BIBLIOGRAPHIC DATA SHEET PN-AAJ-254

WHOLESOME AND PALATABLE DRINKING WATER: A BACKGROUND PAPER ON WATE QUALITY ASPECTS OF WATER SUPPLY; APPENDICES

PERSONAL AUTHORS - CHAMBERLIN, C. E.
BOLAND, JOHN
MALIK, ARUNPAL
SHIPMAN, HAROLD

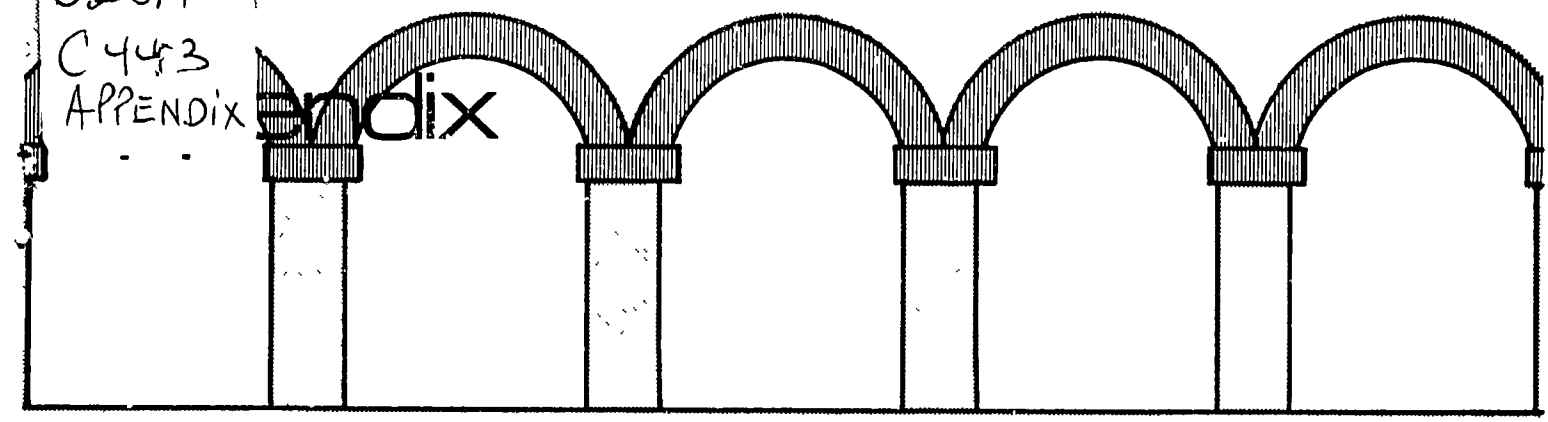
CORPORATE AUTHORS -

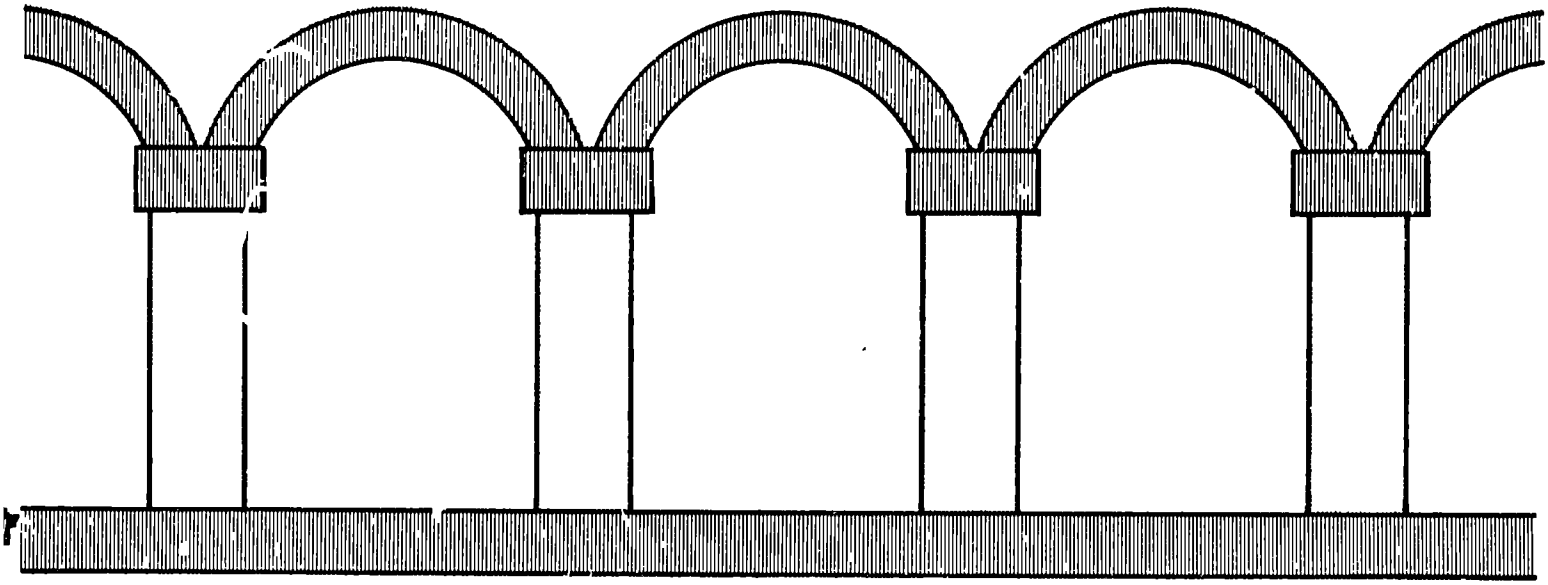
1979, 61P.
(MAIN REPORT, 10BP.: PN-AAJ-253)

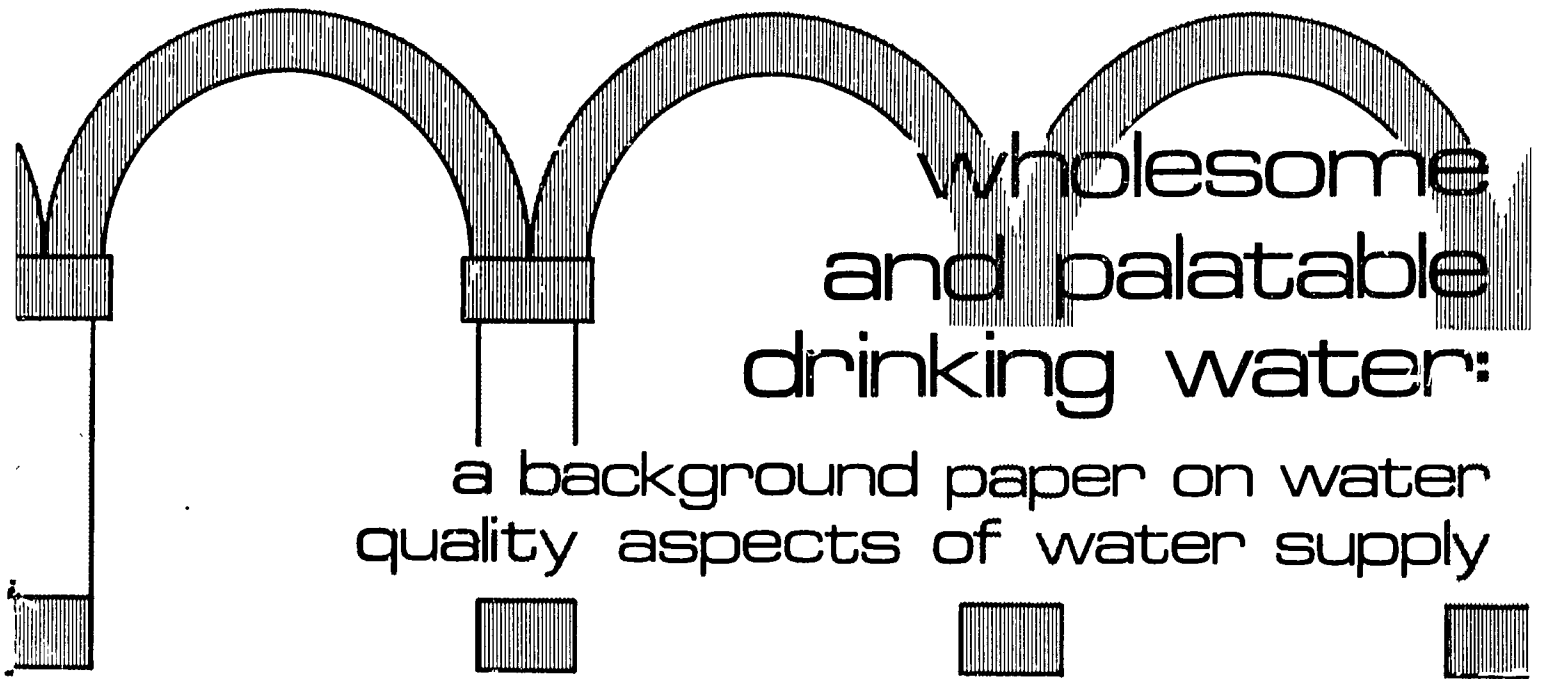
ARC NUMBER - 628.1.C443
CONTRACT NUMBER - DS/H
PROJECT NUMBERS -
SUBJECT CLASS - AP1000000000

DESCRIPTORS - WATER SUPPLY
WATER SUPPLY AND HEALTH
POTABLE WATER
WATER QUALITY
WATER ANALYSIS

Appendix







wholesome and palatable drinking water:

a background paper on water quality aspects of water supply

CHARLES E. CHAMBERLIN / JOHN BOLAND
ARJUNPAL MALIK / HAROLD SHIPMAN

APPENDICES

WHOLESOME AND PALATABLE DRINKING WATER: A BACKGROUND PAPER ON WATER QUALITY ASPECTS OF WATER SUPPLY

By

Charles E. Chamberlin
John Boland
Arunpal Malik
Harold Shipman

31 July 1979

Prepared for
Agency for International Development
Washington, D.C.

