. Commonly these accessory metals are in greater concentrations in the effluent streams than in the ore being smelted, for example, arsenic wastes from copper smelters or cadmium wastes from zinc smelters.

Hardness;

Greater attention has been focused on the role of inorganic chemicals in cardiovascular diseases. Numerous epidemiologic studies have consistently revealed higher cardiovascular death rates in soft water areas when compared to hard water areas, differences in death rates typically ranging between 25 and 50 percent.

Studies on the influence of corrosive waters in introducing lead into Boston drinking water and its relationship to blood-lead levels have suggested the importance of corrosive waters on body burdens of lead. Concentrations of lead in drinking water have been shown to be associated with blood levels in children in Great Britain. A relationship between mental retardation and lead levels in blood has also been demonstrated. These data suggested that the significance of water as a source of lead accumulation in children needs to be evaluated.

Environmental pollution;

Water pollution is rapidly increasing from sources such as domestic and industrial waste, sanitary landfill, wastewater sludges and effluents, feedlot wastes, fertilizers and agricultural chemicals, mine drainage, subsurface disposal of oil-field brines, seepage from septic tanks and storage transmission facilities, and individual on-site waste water disposal systems. The identy of potential pollutants from these sources, which can include a broad spectrum of physical inorganic, organic, radiologic and bacteriologic materials, is largely unknown and characterized at present.

Toxic and public health concerns;

Toxic pollutants are generally defined as substances which, by themselves or in combination with other chemicals, are harmful to human health or animal life.

This group includes some of the metals, pesticides, and other synthetic organic pollutants that contaminate water, fish tissue, and bottom sediments. Selected human health and aquatic life effects of fifteen of the most studied toxics, as observed under test conditions, carried out by U.S.EPA are summarized in Table. 11.(14)

Table 11. Selected Human Health and Environmental Effects from Toxic Chemicals

	Human Health Effects[1]			
Chemical	Carcinogen[2]	Teratogen[2]	Others	Environmental Effects
Aldrin/dieldrin	●	●	Tremors, convulsions, kidney damage	Toxic to awuatic organisms, reproductive failure birds and fish, bioaccumulation in aquatic organisms
Arsenic	●	●	Vomiting, poisoning, liver and kidney damage	Toxic to legume crops
Benzene	●	●	Anemia, bone marrow damage	Toxic to some fish and aquatic invertebrates
Cadmium		●	Suspected causal factor in many human pathologies: tumors, renal dysfunction, hypertension, arteriosclerosis, Itai-itai disease (weakended bones), emphysema	Toxic to fish, bioaccumulates significantly in bivalve mollusks
Carbon tetrachloride	●		Kidney and liver damage, heart failure	
Chromium			Kidney and gastrointestinal damage, respiratory complications	Toxic to some aquatic organisms
Copper			Gastrointestinal irritant, liver damage	Toxic to juvenile fish and other aquatic organism

DDT	●	● (minimal)	Tremors, convulsions, kidney damage	Reproductive failure in birds and fish, bioaccumulates in aquatic organisms, biomagnifies in food chain
Di-*n*-butyl-phthalate			Central nervous system damage	Eggshell thinning in birds, toxic to some fish
Dioxin	●	●	Acute skin rashes, systemic damage, mortality	Bioaccumulates, lethal to aquatic organisms, birds and mammals
Lead		●	Convulsions, anemia, kidney and brain damage	Toxic to domestic plants and animals, biomagnifies to some degree in food chain
Methyl mercury		●	Irritability, depression, kidney and liver damage, Minamata disease	Reproductive failure in fish species, inhibits growth and kills fish; biomagnifies
PCBs	●	●	Vomiting, abdominal pain, temporary blindness, liver damage	Liver damage in mammals, kidney damage and eggshell thinning in birds, suspected reproductive failure in fish
Phenols			Effects on central nervous system, death at high doses	Reproductive effects in aquatic organisms, toxic to fish
Toxaphene	●	●	Pathological changes in kidney and liver; changes in blood chemistry	Decreased productivity of phytoplankton communities, birth defects in fish and birds, toxic to tish and invertebrates

1 In many cases, human health effects are based upon the results of animal tests.

2 If a substance is identified as a carcinogen, there is evidence that it has the potential for causing cancer in humans; if it is identified as a teratogen, it has the potential for causing birth defects in humans.

Source : The conservation Foundation. *State of the Environment, 1982* (modified).

Pollution control through discharge;

The pollution control policy through effluent discharge depends on the definition and enforcement of appropriate standards for the effluent. The 1912 U.K. Royal Commission 20/30 standard was an early attempt to define "normal" standards for discharges from sewage treatment works, confirmed by the Ministry of Housing and Local Government memorandum in 1966.

Trent Water Authrities has demonstrated to set consent conditions that vary according to the individual effluent, the state of the receiving waters, to maintain the better water qualities of downstream river. Tabel 12 shows, in a hypothetical case, how higher standards of quality are required simply to maintain a constant pollution load and a constant river quality.

