New Standards of Chemical Quality for Drinking Water

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IN REGARD to the 1961 revision of the Public Health Service Drinking Water Standards, there has been national interest in the concepts and rationale which guided the advisory committee in selecting new standards of chemical quality. These concepts and rationale will be presented in detail in the appendix to the Drinking Water Standards, which is in process of publication. The following material was derived from the preliminary draft of the appendix, supplemented by the other references cited in the text.

This discussion of the reasoning behind selection of the chemical limits for the 1961 Drinking Water Standards is concerned principally with toxic or other physiological effects from ingestion of excessive quantities of given substances. For several chemicals, however, limits have been recommended purely for esthetic reasons, in accordance with the intention that the Public Health Service Drinking Water Standards represent a standard of overall water quality. The full report of the advisory committee and an article presenting the attitude of the Public Health Service toward the use of the standards have been published (*1,2*).

Chemicals Listed

The revised chemical standards are generally more stringent than those of the 1946 edition and include limits for 11 chemicals not previously listed (see table). Two sets of limits are provided:

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1. Recommended limits, which if exceeded indicate that the supply should not be accepted if there are more suitable sources available. These are limits for chemicals which may result in discomfort or undesirable tastes, or which violate esthetic characteristics of a desirable water supply.
2. The second set of limits are those which if exceeded shall constitute grounds for rejection of the supply. These are based on toxicity or other physiological damages known to result from excessive concentrations.

Alkyl benzene sulfonate. Alkyl benzene sulfonate is the surface active agent in most of the anionic detergents manufactured in the United States. About 75 percent of household detergents used are of the anionic type. Therefore, the concentration of alkyl benzene sulfonate represents the order of magnitude of detergent in water. Practical techniques for quantitative analysis of alkyl benzene sulfonate have been developed.

As only a part of alkyl benzene sulfonate in wastes is removed by conventional sewage treatment processes, its presence in water is indicative of contamination. Undesirable effects from detergents in drinking water are tastes, odors, and foaming when water is drawn for use. Inhibition of water treatment processes has also been reported.

There is little to indicate that there is a toxic hazard from ingesting relatively low concentrations of detergents. The limit of 0.5 mg./liter was selected as below taste and foaming thresholds.

Arsenic. Ingestion of as little as 100 mg. of arsenic has produced serious physiological responses. As arsenic can be accumulated in the body, continued low-level intake may also produce chronic effects.

Arsenic has widespread use in insecticides, weedkillers, and industrial processes. As it may be ingested from foods and tobacco as well as from water, the total intake must be considered in the determination of maximum limits. The increase in potential total environmental exposure to arsenic during the past 15 years was recognized by including the recommended limit of 0.01 mg./liter in the revised Drinking Water Standards. The limit for rejection of the supply was kept to 0.05 mg./liter, which is identical to the 1946 standard.

Barium. Acute effects from overexposure to barium salts may include nerve blockage and overstimulation of muscles. A variety of suspected chronic effects include increased blood pressure and tissue damage from local accumulations. Fatalities have been attributed to large doses of barium.

Chemical Limits

Chemical	Recommended maximum limits [1] (milligrams per liter)		Concentrations which constitute grounds for rejection of supply (milligrams per liter)	
	1946	1961 revision	1946	1961 revision
Alkyl benzene sulfonate (detergent)		0. 5		
Arsenic		. 0	0. 05	0. 05
Barium				1. 0
Cadmium				. 01
Carbon-chloroform extract (exotic organic chemicals)		. 2		
Chloride	250	250		
Chromium			. 05	. 05
Copper	3. 0	1. 0		
Cyanide		. 01		. 2
Fluoride		(2)	1. 5	(2)
Iron+manganese	. 3			
Iron		. 3		
Lead			. 1	. 05
Manganese		. 05		
Nitrate		45		
Phenols	0. 001	. 001		
Selenium			. 15	. 01
Silver				. 05
Sulfate	250	250		
Total dissolved solids	500	500		
Zinc	15	5		

[1] Concentration in water should not be in excess of these limits when more suitable supplies can be made available.