APPENDIX A.

American Medical Association House of Delegates (1957). *Statement on Fluoridation of Public Water Supplies.* Cited by NRC Safe Drinking Water Committee, 1977.

American Public Health Association, American Water Works Association and Water Pollution Control Federation (1965). *Standard Methods for the Examination of Water and Wastewater,* 12th ed., New York, APHA.

American Water Works Association (1936). *Water Works Practice.* Williams and Wilkins, Baltimore, Maryland, 814p.

_____ (1950). *Water Quality and Treatment,* 2nd ed. New York: American Water Works Association. Cited by Welsh and Thomas 1960.

Ames, W. R. and M. Robins (1943), "Age and Sex as Factors in the Development of the Typhoid Carrier State, and a Method for Estimating Carrier Prevalence", *AJPH,* 33: 221-230.

Baker, M. N. (1948). *The Quest for Pure Water.* American Water Works Association, New York, 527p.

Balavoine, P. (1948). "Sensibility of the Taste to Toxic Salts". *Mitt. Gebiete Lebensm. Hyg.,* 39:27. Cited by Cohen et al., 1970.

Bartow, E. (ed.) (1908). "Chemical and Biological Survey of the Waters of Illinois". Water Survey Series No. 6, *University of Illinois Bulletin,* 6:1-88.

_____ (1915). "Examination of Drinking Water on Railway Trains". *JAWWA,* 2:74-82.

Baylis, J. R. (1940). "Water Quality Standards". *JAWWA,* 32:1753-1769.

Bisscnnette, G. K., J. J. Jezeski, G. A. McFeters, and D. G. Stuart (1975). "Influence of Environmental Stress on Enumeration of Indicator Bacteria from Natural Waters". *Appl. Microb.,* 29:186-194.

Blake, N. M. (1956). *Water for the Cities.* Syracuse University Press, Syracuse, New York, 341p.

Borgono, J. M., and R. Greiber (1972). "Epidemiological Study of Arsenicism in the City of Antofagasta". In: D. D. Hemphill, ed., Trace Substances in Environmental Health. Proceedings of the University of Missouri's 5th Annual Conference on Trace Substances in Environmental Health, June 29 - July 1, 1971. University of Missouri, Columbia. Cited by NRC Safe Drinking Water Committee.

Bryan, F. L. (1974). "Diseases Transmitted by Foods Contaminated by Wastewater". *Wastewater Use in the Production of Food and Fiber-Proc.* HEW, Public Health Service.

Burnet, M. and D. O. White (1972), *Natural History of Infectious Disease,* 4th ed., Cambridge University Press, London.

Buswell, A. M. (1928). "The Chemistry of Water and Sewage Treatment" [American Chemical Society Monograph Series No. 38]. New York: Chemical Catalog Company, Inc., pp. 104-107.

Butler, R. G., G. T. Orlob, and P. H. McGauhey (1954). "Underground Movement of Bacterial and Chemical Pollutants". *JAWWA,* 46:97-111.

Caird, J. M. (1913). "The Bacteria Count on Gelatin and Agar Media and Its Value in Controlling the Operation of Water Purification Plants". *Proc. AWWA,* 33:325-338.

Caldwell, E.F. (1937a), "Study of an Envelope Pit Privy", *J. Inf. Dis.,* 61: 265-269.

_____(1937b), "Pollution Flow from Pit Latrines when an Impervious Stratum Closely underlies the Flow", *J. Inf. Dis.,* 61: 270-288.

_____ (1938b), "Studies of Subsoil Pollution in Relation to Possible Contamination of the Ground Water from Human Excreta Deposited in Experimental Latrines", *J. Inf. Dis.,* 62: 272-292.

_____ (1938a), "Pollution Flow from a Pit Latrine when Permeable Soils of Considerable Depth Exist Below the Pit", *J. Inf. Dis.,* 62: 225-258.

Caldwell, E. F. and L. W. Parr (1937), "Groundwater Pollution and the Bored Hole Latrine", *J. Inf. Dis.,* 61: 148-183.

_____ (1938), "Direct Measurement of the Rate of Ground Water Flow in Pollution Studies", *J. Inf. Dis.,* 62: 259-271.

California State Water Pollution Control Board (1954). *Report on the Investigation of Travel of Pollution.* Publ. No. 11, prepared by San. Engr. Res. Lab., University of California, Berkeley, 218p.

Chrietzberg, J. E. and F. D. Lewis, Jr. (1957). "Effect of Inadequate Fluorides in Public Water Supply on Dental Caries ". *Ga. Dental J.* Cited by U.S. E.P.A. 1975.

_____ and J. F. Lewis (1962). "Effect of Modifying Sub-Optimal Fluoride Concentration in Public Water Supply". *J. Ga. Dental Assn.* Cited by U.S. E.P.A. 1975.

Cohen, J. M., L. J. Kamphake, E. K. Harris and R. C. Woodward (1960). "Taste Threshold Concentrations of Metals in Drinking Water". *J. Am. Water Works Assn.* 52(5):660-670.

Connelley, Jr., E. J. (1958). "Removal of Iron and Manganese". *J. Am. Water Works Assn.* 50(5):697-702.

Cox, C. R. (1939). "Water-Borne Gastro-Enteritics". *J. Am. Water Works Assn.* 31:1489-1510.

Crabtree, K. T. (1970). *Nitrate Variation in Ground Water.* Technical Completion Report, OWRR B-044-Wis. Office of Water Resources Research. Cited by NRC Safe Drinking Water Committee 1977.

Craun, G. F. and L. J. McCabe (1973). "Review of the Causes of Waterborne - Disease Outbreaks". *J. Am. Water Works Assn.* 65:74-84.

Cross, H. (1952). *Engineers and Ivory Towers.* ed. by R. C. Goodpasture.

Cvjetanovic, B., B. Grab, and K. Uemura (1978), *Dynamics of Acute Bacterial Diseases,* Suppl. No. 1, *Bull. of W.H.O.,* v. 56.

Davies, III, J. C. (1973). "Standard Setting". In: Enthoven, A. C. and A. M. Freeman III (eds.). *Pollution, Resources, and the Environment,* Norton, New York.

Dean, H. T., P. Jay, F. A. Arnold, Jr., and E. Elvove (1941). "Domestic Water and Dental Caries,II. A Study of 2,832 White Children Aged 12 to 14 Years at 8 Suburban Chicago Communities, Including Lactobacillus Acidophilus Studies of 1,761 Children. *Pub. Health Rep.* 56:761 Cited by U.S. E.P.A. 1975.

Dean, H. T., F. A. Arnold, Jr., and E. Elove (1942). "Domestic Water and Dental Cares. v. Additional Studies of the Relation of Fluoride Domestic Waters to Dental Cares Experience in 4,425 White Children, Age 12 to 14 Years, of 13 cities in 4 states". *Pub. Health Rep.* 57:1155. Cited by U.S. E.P.A. 1975.

Derby, R. L., O. C. Hopkins, O. Gullans, J. R. Baylis, E. L. Bean, F. E. Maloney (1960). "Water Quality Standards, a Symposium. *J. Amer. Water Works Assn.* 52:1159-1188.

Dickey, E., W. D. Lembke, T. R. Peck, G. Stone, and W. H. Walker (1972). "Nitrate Levels and Possible Sources in Shallow Wells". *In: Proceedings Second Allerton Conference on Environmental Quality and Agriculture, 1971,* pp. 40-44. University of Illinois, Urbana. Special Publication No. 26. Cited by NRC Safe Drinking Water Committee 1977.

DiPalma, J. R. (1965). *Drill's Pharmacology in Medicine.* 3rd ed. New York: The MacMillan Company, pp. 944-951.

Drown, T. M. (1892). "The Interpretation of Water Analyses", *Annual Report of the Massachusetts State Board of Health,* 24:319, In: G. C. Whipple (1917), *State Sanitation,* Vol. II, Harvard University Press, Cambridge.

Dufour, A. P. and V. J. Cabelli (1975). "Membrane Filter Procedure for Enumerating the Component Genera of the Coliform Group in Seawater". *Appl. Microb.,* 29:826-833.