Table 12. Calculated effect of a 3 percent annual increase in effluent volume on downstream river quality [15]

Year	Effluent: river flow	River BOD ppm	Effluent BOD to maintain downstream river BOD of 4 ppm
0	1:8.0	4.0	20.0
5	1:6.9	4.3	17.8
10	1:6.0	4.6	15.9
15	1:5.1	4.9	14.3
20	1:4.4	5.3	12.9
25	1:3.8	5.7	11.6
30	1:3.3	6.2	10.6

Reduction in inorganic chemical content;

The water treatment systems commonly employed in municipal practice range in removal of inorganic constituents from zero to 100%, depending upon many factors. A key consideration is identity of the constituents and its chemical and physical characteristics, especially particle size.

Treatment systems which have been found effective for removal of inorganic constituents are summarized in Table 13.

Table 13. Most Effective Treatment Methods for Inorganic Contaminant Removal

Contaminant	Most effective methods
Arsenic:	
As^{+3}	Ferric sulfate coagulation, pH 6-8 Alum coagulation, pH 6-7 Excess lime softening Oxidation before treatment required
As^{+5}	Ferric sulfate coagulation, pH 6-8 Alum coagulation, pH 6-7 Excess lime softening
Barium	Lime softening, pH 10-11 Ion Exchange
Cadmium: Cd^{+3}	Ferric sulfate coagulation, above pH 8 Lime softening Excess lime softening
Chromium:	
Cr^{+3}	Ferric sulfate coagulation, pH 6-9 Alum coagulation, pH 7-9 Excess lime softening

Cr^{+6}	Ferrous sulfate coagulation, pH 7-9.5
Fluoride	Ion exchange with activated alumina or bone char media
Lead	Ferric sulfate coagulation, pH 6-9 Alum coagulation, pH 6-9 Lime softening Excess lime softening
Mercury:	
Inorganic	Ferric sulfate coagulation, pH 7-8
Organic	Granular activated carbon
Nitrate	Ion exchange
Selenium:	
Se^{+4}	Ferric sulfate coagulation, pH 6-7 Ion exchange Reverse osmosis
Se^{+6}	Ion exchange Reverse osmosis
Silver	Ferric sulfate coagulation, pH 7-9 Alum coagulation, pH 6-8 Lime softening Excess lime softening

Reduction in organic chemical content; Activated carbon has demonstrated excellent capability for adsorption and removal of many chemicals. When combined with conventional treatment for surface water, it appears that activated carbon often could be effective in attaining substantial removals of pesticides and for many other organic chemicals, as well.

Granular activated carbon has exhibited greater efficiency than powdered carbon for removing many organics. That can be attributed to the hydrodynamic characteristics of carbon colums, which are capable of more effective adsorption than single-stage addidition of powdered activated carbon in a conventional teratment system.

A study of operating water treatment plants in the U.S.A. indicated that that trihalomethanes in water supplies can be reduced by 59-90%. The trihalometanes can be removed through adsorption on granular activated carbon to the extent of 23-60%. A change in the type of disinfectant used to pretreat water at the plant influent by using chlorine dioxide was capable of reducing THM by 59-90%.

A very effective method for reducing THM concentration in the finished water is through preventing its formation by removing precursor before chlorination. That can be granular activated carbon, or by changing the location of disinfection to a point after removal of most of the organics through coagulation and sedimentation. This was capable of reducing THM formation by 76%.

SUMMARY and CONCLUSIONS

Water is physiologically necessary for human survival. Water is taken into the body in food and drink, including water and water-based fluids, Therefore, there are lots of chance to intake of organisms or of substances in water.

Thus, in establishing drinking water quality standards for those substances, the long term average intake by the body from all sources of contaminants must be weighed against the quantity which might be hazardous to health. Adding a safety factor, the allowable maximum concentration in drinking water can be determined.

Studies showed that the convenience and implicity, the quantity of water close at hand, and convenient excreta disposal had a significant impact on prevalence of water-related diseases.

Through the discussion, differences of certain aspects of drinking water quality standards were noted between WHO and the developed countries, depending their viewpoints, environmental and economic conditions together with science and technology involved.

With respect to protection of health, we need more reliable and better quality standards or a goal statement for carrying out the policies.

Drinking water quality are closely interrelated with water quality management programs. In managing the water resources of the local both the quality and quantity aspects of surface and ground waters must be considered.

In conlusions, the following **pending problems may be drawn;**

1. For betterment of drinking water quality it should be noted that the environmental characteristics include soils, geology, aquatic ecology, terrestrial ecology, climate, etc of an area which established the environment and thus water quality prior to man's disruption natural condition.
2. Organic contaminants, especially pesticides in drinking water have greatly expanded. Therefore, new techniques for identifying organic contaminants, must be developed.
3. Chlorination, the most widely used water treatment mothod, is being criticized. This practice is being investigated due to of the reaction of chlorine with organic material in water. A number of alternative methods for disinfection of water supplies should be developed.
4. Standards should be developed, based on latest data, for establishment of values and the relative carcinogenicity, mutagenicity, and teratogenicity of drinking water contaminants.
5. Research is needed to elucidate the extent to which both inorganic and organic contaminants in drinking water are involved in the etiology of human cancer and epidemiologic studies are needed to determine the causative factors in the cardiovascular soft water phenemenon which is marked as leading causes of death in the developed and developing countries.