[2] Fluoride concentration and temperature relationships are discussed in the text.

As barium salts are used in industrial processes, limits for occupational exposure have long been established. This experience supported the derivation of a limit of 1.0 mg./liter of barium in drinking water. Because of the serious toxic potential of barium, only a limit for rejection of the supply was considered.

Cadmium. Only one State and the U.S.S.R. (*3*) have adopted a standard for cadmium in the water supply, although cadmium salts are used in several industrial processes whose waste products may pollute drinking water sources. Cadmium plating of food utensils has long been recognized as a hazard, and several health departments have forbidden the use of cadmium-plated food containers and piping for beverages (*3*).

Cadmium has a high toxicity and provides no beneficial dietary function. It will accumulate in soft tissue, and some investigators have associated cadmium accumulation with anemia and hypertension. However, the chronic hazards need further study both as to the effects and the mechanisms through which the effects are exerted.

As with barium, the potential toxicity of cadmium prompted the determination of only a limit for rejection of the supply. The limit below which no effects would be felt was derived to be 0.01 mg./liter.

Carbon-chloroform extractibles. A variety of chemical wastes and petroleum products can be detected by carbon filtration and extraction with chloroform. Thus, the toxicity of any carbon-chloroform extract can be defined only in terms of its constituents. As most such products are esthetically undesirable as well as ill defined as to toxicity, a recommended limit of 0.02 mg./liter in drinking water was proposed.

Chloride. The sources of chlorides include natural minerals as well as waste products. Enteric distress may be experienced by some persons when the concentration of chlorides exceeds 250 mg./liter. However, water supplies with chloride concentrations of more than 500 mg./liter are used with no apparent lasting harm (*3*). The attendant problems of taste and increased corrosiveness of waters with high chloride content, however, may be particularly objectionable (*3*).

The recommended limit of 250 mg./liter is the same as that recommended in 1946.

Chromium. Although the long-term human tolerance to hexavalent chromium has not been determined, chromium has been accredited with carcinogenic properties, and salts of hexavalent chromium are gastrointestinal irritants. Chromium salts supply no known dietary requirements or other benefits to human growth or metabolism. With this background, it was considered prudent to limit the intake of chromium salts to the lowest level practicable. The lower limit of analysis for chromium by current procedures was therefore the principal criterion for selection of the standard.

The concentration which constitutes grounds for rejection of the supply, 0.05 mg./liter, remains the same as in the 1946 standards.

Copper. The presence of copper in a water supply, except in trace amounts, is an indicator of some form of pollution, possibly from corrosion of copper plumbing, industrial waste, or the use of copper compounds for control of aquatic vegetation (*3*).

Small quantities of copper are essential in the diet. Although large doses of copper may produce nausea and intestinal irritation, such doses make the taste unacceptable to most persons. Copper is not considered a cumulative systemic poison.

The recommended limit of 1.0 mg./liter is based on the lower threshold of taste perception in water.

Cyanide. The International Standards for Drinking Water and other water supply standards have recognized the toxicity of cyanide.

Although the known level of toxicity for man is much higher than the limit of the standard, simple treatment (for example, chlorination) will reduce cyanide concentration to the recommended limit of 0.01 mg./liter. The limit that constitutes grounds for rejection of a supply (0.2 mg./liter) has a large safety factor that is justifiable because of the rapid action of cyanide once it reaches a lethal level. Should the normal cyanide detoxifying mechanism of the body not function properly, there would be little chance of accumulating toxic quantities from ingestion at this limit.

Fluoride. Optimum fluoride levels for drinking water, as a positive contribution to dental health, vary with climate. Selection of this optimum is facilitated by a table in the Drinking Water Standards which gives a range of dosage for specified ranges of temperature. The average temperature range used to select the limits for fluoride for a given geographic area should be based on temperature data for that area for a minimum of 5 years. For example, for a mean maximum daily temperature of 70.9°–79.2° F., the recommended average concentration should not be less than 0.7 mg./liter nor more than 1.0 mg./liter if fluoridation is practiced to increase the fluoride content of the supply.