Duggan, R. E., and G. Q. Lipscomb (1969). "Dietary Intake of Pesticide Chemicals in the United States - June 1966 - April 1968". *Pesticide Monit. J.,* 2:153. Cited by NRC Safe Drinking Water Committee 1977.

Durfor, C. N. and E. Becker (1964). *Public Water Supplies of the 100 Largest Cities in the United States, 1962.* [U.S.G.S. Water Supply Paper 1812] (Government Printing Office, Washington, D.C.). Cited by NAS-NAE Committee on Water Quality Criteria 1972.

Durum, W. H., J. D. Hem, and S. G. Heidel (1971). Reconnaissance of Selected Minor Elements in Surface Waters of U. S. U.S.G.S. Circular 643. Cited by NRC Safe Drinking Water Committee 1977.

Edwards, G. P. (1947). "What is Safe and Satisfactory Water from a Chemical Standpoint". *J. Amer. Water Works Assn.,* 61(3):260-266.

Eliassen, R. and R. H. Cummings (1948). "Analysis of Waterborne Outbreaks, 1938-45". *J. Amer. Water Works Assn.,* 40:509.

Ericsson, Y., and U. Ribelius (1971). "Wide Variations of Fluoride Supply to Infants and Their Effect". *Caries Res.,* 5:78-88. Cited by NRC Safe Drinking Water Committee 1977.

Farlow, W. G. (1879). "On Some Impurities of Drinking-Water Caused by Vegetable Growths". *Supplement to First Annual Report, Massachusetts Board of Health, Lunacy and Charity.* In: G. C. Whipple (1917), *State Sanitation,* Vol. II, Harvard University Press, Cambridge.

Federal Water Pollution Control Administration (1968). U. S. Department of Interior. *Water Quality Criteria: Report of the National Technical Advisory Committee to the Secretary of the Interior,* (Government Printing Office, Washington, D.C.).

Feinglass, E. J. (1973). "Arsenic Intoxication from Well-Water in the United States". *N. Engl. J. Med.,* 288:828-830. Cited by NRC Safe Drinking Water Committee 1977.

Flinn, M. W. (1968). *Public Health Reform in Britain.* St. Martin's Press, New York, 72p.

Fox, C. B. (1886). *Sanitary Examinations of Water, Air, and Food,* 2nd ed. J. A. Churchill, London, 563p.

Frontinus, S. J. (97). *The Two Books on the Water Supply of the City of Rome.* Trans. by Clemens Herschel (1913), 2nd ed., Longmans, Green, and Company, London.

Frost, W. H. (1915). "Some Considerations in Estimating the Sanitary Quality of Water Supplies". *J. Amer. Water Works Assn.,* 2:712-722. Disc 2:723-734.

Fuhs, G. W. (1975). "A Probabilistic Model of Bathing Beach Safety". *Science of the Total Environment.* 4:165-175.

Fuller, G. W. (1915). "Biochemical and Engineering Aspects of Sanitary Water Supply". *J. of the Franklin Institute.* 180(1):17-61.

Geldreich, E. E. (1966). *Sanitary Significance of Fecal Coliforms in the Environment.* U. S. Dept. of Interior, Federal Water Pollution Control Administration, Water Pollution Control Research Series Publ. No. WP-20-3.

——————— (1979), "Microbiology of Water", *JWPCF,* 51: 1721 - 1743.

Gilcreas, F. W. (1952). "Limitations of Standard Bacteriologic Methods in Evaluating Sanitary Quality of Water". *JNEWWA,* 66:167-176.

Goldsmith, J. R., M. Deane, J. Thom, and G. Gentry (1972). *Water Res.* 6: 1133-1136. Cited by NRC Safe Drinking Water Committee 1977.

Gorman, A. E. and A. Wolman (1939). "Waterborne Outbreaks in the United States and Their Significance". *J. Amer. Water Works Assn.,* 31: 255-373.

Greenberg, L. W., C. E. Nelsen, and N. Kramer (1974). "Nephrogenic Diabetes Insipidus with Florosis". *Pediatrics,* 54:320-322. Cited by NRC Safe Drinking Water Committee 1977.

Griffin, A. E. (1958). "Problems Caused by Manganese in Water Supplies". *J. Amer. Water Works Assn.,* 50:1386-1388.

——————— (1960). "Significance and Removal of Manganese in Water Supplies". *J. Amer. Water Works Assn.,* 52:1326.

Hagan, T. L., M. Pasternack, and G. C. Scholz (1954). "Waterborne Fluorides and Mortality". *Pub. Health Report,* 69:450-454. Cited by NRC Safe Drinking Water Committee 1977.

Hazen, A. (1895). *The Filtration of Public Water Supplies.* New York: John Wiley and Sons, 186p.

Herschel, C. (1913). *The Two Books on the Water Supply of the City of Rome of Sextus Julius Frontinus*, translation with explanatory material, 2nd ed., Longmans, Green, and Company, London, 296p.

Hibbard, P. L. (1934). "The Significance of Mineral Matter in Water". *J. Amer. Water Works Assn.*, 26(7):884-890.

Hinman, Jr., J. J. (1920). "Standards of Quality of Water". *J. Amer. Water Works Assn.*, 7:821-840.

_____ (1921). "American Standards of Quality of Water". *J. of Soc. of Chem. Industry, Review*, 4:325R-327R.

_____ (1938). "Desirable Characteristics of a Municipal Water Supply". *J. Amer. Water Works Assn.*, 30(3):484-494.

Hobbs, A. T. (ed.) (1950). *Manual of British Water Supply Practice*, 2nd ed. Institution of Water Engineers, Heffer and Sons, Cambridge, England.

Hodge, H. C. and F. A. Smith (1954). "Some Public Health Aspects of Water Fluoridation". In: Shaw, J. H., (ed.) *Fluoridation as a Public Health Measure*, A.A.A.S. Pub. No. 38, Washington, D.C., pp. 79-109. Cited by U.S. & P.A. 1975.

Hodge, H. D. (1961). "Metabolism of Fluorides". *J. Am. Med. Assn.*, 117: 313-316. Cited by NRC Safe Drinking Water Committee 1977.

_____, and F. A. Smith (1970). *Minerals: Fluorine and Dental Caries*. Advances in Chemistry Series No. 96:93-115. Cited by NRC Safe Drinking Water Committee 1977.

Holdeman, L. V., I. J. Good, and W. E. C. Moore (1976). "Human Fecal Flora: Variation in Bacterial Composition within Individuals and a Possible Effect of Emotional Stress". *Appl. and Env. Microb.*, 31: 359-375.

Hoskins, J. K. and C. T. Butterfield (1935). "Determining the Bacteriological Quality of Drinking Water". *J. Amer. Water Works Assn.*, 27: 1101-1109.

International Bank for Reconstruction and Development (1976), *Measurement of the Health Benefits of Investments in Water Supply*, P. U. Report No. PUN 20.

Johnson, G. A. (1913). "Pure and Wholesome Water". *Proc. AWWA.*, 33:399-431. *Disc.* 33:432-456.

Jones, D. D. (1929). "Edwin Chadwick and the Early Public Health Movement in England". *University of Iowa Studies*, New Series No. 197, 9(3): 1-160.

Jorgensen, J. H., J. C. Lee and H. R. Pahren (1976), "Rapid Detection of Bacterial Endotoxins in Drinking Water and Renovated Wastewater", *Appl. and Env. Microb.*, 32: 347-351.

Juncos, L. I., and J. V. Donadio, Jr., (1972). "Renal Failure and Fluorosis". *J. Am. Med. Assn.*, 222:783-785. Cited by NRC Safe Drinking Water Committee 1977.

Kargon, R. H. (1977). *Science in Victorian Manchester.* The Johns Hopkins University Press, Baltimore, 283p.

Kawata, Kazuyoshi (1978a), "Of Typhoid Fever and Telephone Polls: Deceptive Data on the Effect of Water Supply and Privies on Health in Tropical Countries", *Prog. Wat. Tech., II*, Nos. 1/2, p. 37-43, Pergamon Press Ltd., IAWPR.

_____ (1978b), "Water and Other Environmental Interventions — The Minimum Investment Concept", *Am. J. Clin. Nutr.*, 31: 2114-2123.

Kehoe, R. A., J. Cholak and E. J. Largent (1944a). "The Concentrations of Certain Trace Metals in Drinking Water". *J. Am. Water Works Assn.*, 36(6):637-644.

_____ (1944b). "The Hygenic Significance of the Contamination of Water with Certain Mineral Constituents". *J. Am. Water Works Assn.*, 36(6):645-657.

Kettering Laboratory (1957). *Iron, Physiological Aspects of Water Quality Criteria with Regard to Man.* Ohio River Valley Water Sanitation Commission, Interim Report, The Kettering Laboratory, College of Medicine, University of Cincinnati, Cincinnati, Ohio. Cited by McKee and Wolf 1963.

Kliger, I. J. (1921). "Investigation on Soil Pollution and Relation of Various Types of Privies to Spread of Intestinal Infections". *Rockefeller Inst. Med. Res. Monographs.* No. 15.