6. Studies should be undertaken to determine the relationships between water quality, plumbing system characteristics and time on the introduction of inorganic contaminants (e.g., lead, cadmium, copper) into water by corrosion of distribution and pluming systems.
7. Since monitoring for the presence of all organic chemicals is not technologically or economically feasible, the regulations require that synthetic organic contaminants should be treated by using granulated activated carbon.

要 約

飮用水는 人體 生理機能上 必須不可缺한 要素이다. 하루 平均 2릿터식 飮用하는 以外 食品이나 飮料水로 平生동안 攝取하는 量까지 考慮하고 또한 現代生活의 大都市圈 給水規模를 보면 保健上 莫大한 惠澤과 바람직하지 않은 影響을 줄 수 있는 可能性을 띠고 있다.

WHO는 國際飮用水質基準을 1984年 改定하여 各國이 地域事情을 감안한 自國의 基準을 設定·開發하는데 基礎로 삼도록 各種物質과 項目別로 最大許容値를 建議하고 있다.

先進國인 美國, 카나다등은 WHO의 이런 基準과는 별도의 獨自的인 基準을 適用하고 있어 이들의 制定背景과 科學的根據를 再照明하여 앞으로 方向設定에 參考하자는 것이다.

飮用水質은 當該地域의 地質·氣候·生態系등 自然條件과 産業·農業·牧畜業·鑛業등, 人爲的인 活動, 그리고 處理技術과 密接한 關係가 있다.

有機化學物質은 地表·地下水에 急增되고 있고 그 極微量物質의 測定은 高度의 技術을 要하며 其中 一部는 保健上 極히 有害한 物質로 알려져 警覺心을 불러 일으킨다.

鹽素消毒法은 今世紀 最適의 飮用水 殺菌·消毒劑로 活用되어 왔음에도 自然의 有機物質과 作用하여 發癌性인 trihalomethane(主로 Chloroform)을 生成한다 해서 論難의 對象이 되고 있으며 軟水는 硬水에 比해 循環器系疾患의 死亡率이 增加된다는 硏究報告가 있고 上水管의 腐蝕으로 飮用者의 血中 납 濃度가 增加되었다는 指摘도 있다.

WHO와 이들 先進國間에는 規制項目數나 許容値에 있어 相異한 點이 있으므로 國別環境狀態·經濟條件은 且置하고라도 科學的인 資料와 硏究진척에 큰 關心을 쏟게 된다.

다만, 先進國마저 究明하지 못하였거나 未盡한 一部物質의 許容値, 보다 便宜한 測定法, 그리고 經濟的인 處理技法등 信賴性이 높은 根據를 마련해 줄것이 要講된다.

Reference

1. F. Eugene McJunkin; Water and Human Health, 1982.
2. WHO; Guidelines for Drinking Water Quality Vol. 1. Recommendations, 1984.
3. WHO; International Standards for Drinking-Water, 1971.
4. U.S. EPA; A Handbook of Key Federal Regulations and Criteria for Multimedia Environmental Control, 1979.
5. U.S. Council on Environmental Quality; Environmental Quality, 1979, 1979.
6. U.S. Office of the Federal Register, National Archives and Records Service, General Service Administration; 40 Code of Federal Regulations, 1985.
7. U.K. Department of Environment; Water Treatment Technology, 1979.

8. UNEP; Cumulative Index to the International Directory of Source, The International Information System, 1986.
9. Canada Ministry of National Health and Welfare; Guidelines for Canadian Drinking Water Quality, 1978.
10. Japan International Cooperation Agency; Water Supply Engineering Vol. 1, 1981.
11. P. Walton Purdom; Environmental Health, 1980.
12. U. S. Department of Health, Education, and Welfare; Human Health and Environment, 1976.
13. G. M. Fair, J. C. Geyer; Elements of Water Supply and Waste-Water Disposal, 1964.
14. U. S. EPA; National Water Quality Inventory (1984 Report to Congress), 1985.
15. Elizabeth Porter; Water Management in England and Wales, 1978.
16. U. S. EPA; EPA Journal (Water for Living) Volume 8, Number 2, March-April, 1982.
17. Ontario Ministry of the Environment; Ontario Drinking Water Objectives, 1983.
18. U. S. Department of Health and Human Services; National Toxicology Program, 1985.
19. Sweden Ministry of Agriculture; Acidification Today and Tomorrow, 1981.
20. U. S. EPA; Environmental Progress and Challenges, 1984.