A water supply should be rejected if the naturally occurring fluoride concentration averages more than twice the theoretical optimum concentration for that temperature range. In the example cited above, the table shows the optimum concentration to be 0.8 mg./liter. Therefore, the average concentration of naturally occurring fluoride in the finished water should not exceed 1.6 mg./liter.

Iron. The limit for iron and manganese combined has been changed to a separate limit for each.

Iron is limited not because of a toxic potential, but because it stains plumbing fixtures and clothing. Its taste and appearance as a sediment are also esthetically offensive. The recommended limit of 0.3 mg./liter is to assure water of high quality for household use.

Manganese. Manganese, which frequently accompanies iron, may enter the stream from natural sources or as an industrial waste, especially as a mining waste (*3*).

Although there is evidence that industrial workers have suffered toxic effects from fumes of manganese, there is no evidence that the metal is a hazard in drinking water. Manganese is chiefly an esthetic nuisance, as it stains laundry, cooking utensils, and plumbing fixtures. It also interferes with filtration processes in water treatment.

The recommended limit of 0.05 mg./liter was set to protect the quality of public water supplies for all uses.

Lead. Lead is a systemic poison that is concentrated in the body from a succession of small doses. Small quantities ingested regularly can produce mental deficiency, neurological disease, and other symptoms (*3*). As lead may be ingested from a variety of sources, water, air, food, paint, or tobacco, and as the potential of exposure to lead from all sources has increased in recent years, the limit for rejection of a water supply was reduced from the 1946 standard of 0.1 to 0.05 mg./liter.

Nitrate. Methemoglobinemia, resulting in oxygen starvation of infants (blue babies), has occurred frequently where families drew water from wells high in nitrate. Fertilizers have been assumed to be the chief source of the chemicals. There has been no evidence of a gross effect upon adults.

As the reported tolerance levels of infants to nitrate from water range widely, there are many uncertainties as to the precise importance of nitrate concentration, physical conditions, and other factors of an infant's environment in relation to methemoglobinemia. The recommended limit of 45 ppm nitrate was established, therefore, with the admonition to health authorities that they warn the public not to use waters exceeding this amount for infant feeding.

Phenols. High concentrations of phenols (75,000 ppm), which include cresols and xylenols, may cause physiological responses. However, the taste threshold is quite low, especially when phenol appears in the presence of chlorine. The recommended limit (1 ppm), unchanged from 1946, is based on protection of the taste quality of chlorinated drinking water.

Selenium. Selenium is the cause of "alkali disease" in livestock of the Great Plains region. Previously considered only of regional importance, selenium appears in recent studies to be a possible cause of dental caries and some cancers. The effect on cattle may be an indication of its toxic properties.

The potential hazards of selenium in drinking water prompted reduction of the maximum acceptable limit to 0.01 mg./liter.

Silver. Water may contain relatively small concentrations of silver from natural sources, but the presence of silver is usually an indication of pollution from industrial processes.

The chief objection to excessive silver is cosmetic. A permanent blue discoloration of skin and eyes (argyria, argyrosis) seems to result only from ingestion or injection (not skin absorption) of excessive amounts of silver.

The limit for rejection is established accordingly at 0.05 mg./liter.

Sulfate and dissolved solids. The importance of sulfates and dissolved solids hinges upon their taste and laxative and corrosive properties. The characteristic taste has been known to cause consumers to reject a water supply otherwise of good quality in favor of a riskier but better tasting source.

Among many studies concerning the effects of dissolved solids and the threshold of taste, one of the more comprehensive, conducted by the North Dakota State Department of Health, shows that combinations of some ions, as Mg. with SO_4, are more laxative than combinations of others.

As these studies confirmed the recommended limits of the 1946 Drinking Water Standards, the same limits are recommended in the revised standards: 250 mg./liter for sulfates and 500 mg./liter for dissolved solids.

Zinc. Zinc is an essential trace element in the human diet, required by the eye, prostate, and general metabolism. Excessive zinc salts, however, are known to have caused gastrointestinal irritation and nausea, undesirable tastes, and a milky appearance in water.