Klut, H. (1938). "The Economic Costs of Waters Containing Iron and Manganese". *Gas-μ Wasser.* 81:4. Abstracted in *J. Amer. Water Works Assn.* 30(5):828-829pp.

Kneese, A. V., and B. T. Bower (1968). "Standards, Charges, and Equity". In: Dorfman, R. and N. S. Dorfman (eds.) (1972), *Economics of the Environment,* Norton, New York.

Kopp, J. F., and R. C. Kroner (1967). *Trace Metals in Waters of the United States (Oct. 1, 1962 - Sept. 30, 1970).* U. S. Department of the Interior, Federal Water Pollution Control Administration. Division of Pollution Surveillance, Cincinnati, Ohio. Cited by NRC Safe Drinking Water Committee 1977.

Kramer, L., D. Osis, E. Wiatrowski, and H. Spencer (1974). "Dietary Fluoride in Different Areas in the United States". *J. Am. Clin. Nutr.* 27:590-594. Cited by NRC Safe Drinking Water Committee 1977.

Larson, T. E., and L. Henley (1966). *Occurrence of Nitrate in Well Waters. Final Report.* Project 65-056. University of Illinois Water Resources Center, Urbana. Cited by NRC Safe Drinking Water Committee 1977.

Leone, N. C., M. B. Shimkin, F. A. Arnold, Jr., C. A. Stevenson, E. R. Zimmerman, P. B. Geiser and J. E. Lieberman (1954). "Medical Aspects of Excessive Fluoride in a Water Supply". *Pub. Health Rep.* 69: 925-936. Cited by NRC Safe Drinking Water Committee 1977.

Lockart, E., C. Tucker, and M. Merritt (1955). "The Effect of Water Impurities on the Flavour of Brewed Coffee". *Food Research.* 20:598. Cited by Cohen et al. 1960.

Levine, M., P. Carpenter, and J. M. Coblentz (1939). "Bacteria from Chlorinated Waters". *J. Amer. Water Works Assn.* 31:1511-1523.

Levi-Strauss, C. (1966). *The Savage Mind.* University of Chicago Press, Chicago, 290p.

Lloyd, G. E. R. (ed.) (1978), *Hippocratic Writings,* Translated by J. Chadwick and W. N. Mann, Penguin Books, Middlesex, England.

Longley, F. F. (1915). "Present Status of Disinfection of Water Supplies". *J. Amer. Water Works Assn.* 2:679-686.

Longmate, N. (1966). *King Chlorea.* Hamish Hamilton, 271p.

Marston, M. (1925). *Sir. Edwin Chadwick.* Small, Maynard and Company. Boston, 186p.

Mason, W. P. (1905). "Interpretation of a Water Examination". *Science.* 21:648-653.

_____ (1912). *Examination of Water.* John Wiley and Sons, New York, 180p.

_____ (1916). *Water-Supply,* 4th ed. John Wiley and Sons, New York, 528p.

Maxey, K. F. (1956). *Preventive Medicine and Public Health,* 8th ed. New York: Appleton-Century-Crcfts, Inc. Cited by Welsh and Thomas 1960.

McCabe, L. J., J. M. Symons, R. D. Lee, and G. G. Roebuck (1970). "Survey at Community Water Supply Systems". *J. Amer. Water Works Assn.* 62 (11):670-687. Cited by U.S. & P.A. 1975.

McKee, I. E., and H. W. Wolf, eds. (1963). *Water Quality Criteria,* 2nd ed. State Water Quality Control Board, Sacramento, California. Publication No. 3-A.

Mechalas, B. J., L. K. Hekimian, L. A. Schinazi, and R. H. Dudley (1972). *An Investigation into Recreational Water Quality.* Water Quality Criteria Data Book, Vol. 4., USEPA, EP1.16:18040, DAZ 04172.

Mills, H. F. (1890). "Typhoid Fever in its Relation to Water Supplies". *Annual Report of the Massachusetts State Board of Health.* 22:525, In: G. C. Whipple (1917), *State Sanitation,* Vol. II, Harvard University Press, Cambridge.

Ministry of Health (1934). *The Bacteriological Examination of Water Supplies.* No. 71, U.K. Ministry of Health Series. His Majesty's Stationery Office, 38p. Reprinted in part in *Standard Methods* (1956).

Mitzuta, N., M. Mizuta, F. Ito, T. Ito, H. Uchida, Y. Watanabe, H. Akama, T. Mu[illegible]kami, F. Hayashi, K. Nakamura, T. Yamaguchi, W. Mizuia, S. Oish[illegible], and H. Mat[illegible]mura (1956). "An Outbreak of Acute Arsenic Poisoning Caused by Arsenic Contaminated Soy-Sauce (shoyu): "A Clinical R[illegible]t of 220 Cases". Bull. Yamaguchi Med. Sch., 4(2,3): 131-150. Cited by NRC Safe Drinking Water Committee 1977.

Merselis, Jr., J. G., D. Kaye, C. S. Connolly, and E. W. Hook (1964), "Quantitative Bacteriology of the Typhoid Carrier State", *Am. J. of Trop. Med. and Hygiene,* 13: 425-429.

Mohler, H. (1951). "Iron and Manganese as Disturbing Factors in Ground Water." *Schweiz. Ver. Gas-u. Wasserfach Monats-Bul.* 31:293. Abstracted in *J. Amer. Water Works Assn.* 44(10):42(1952).

Monier-Williams, G. W. (1949). *Trace Elements in Food.* New York: John Wiley and Sons, Inc., pp. 162-206. Cited by U.S. & P.A. 1975.

Monfort, W. F. (1915). "A Special Water Standard". *J. Amer. Water Works Assn.* 2:65-73.

Morse, R. B. and A. Wolman (1918). "The practicability of Adopting Standards of Quality for Water Supplies". *J. Amer. Water Works Assn.* 5:198-228.

National Academy of Sciences, National Academy of Engineering, Environmental Studies Board (1972). *Water Quality Criteria 1972: A Report of the Committee on Water Quality Criteria.* (Government Printing Office, Washington, D.C.)

National Research Council, Food Nutrition Board (1968). Recommended Daily Allowance, 7th Revised Edition, Publication 1964, National Academy of Sciences, Washington, D.C. 55p. Cited by U.S. & P.A. 1975.

Negus, S. S. (1938). "The Physiological Aspects of Mineral Salts in Public Water Supplies". *J. Amer. Water Works Assn.* 30(2):242-264.

Neubauer, O. (1947). "Arsenical Cancer: A Review". *Brit. J. Cancer.* 1: 192. Cited by U.S. E.P.A. 1975.

Nichols, W. R. (1878). "The Filtration of Potable Water". *Annual Report of the Massachusetts State Board of Health.* 9:139, In: Whipple, G. C. (1917), *State Sanitation,* Vol. II, Harvard University Press, Cambridge.

Norcom, G. D. (1939). "Sumposium on Water Quality, Introductory Statement". *J. Amer. Water Works Assn.* 31:1475-1478.

Norcom, G. D., C. R. Cox, L. B. Reynolds, W. M. Wallace, and L. F. Warrick (1939). "Typhoid Fever in Minneapolis and Gastro-enteritis in Milwaukee". *J. Amer. Water Works Assn.* 31:374-387.

Oliveri, V., C. W. Kruse and K. Kawata and J. Smith (1977). *Microorganisms in Urban Stormwater.* EPA-600/2-77-087, 194p.

Orchard, W. J. (1918). "Water Quality Standards and Their Improvement". *J. Amer. Water Works Assn.* 5:49-59. Disc., 5:59-62.

Palmer, R. R. and J. Colton (1965). *A History of the Modern World.* Alfred A. Knopf, New York.

Phelps, E. B. (1907). "A Method for Calculating the Numbers of *B. coli* from the Results of Dilution Tests". *Am. J. of Public Hygiene.* 18: 141p.

_____ (1948). *Public Health Engineering.* New York: Wiley and Sons, Inc. Cited by Welsh and Thomas 1960.

Plamenatz, J. P. (1966). *The English Utilitarians.* Basil Blackwell, Oxford, 192p.

Prescott, S. C. and C.-E. A. Winslow (1915). *Elements of Water Bacteriology,* 3rd ed. John Wiley and Sons, New York, 318p.

_____ and M. H. (1946). *Water Bacteriology.* John Wiley and Sons, New York, 368p.

Rafter, G. W. (1889). "On the Fresh Water Algae and their Relation to the Purity of Public Water Supplies". *Trans. ASCE.* 21:483-504. With Disc. 21:505-557.

Rector, F. L. (1915). "The True Object of Water Analysis". *J. Amer. Water Works Assn.* 2:709-711.

Richards, L. F., W. W. Westmoreland, M. Tashiro, C. M. McKay, and J. T. Morrison (1967). "Determining Optimum Fluoride Levels for Community Water Supplies in Relation to Temperature". *J. Amer. Dental Assn.* 74:389-397. Cited by NRC Safe Drinking Water Committee 1977.

_____ et al. (1967). "Determining Optimum Fluoride Levels for Community Water Supplies in Relation to Temperature". *J. Amer. Dental Assn.* 75p. Cited by U.S. E.P.A. 1975.

Richter, C. P., and A. McLean (1939). "Salt Taste Threshold of Humans". *Am. J. Physiol.* 126:1-6. Cited by U.S.P.H.S. 1962.

Riddick, T. M., N. L. Lindsay and A. Tomassi (1958). "Iron and Manganese in Water Supplies". *J. Amer. Water Works Assn.* 50(5):688-696.

Roholm, K. (1937). *Fluorine Intoxication. A Clinical-Hygenic Study.* London: Lewis and Company, Ltd. Cited by U.S. & P.A. 1975.

Rosen, George (1958). *A History of Public Health.* MD Publications, Inc., New York, 551p.

Safe Drinking Water Committee (1977). *Drinking Water and Health.* National Academy of Sciences, Washington, D. C. 939p.

Salvato, Jr., J. A. (1972). *Environmental Engineering and Sanitation,* 2nd ed., Wiley-Interscience, New York, 919p.

Sartwell, P. E., ed. (1973). *Maxcy-Rosenau, Preventive Medicine and Public Health,* 10th ed. New York: Appleton-Century-Crofts, Inc.

Sattelmacher, P. G. (1962). "Methemoglobinemia from Nitrates in Drinking Water". *Schriftenreiche des Vereins fur Wasser Boden und Lufthygiene,* No. 21. Cited by Winton et al. 1971.

Sauerbrunn, B. J. L., C. M. Ryan and J. F. Shaw (1965). Chronic Fluoride Intoxication with Fluorotic Radiculomyelopathy". *Ann. Intern. Med.* 63:1074-1078. Cited by NRC Safe Drinking Water Committee 1977.

Saunders, R. J. and J. J. Warford (1976). *Village Water Supply.* The Johns Hopkins University Press for The World Bank, Baltimore, Maryland.

Schlirf, K. (1941). "Problems of Water Hygiene". *Off. Gesundh-Dienst.* 7(2):41. Abstracted in *J. Amer. Water Works Assn.* 38(4):588 (1946).

Schroeder, H. A., and J. J. Balassa (1966). "Abnormal Trace Metals in Man". *J. Chron. Dis.* 19:85-106. Cited by U.S. E.P.A. 1975.

Sedgwick, W. T. (1890). "Microscopical Analysis". *Report on Water Supply and Sewerage of the Massachusetts State Board of Health,* Vol. II, 796p. In: G. C. Whipple (1917), *State Sanitation,* Vol. II, Harvard University Press, Cambridge.

_____ (1902). *Principles of Sanitary Science and the Public Health,* MacMillan Company, New York, 368p.

_____ and J. S. MacNutt (1910). "On the Mills - Reincke Phenomenon and Hazen's Theorem...". *J. of Infectious Diseases.* 7: 489-564.

Shattuck, L., N. P. Banks, Jr., J. Abbott (1850). *Report of the Massachusetts Sanitary Commission.* In: G. C. Whipple (1917), *State Sanitation,* Vol. I, Harvard University Press, Cambridge.

Shuval, H. I., and N. Gruener (1973). *Health Effects of Nitrates in Water. Final Report.* Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. (Grant No. 06-012-3). Cited by NRC Safe Drinking Water Committee 1977.

Simon, C., M. Mazke, H. Kay, and G. Mrowitz (1964). "Uber Vorkommen, Pathogenes und Moglichkeiten zur Pronylaxe der durch Nitrit Verusachten Methamoglobinamia". *Z. Kinderheilk.* 91:124. Cited by Winton et al. 1971.

Smith, G. E. (1970). "Nitrate Pollution of Water Supplies." *Trace Subst. Environ. Health.* 3:273-287. Cited by NRC Safe Drinking Water Committee 1977.

Snow, J. (1855). *On the Mode of Communication of Cholera,* 2nd ed. In: *Snow on Cholera,* The Commonwealth Fund, New York, 1936.

Soper, G. A. (1907). "The Sanitary Protection of Surface Water Supplies". *Proc. AWWA.* 27:486-492.

Stanier, R. Y., E. A. Adelberg, and J. L. Ingraham (1976). *The Microbial World,* 4th ed. Prentice-Hall, Englewood Cliffs, New Jersey, 871p.

Stiles, C. W., H. R. Crohurst, and G. E. Thomas (1927). *Experimental Bacterial and Chemical Pollution of Wells via Ground Water, and the Factors Involved.* U.S.P.H.S. Bull., No. 147, June 1927.

Stokinger, H. E. and R. L. Woodward (1958). "Toxicological Methods for Establishing Drinking Water Standards". *J. Amer. Water Works Assn.* 50:515-529.

Streeter, H. W. (1935). "Limiting Standards of Bacterial Quality for Sources of Purified Water Supplies". *J. Amer. Water Works Assn.* 27:1110-1119p.

_____ (1939). "Standards of Raw and Treated Water Quality". *J. Amer. Water Works Assn.* 31:1479-1488p.

Taylor, D. H., and G. D. Hutchinson (1975). "Evaluating State Drinking Water Quality Surveillance Programs". In: McJunkin, F. E. (ed.), *The State of America's Drinking Water,* National Symposium on Drinking Water, Raleigh, North Carolina 1974.

Thomas, Jr., H. A. (1955). "Statistical Analysis of Coliform Data". *Sewage and Industrial Wastes.* 27:212-222p.

_____ (1963). "The Animal Farm: A Mathematical Model for the Discussion of Social Standards for the Control of the Environment". *Quarterly J. of Econ.* Feb. 1963.

Thornton, A. M. (1975). *The Philosophic Radicals.* Pomona College, Claremont, California, 40p.

Tseng, Wen-Ping (1976). "Effects and Dose-Response Relationships of Skin Cancer and Blackfoot Disease with Arsenic". International Conference on Arsenic. Fort Lauderdale, Florida. Cited by NRC Safe Drinking Water Committee 1977.

U. S. Department of Health, Education and Welfare (1969). *Natural Fluoride Content of Community Water Supplies.* Cited by NRC Safe Drinking Water Committee 1977.

U. S. Environmental Protection Agency (1975a). *Scientific and Technical Assessment Report on Manganese.* EPA 600/6-75-002. National Environmental Research Center, Research Triangle Park, North Carolina, 2-3pp.

U. S. Public Health Service (1913). *Annual Report of the Surgeon General".* Government Printing Office, Washington, D.C.

_____ (1925). "Drinking Water Standards". *Public Health Rep.* 40:693-722.

_____ (1943). "Drinking Water Standards". *Public Health Rep.* 58:69-111.

_____ (1946). "Drinking Water Standards". *J. Amer. Water Works Assn.* 38:361-370.

_____ (1962). "Drinking Water Standards". *Public Health Service Publ.* No. 956. U. S. Department of Health, Education, and Welfare, Washington, D.C.

_____ (1969). National Institutes of Health, Division of Dental Health. *Natural Fluoride Content of Community Water Supplies.* Bethesda, Maryland.

U. S. Treasury Department (1914). "Bacteriological Standard for Drinking Water". *Public Health Rep.* 29:2959-2966.

Vogelsang, T. M. and J. Boe (1948), "Temporary and Chronic Carriers of *Salmonella typhi* and *Salmonella paratyphi* B", *J. of Hygiene,* (Cambridge), 46: 252-261.

Walton, G. (1951). "Survey of Literature Relating to Infant Methemoglobinemia Due to Nitrate Contaminated Water". *Am. J. Pub. Health.* 41:986-996. Cited by U.S.P.H.S. 1962.

Weibel, S. R., F. R. Dixon, R. B. Weidner and L. J. McCabe (1964). "Waterborne Disease Outbreaks, 1946-1960". *J. Amer. Water Works Assn.* 56:947-958.

Welsh, G. B. and J. F. Thomas (1960). "Significance of Chemical Limits in U.S.P.H.S. Drinking Water Standards". *J. Amer. Water Works Assn.* 52(3):289-300.

Weston, A. D., C. R. Cox, A. N. Beck, D. B. Lee, and T. A. Filipi (1949). "Factors Involved in Control of Water Supply Quality". *J. Amer. Water Works Assn.* 41:874-890.

Whipple, G. C. (1907). *The Value of Pure Water.* John Wiley and Sons, New York, 84p.

_____ (1916). "The Element of Chance in Sanitation". *J. of the Franklin Institute.* 182:37-59.

_____ (1917). *State Sanitation.* Vol. I and II, Harvard University Press, Cambridge.

White, G. F. (1977). *Water Supply Service for the Urban Poor: Issues.* P.U. Report No. PUN31, Public Utilities Notes, Energy, Water and Telecommunications Department, International Bank for Reconstruction and Development.

_____, and D. J. Bradley and A. U. White (1972). *Drawers of Water, The University of Chicago Press.* Chicago, Illinois, 306p.

White, J. W., Jr., (1975). "Relative Significance of Dietary Sources of Nitrate and Nitrite". *J. Agric. Food Chem.* 23:886-891. Cited by NRC Safe Drinking Water Committee 1977.

Whitsell, W. J., G. D. Hutchinson, and D. H. Taylor (1975). "Problems of Individual Supplies". In: McJunkin, F. E., (ed.), *The State of America's Drinking Water.* National Symposium on Drinking Water, Raleigh, North Carolina, 1974.