The recommended limit of the 1946 Drinking Water Standards was reduced to 5 mg./liter in the revised standards.

Limits Suggested But Not Included

It was not feasible to determine limits for all the many potentially toxic chemicals. Consideration was given to the chlorinated hydrocarbons and organophosphate insecticides, for example. Data concerning physiological response and satisfactory procedures for analysis were insufficient, unfortunately, to establish specific limits. The concentrations of these chemicals in the water supplies where sampled were not judged to constitute a health hazard. However, realizing that such pollution is on the increase and represents a potential health hazard, the advisory committee recommends (*a*) that such chemical pollution be kept under surveillance, and (*b*) that regulatory actions undertake to minimize concentrations of such chemicals in water supplies to the degree practicable.

The committee further recommended that a mechanism be established for continuous appraisal and revision of the Drinking Water Standards.

The need for continuous reappraisal of chemical limits was felt to be apparent by those concerned with the expanding potential for pollution of water sources by chemical products and wastes. Approving and certifying authorities for the interstate quarantine regulations and public health authorities adopting the PHS standards as official State drinking water standards were urged to take cognizance of this potential by (*a*) strict enforcement of standards as the minimum for drinking water (*4*), and (*b*) routine compilation of basic data concerning chemical quality of raw and treated water, to provide a basis for reappraisal and revision by procedures to be established.

REFERENCES

(*1*) Drinking Water Standards, 1961; U.S. Public Health Service. J. Am. Water Works A. 53: 935–945, August 1961.

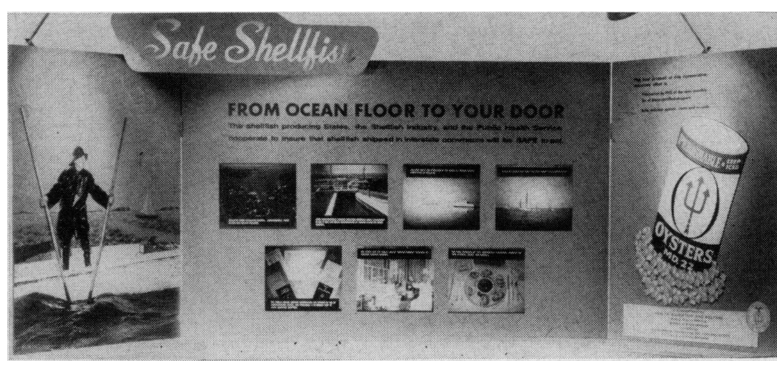
(*2*) Hopkins, O. C.: Attitude of U.S. Public Health Service in development of Drinking Water Standards, 1961. J. Am. Water Works A. 53: 946–950.

(*3*) California Water Pollution Control Board: Water quality criteria. Publication No. 3. Sacramento, 1957.

(*4*) AWWA resolution endorses USPH standards as minimum. Willing Water (American Water Works Association) 5: 1, 2, October 1961.

Exhibits

Safe Shellfish



Specifications: (No. E–509 Safe Shellfish). Free-standing exhibit, 7 feet 4 inches high, 11 feet 6 inches wide, and 32 inches deep, total weight 450 pounds including packing crate. Lighting fixtures require one 500-watt outlet.

Designed for health and shellfish conferences and seminars, this exhibit describes the joint State-Public Health Service-industry program for the certification of interstate shellfish shippers and shows how the Federal and State governments cooperate with industry to keep contaminated shellfish out of the market.

Color transparencies of shellfish harvesting and inspection scenes are used to show that operating controls, including the examination of shellfish growing areas, patrolling of polluted areas, supervision of harvesting boats, and inspection of shellfish plants, are exercised by the States. The Public Health Service's role is to develop uniform standards, continuously appraise State programs, and publish semimonthly lists of State-approved shellfish shippers.

The exhibit is available on loan from the Milk and Food Branch, Division of Environmental Engineering and Food Protection, Washington 25, D.C. Requests should be made several months in advance of the date desired. The branch will pay the costs of shipping and installing at large national and regional meetings. Instructions for assembling the exhibit are attached to the inside door of the packing crate.