Winton, E. F., R. G. Tardiff, and L. J. McCabe (1971). "Nitrate in Drinking Water". *J. Amer. Water Works Assn.* 63:95-98.

Wolman, Abel (1918). "A Preliminary Analysis of the Degree and Nature of Bacterial Removal in Filtration Plants". *J. Amer. Water Works Assn.* 5(3)

_____ (1919). "Index Numbers and Scoring of Water Supplies". *J. Amer. Water Works Assn.* 6:444-456.

_____ (1920a). "Index Numbers and Scoring of Water Supplies - Part II". *J. Amer. Water Works Assn.* 7:927-930.

_____ (1920b). "The Statistical Method in Problems of Water Supply Quality". *Quarterly Publications of the American Statistical Assn.* New Series No. 130:188-202.

_____ (1940). "An Inquiry into Standards Proposed for Stream Cleanliness". *Sewage Work Journal.* 12:1, 116-120.

_____ (1950). "Bacterial Standards for Natural Waters". *J.W.P.C.F.* 22:346-352.

_____ (1960). "Concepts of Policy in the Formulation of So-Called Standards of Health and Safety". *J. Amer. Water Works Assn.* 52:

_____, and A. E. Gorman (1931). *The Significance of Waterborne Typhoid Fever Outbreaks, 1920-1930.* Williams and Wilkins, Baltimore, Maryland, 82p. Also in *J. Amer. Water Works Assn.* 23:160-201.

Wolman, A. and K. B. Stegmaier, Jr. (1940). "Manganese in the Loch Raven Reservoir". *J. Amer. Water Works Assn.* 32(12):2015-2037.

World Bank (1976), *Village Water Supply, A World Bank Paper*, Washington, D.C., 98p.

World Health Organization (1958). *International Standards for Drinking Water.* Geneva.

_____ (1961). *European Standards for Drinking-Water.* Geneva.

_____ (1963). *International Standards for Drinking-Water*, 2nd ed. Geneva.

_____ (1970). *European Standards for Drinking-Water*, 2nd ed. Geneva.

_____ (1970a). *Fluorides and Human Health.* WHO Monograph Series No. 59. Cited by NRC Safe Drinking Water Committee 1977.

_____ (1971). *International Standards for Drinking-Water*, 3rd ed. Geneva.

Zagday, M. I. (1948). "Bentham and the Poor Law". Chp. 3 in G. W. Keeton and G. Schwarzenberger (eds.), *Jeremy Bentham and the Law, a Symposium*, Stevens and Sons, Ltd., London.

Zaldivar, R. (1974). "Arsenic Contamination of Drinking Water and Food Stuffs Causing Endemic Chronic Poisoning". *Beitr. Pathol. Bd.* 151: 384-400. Cited by NRC Safe Drinking Water Committee 1977.

Zapffe, C. (1933). "The History of Manganese in Water Supplies and Methods for its Removal". *J. Amer. Water Works Assn.* 25(5):655-676.

Zubrzycki, L. and E. H. Spaulding (1962). "Studies on the Stability of the Normal Human Fecal Flora". *J. Bact.* 83:968-974.

Zwick, D. R. (1973). "A Criticism of the Effluent Charge". In: Enthoven, A. C. and A. M. Freeman III (eds.). *Pollution, Resources, and the Environment*, Norton, New York.

Appendix B

Historic and Contemporary Drinking Water Standards

Types of Water Supplies to Which the Standards Apply

The U. S. Treasury Department Standard and all the U. S. Public Health Service Standards are intended to apply to water supplied by common carriers engaged in interstate commerce.

The 1975 National Interim Primary Drinking Water Regulations administered by the U. S. Environmental Protection Agency are applicable to public water systems.[1] A public water system is either a "community water system"[2] or a "non-community water system"[3]. The maximum contaminant levels for nitrate and coliform bacteria are applicable to both community and non-community water systems. The levels for turbidity are applicable to both systems if they use surface water sources in whole or in part. The levels for the other inorganic chemicals, the organic chemicals, and for radioactivity, are only applicable to community water systems.

The WHO International Standards are applicable to all communal supplies for which control of treatment and distribution is essential for safe and sanitary quality. The 1971 International Standards have separate bacteriological requirements for piped supplies and individual or small community supplies.

The WHO European Standards are primarily intended for piped supplies[4] of water for domestic use.

---

[1]Defined as a system for the provision to the public of piped water for human consumption, if such a system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

[2]A public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

[3]A public water system that is not a community water system.

[4]Defined as drinking water which is supplied through a distribution system and which is under the control of, or regulated by, communal or local authorities.

Recommended Methods

The analytical methods recommended in the various standards are for the most part those described in the then current editions of the Standard Methods* manual of the American Public Health Association. For some of the more uncommon contaminants, however, other techniques are recommended.

The earlier WHO International Standards contained lengthy sections describing suitable analytical methods. These were largely omitted in the latest edition of the International Standards and both the 1961 and 1970 European Standards. The latter, although recommending the Standard Methods manual, have also made references to alternative methods.

All the WHO Standards contain sections prescribing suitable sampling procedures and various precautions that should be taken in the collection, processing and analysis of samples.

*This manual has been published under several different titles.

Requirements regarding source and protection

U.S. Treasury Department Standard - 1914

-none-

U.S. Public Health Service Standards

1925

(1) The water supply shall be-

(a) Obtained from a source free from pollution; or
(b) Obtained from a source adequately protected by natural agencies[1] from the effects of pollution; or
(c) Adequately protected by artificial treatment.[1]

(2) The water supply system, including reservoirs, pipe lines, wells, pumping equipment, purification works, distributing reservoirs, mains and service pipes shall be free from sanitary defects.[1]

(An outline of the general scope of a sanitary survey is provided in an appendix of the Standards.)

1943

(1) See item (1) under 1925 USPHS Standards above.

(2) The water supply system[1] in all its parts shall be free from sanitary defects[1] and health hazards[1] and shall be maintained at all times in a proper sanitary condition.

(A manual of recommended water sanitation practice is also provided. It is not part of the Standards.)

1946

(1) See item (1) under 1925 USPHS Standards above.

(2) The water supply system[1] in all its parts should be free from sanitary defects[1] and health hazards[1], and all known sanitary defects and health hazards shall be systematically removed at a rate satisfactory to the reporting agency and certifying authority.

Additional guidelines regarding sanitation practice, and responsibility for conditions in the water supply system, are included in the Standards.

---

[1]These terms are defined in the Standards.

1962

(1) The water supply should be obtained from the most desirable source which is feasible, and effort should be made to prevent or control pollution[1] of the source. If the source is not adequately protected by natural means, the supply shall be adequately protected by treatment.

(2) Frequent sanitary surveys shall be made of the water supply system[1] to locate and identify health hazards[1] which might exist in the system. The manner and frequency of making these surveys, and the rate at which discovered health hazards[1] are to be removed, shall be subject to the approval of the Reporting Agency and the Certifying Authority.

Additional guidelines regarding sanitation practice, and responsibility for conditions in the water supply system, are included in the Standards.

U.S. Environmental Protection Agency Regulations - 1975

-none-

[1]These terms are defined in the Standards.

Requirements Regarding Source and Protection

World Health Organization

A. International Standards

Specific requirements are not stated, however, general guidelines are provided. The more important guidelines are summarized below.

1958

The sanitary survey of a new supply should include the detection of all potential sources of pollution and the assessment of their present and future importance.

For existing supplies, the sanitary survey should be made at a frequency compatible with the control of the pollution hazards and the maintenance of a good sanitary quality.

1963

Standards of quality for water sources are specified, these are presented in the section on raw water standards.

Guidelines regarding sanitary surveys are identical to those of the 1958 International Standards.

1971

Guidelines regarding sanitary surveys include those of the 1958 International Standards. It is also recommended that when sanitary inspection shows that a water, as distributed, is liable to pollution, it should be condemned irrespective of the results of chemical or bacteriological examination.

Treatment of the water should be adequate to deal with changes in the quality of the raw water and produce a finished product of consistently high quality however great the demand on the supply may be.

It is also recommended that measures be taken to prevent the formation of a biological layer on the inside surfaces of the mains and service pipes.

B. European Standards

1961

A complete sanitary survey should be regularly carried out on all water supply systems. When sanitary inspections show a water, as

distributed, to be obviously subject to pollution, the water should be condemned irrespective of the results of chemical or bacteriological examination.

1970

See 1961 European Standards above.

Bacteriological Standards

U.S. Treasury Department Standard - 1914

Maximum limits of permissible bacteriological impurity:

(1) The total number of bacteria developing on standard agar plates, incubated 24 hours at 37°C shall not exceed 100 per cubic centimeter. The estimate shall be made from not less than two plates and should be reliable and accurate.

(2) Not more than one out of five 10c.c. portions of any sample examined shall show the presence of B. coli.[c] (A testing procedure which demonstrates the presence of aerobic, gas forming, lactose-fermenting organisms is outlined; this procedure is essentially equivalent to a completed test.)

U.S. Public Health Service Standards

1925

(1) Not more than 10% of all the 10c.c. portions[a] examined shall show the presence of B. coli.[b,c].

(2) Occasionally, three or more of the five 10c.c. portions of a sample may show the presence of B. coli. This shall not be allowed if it occurs in more than-
(a) 5% of the samples when 20 or more samples are examined;
(b) One sample when less than 20 samples are examined.

The series of samples must conform to both requirements (1) and (2) above. The completed test is considered evidence of the presence of B. coli.

1943

These standards allow for the use of either 10 ml. portions[a] or 100 ml. portions[d].

---

[a] 5 standard portions of 10c.c. (ml.) each constitute a standard sample. The term "standard" (portion or sample) has been omitted in the text for brevity.

[b] B. coli group as defined in Standard Methods of Water Analysis, 1923.

[c] See note at end of this section.

[d] 5 standard portions of 100 ml. each constitute a standard sample. The term "standard" (sample or portion) has been omitted in the text for brevity.

If 10 ml. portions used:

(1) Not more than 10% of all the 10 ml. portions examined per month shall show the presence of the coliform group[e].

(2) Occasionally 3 or more of the 5 10 ml. portions of a sample may show the presence of the coliform group. This shall not be allowable if it occurs in consecutive samples or in more than

(a) 5% of the samples when 20 or more samples are examined per month.
(b) One sample when less than 20 samples are examined per month.

If 100 ml. portions used:

(3) Not more than 60% of all the 100 ml. portions examined per month shall show the presence of the coliform group.

(4) Occasionally all of the five 100 ml. portions of a sample may show the presence of the coliform group. This shall not be allowed if it occurs in consecutive samples or in more than-

(a) 20% of the samples when 5 or more samples are examined per month.
(b) One sample when less than 5 samples are examined per month.

The series of samples must conform to either requirements (1) and (2) or requirements (3) and (4) above.

(5) When three or more of the five 10 ml. portions, or all 5 of the 100 ml. portions, constituting a standard sample show the presence of the coliform group, daily samples shall be collected promptly and examined until the results be of satisfactory quality.[f]

The completed test or the confirmed test under certain conditions specified in the Standards, is considered evidence of the presence of the coliform group.

1946

Standards are identified to the 1943 USPHS Standards except that it is now stated that samples collected following an unsatisfactory sample (e.g. as in item (5) above) shall not be included in the determination of the number of samples examined monthly. Neither shall subsequent unsatisfactory samples in this daily series be used as a basis for prohibiting the supply, provided that (1) immediate, active efforts are made to locate the cause of contamination, (2) immediate action is taken

---

[e]Coliform group of bacteria includes all organisms of the coli-aerogenis group as set forth in Standard Methods for Examination of Water and Sewage, 1936. See note at end of this section.

[f]When this occurs in waters of unknown quality, simultaneous tests should be made on multiple portions of a geometric series.

to eliminate such cause and (3) samples taken following such remedial action are satisfactory.

1962

These standards allow for use of either the fermentation tube method or the membrane filter technique.

If fermentation tube method used with either 10 ml. or 100 ml. portions: Standards are essentially identical to the 1946 USPHS Standards, except for a few minor changes in wording.

If membrane filter technique used:

(1) The arithmetic mean coliform[g] density of all standard samples examined per month shall not exceed one per 100 ml.

(2) Coliform colonies per standard sample shall not exceed 3/50 ml., 4/100 ml., 7/200 ml. or 13/500 ml. in:

    (a) Two consecutive samples;
    (b) More than one sample when less than 20 are examined per month;
    (c) More than 5% of the samples when 20 or more are examined per month.

(3) When coliform colonies in a single standard sample exceed the above values, daily samples shall be collected promptly and examined until the results obtained from two consecutive samples show the water to be of satisfactory quality[f]. These unsatisfactory samples are regarded in the same manner as those used for the fermentation tube method - see 1946 USPHS Standards.

U.S. Environmental Protection Agency Regulations - 1975

Maximum contaminant levels.

These standards also allow for the use of either the fermentation tube method or the membrane filter technique.

If membrane filter technique used:

(1) See corresponding item (1) in 1962 USPHS Standards above.

(2) The number of coliform bacteria shall not exceed 4/100 ml. in:

    (a) More than one sample when less than 20 are examined per month; or
    (b) More than 5% of the samples when more than 20 are examined per month.

---

[g]Coliform group as defined in Standard Methods for the Examination of Water and Wastewater, current edition. See note at end of this section.

(3) When the coliform bacteria in a single sample exceed 4/100 ml., at least two consecutive daily check samples shall be collected and examined until the results from two consecutive samples show less than one coliform bacterium per 100 ml.

If fermentation tube method used, with either 10 ml. or 100 ml. portions:

Standards are essentially identical to those specified in items (1), (2), (3), and (4) of the 1943 USPHS Standards except for the elimination of the requirement regarding the number of portions showing the presence of coliforms in consecutive samples.

The requirement in these Standards corresponding to item (5) in the 1943 USPHS Standards is more stringent in that twice daily resampling (check samples) must be continued until the results from two consecutive samples show no positive tubes.

Check samples, both for fermentation tube and membrane filter techniques, shall not be included in calculating the number of samples taken each month for compliance with sampling frequency requirements. Neither check samples nor special purpose samples shall be used to determine compliance with maximum contaminant levels for coliform bacteria.

In addition there are requirements for record maintenance, routine reports to the State and, in the event that a maximum contaminant level is exceeded, for notification of the State and the public.

Note: The definitions of B. coli, the "coli-aerogenes group" and the "coliform group" are considered equivalent (APHA 1965).

Bacteriological Standards

World Health Organization Standards

International

1958

I. Recommended standards for treated water.

a. Coliform[f] bacteria shall not be detected in 90% of the samples examined in any year, or the MPN index[g] shall be $\leq$ 1.0.

b. No sample shall have an MPN index $\geq$ 10.

c. An MPN index of 8-10 should not occur in consecutive samples.

d. See item d below.

II. Recommended standards for untreated water.

a. The MPN index of 90% of the samples examined in any year should be $\leq$ 10.

b. No sample should show an MPN under $\geq$ 20.

c. An MPN index $\geq$ 15 should not be permitted in consecutive samples.

d. When two consecutive samples show an MPN index $\geq$ 8, in the case of treated water, or $\geq$ 10 in the case of untreated water, additional samples from the sampling point should be examined immediately. Further investigation may also be desirable.

1963

These standards also allow for the use of the membrane filter technique.

I. Recommended standards for treated water.

Requirements are identical to those of 1958 International Standards.

---

[f]Coliform group includes all aerobic and facultative anaerobic Gram-negative non-spore-forming rods capable of fermenting lactose with the production of acid and gas at 35-37°C in $\leq$ 48 hours.

[g]MPN index for coliform bacteria (in all cases here).

If membrane filter technique used:

The arithmetic mean of numbers of coliform group organisms shall be < 1 per 100 ml., and shall not exceed 4 per 100 ml. in two consecutive samples or in more than 10% of the samples examined.

II. Recommended standards for untreated water.

Requirements include all those of 1958 International Standards and an additional requirement that no more than 40% of the number of coliform microorganisms shown by the MPN index shall be faecal coliform bacteria[h].

If membrane filter technique used:

The arithmetic mean of the numbers of coliform group bacteria determined shall be < 10 per 100 ml., and shall not be > 20 per 100 ml. in two consecutive samples or in more than 10% of the samples examined.

1971

I. Standards recommended for piped supplies.

1. Water entering the distribution system.

(a) Chlorinated or otherwise disinfected supplies.
Coliform[f] organisms should be absent in any sample of 100 ml. If this standard is not met, an immediate investigation into the efficacy of the purification process and the method of sampling and testing.

(b) Non-disinfected supplies.
E. coli[i] should be absent in 100 ml. Occasionally, if E. coli is absent, the presence of ≤ 3 coliform organisms per 100 ml. may be tolerated. If this is exceeded the supply should be considered unsuitable for use without disinfection.

2. Water in the distribution system.

(1) 95% of the samples in any year should not contain any coliform organisms in 100 ml.

---

[h] Faecal coliform group is defined as a Gram-negative non-spore-forming rod which is capable of fermenting lactose with the production of acid and gas at 44°C in < 24 hours.

[i] E. coli is regarded as a Gram-negative, non-spore-forming rod capable of fermenting lactose with the production of acid and gas at both 37°C and 47°C in < 48 hours; it produces indole in peptone water containing tryptophane and is incapable of utilizing sodium citrate as its sole source of carbon.

(2) No sample should contain E. coli in 100 ml.

(3) No sample should contain more than 10 coliform organisms per 100 ml.

(4) Coliform organisms should not be detectable in 100 ml. of any two consecutive samples.

If any coliform organisms are found the minimum action required is immediate re-sampling. Additional investigation may be advisable, depending on local conditions.

II. Standards recommended for individual or small community supplies.

The standard for piped supplies should be aimed at and everything possible should be done to prevent pollution of the water.

It should be possible to achieve a coliform count of < 10 per 100 ml. Persistent failure to achieve this, especially if E. coli is repeatedly found, should lead to condemnation of the supply.

European

1961

Standards recommended for piped supplies.

1. Water entering the distribution system.
   Coliform[f] organisms must be absent, whether the water is disinfected or naturally pure. In either case, the presence of coliform organisms calls for immediate investigation.

2. Water in the distribution system.
   The presence of one or more coliform organisms in a 100 ml. sample can be permitted in 5% of the samples examined if a positive result is not obtained in two or more consecutive samples and at least 100 samples of 100 ml. each, regularly distributed over the year, are examined.

When one 100 ml. sample shows the presence of coliform organisms, a further sample from the sampling point should be examined immediately. Additional investigation may be advisable, depending on local conditions.

1970

Standards are essentially identical to the 1961 European Standards.

Frequency of Sampling for Bacteriological Examination

U.S. Treasury Department Standard - 1914

-none specified-

U.S. Public Health Service Standards

1925

The number and spacing of samples examined shall be sufficient, in the judgement of the certifying authority, to indicate the quality of the supply, with due regard to all facts known as to its source and protection.

1943

(1) The frequency of sampling and the location of sampling points on the distribution system should be such as to determine properly the bacteriological quality of the supply. This will be subject to regulation by the certifying authority.

(2) The minimum number of samples to be collected from the distribution system and examined each month should be in accordance with the number determined from the graph in figure B-1.

1946

(1) See item (1) in 1943 USPHS Standards; frequency of sampling is now subject to regulation by both the certifying authority and the reporting agency.

(2) See item (2) under 1943 USPHS Standards.

1962

(1) Essentially identical to item (1) under the 1946 USPHS Standards.

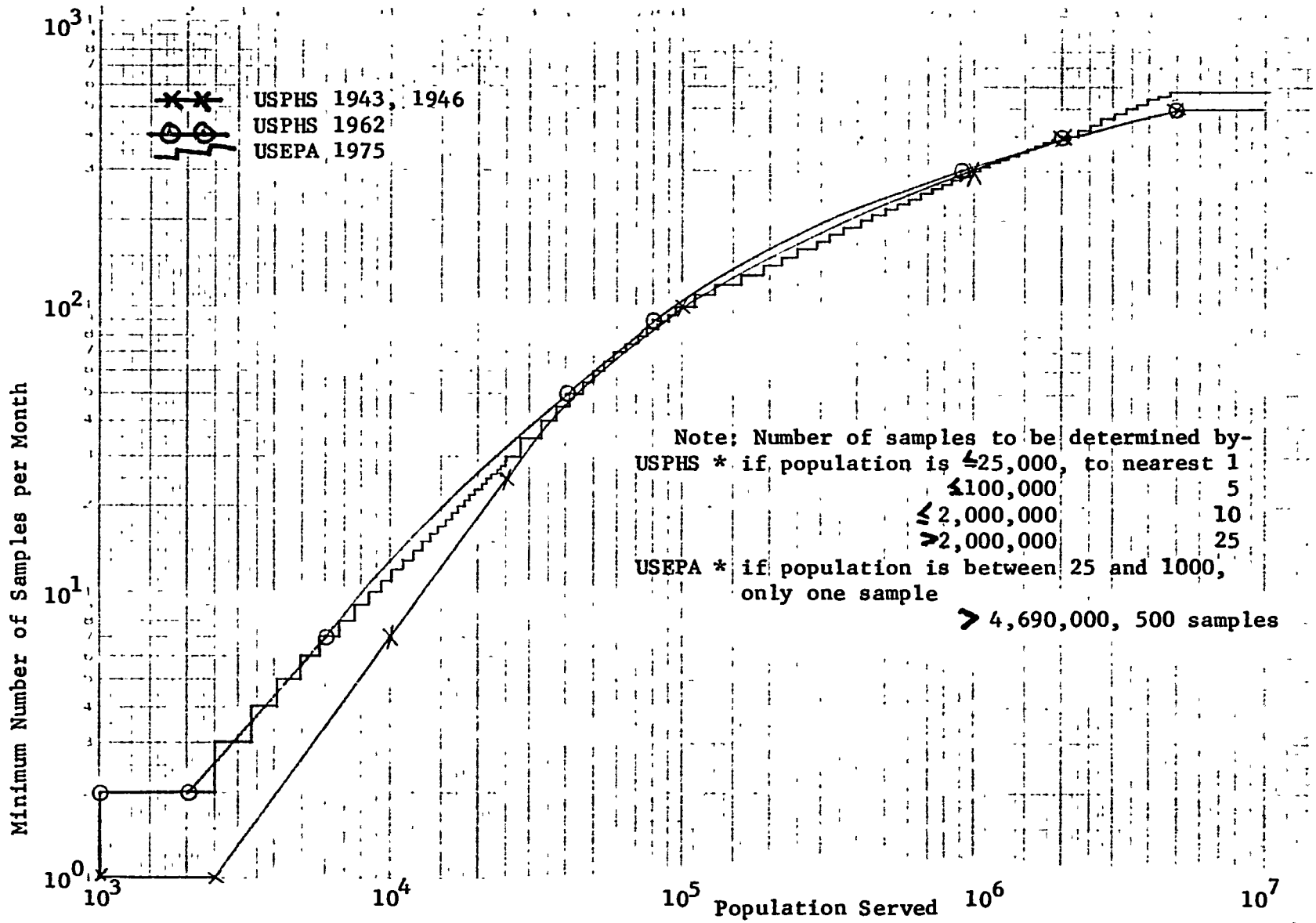
(2) The minimum number of samples to be collected from the distribution system and examined each month are recorded in figure B-1

U.S. Environmental Protection Agency Regulations - 1975

For community water systems:

The minimum number of samples to be collected each month are recorded in figure B-1.

Figure B-1 Minimum Sampling Frequency for Bacteriological Examination



For non-community water systems:

The supplies shall sample for coliforms in each calendar quarter during which the system provides water to the public.

For both community and non-community water systems, chlorine residual monitoring may be substituted for not more than 75% of the samples required to be taken, subject to provisions described in the Regulations and approval by the State.

Frequency of Sampling for Bacteriological Examination

World Health Organization

All the International and European Standards have virtually identical proposed requirements; there are a few differences in the general recommendations; these are identified in the footnotes.

The frequency of bacteriological examination of a supply, and the location of the sampling points should be such as to enable proper supervision of the bacteriological quality of the water supply to be maintained.

The frequency of examination of routine samples of naturally pure water entering the distribution system and of water in the distribution system, should be based on the size of the population served; these examinations should be spaced out over time, according to the danger of pollution, geographical situation, and protection of the source.

Treated water, as it enters the distribution system from each treatment point should be examined at least once a day. When safety depends on disinfection, examination at a frequency of not less than once a week is recommended[1].

Examination of disinfected water as it enters the distribution system from each treatment point should be carried out at least once a day. With supplies serving 10,000 people or less, only weekly sampling may be practical; reliance will have to be placed on proper control of disinfectant dosage. The interval may have to be even longer in the smallest supplies[2].

Water requiring disinfection should be examined at least once a day as it enters the distribution system from each treatment point[3].

In the case of supplies which do not require disinfection, but are chlorinated as a precautionary measure, the frequency of examination proposed below for non-disinfected water entering the distribution system could be suitable[4].

---

[1] Only in 1958 and 1961 International Standards.

[2] Only in 1970 European and 1971 International Standards.

[3] Only in 1961 European Standards.

[4] Only in 1971 International, 1961 and 1970 European Standards.

A check on the concentration of the chemical disinfectant should be carried out several times a day at the treatment point, and preferably at other points in the distribution system.

For non-disinfected water entering the distribution system, the following maximum intervals between successive routine examinations are proposed:

Population served	Maximum interval between successive samples
≤ 20,000	1 month
20,000-50,000	2 weeks
50,001-100,000	4 days
≥ 100,000	1 day

Samples should be taken at all the points at which water enters the distribution system.

For water in the distribution, whether disinfected or not, the following maximum intervals between successive samples and the minimum numbers of samples to be examined in each month are proposed:

Population served	Maximum interval between successive samples	Minimum number of samples to be taken from whole distribution system each month
≤ 20,000	1 month	1 sample per 500 of population per month
20,000-50,000	2 weeks	
50,001-100,000	4 days	
≥ 100,000	1 day	1 sample per 10,000 of population per month

Choice of sampling point should be made by expert advisors.

More frequent examination will be required under certain circumstances- in the event of an epidemic or immediate danger of pollution, among others.

Virological Standards

Virological standards are not mentioned in any of the U.S. Standards and only the two more recent WHO Standards, the 1970 European and 1971 International, consider them. In both cases a standard, as such, is not specified, it is merely stated that "if not even one plaque-forming unit (PFU) can be found in one liter of water it can reasonably be assumed that the water is safe to drink."

Neither methods nor sampling frequency are specified.

Physical and Chemical Standards

U.S. Treasury Department Standard - 1914

It is recommended that water supplies be excluded from use when, in the opinion of the Surgeon General, physical or chemical characteristics render them definitely injurious to health or grossly offensive.

U.S. Public Health Service Standards

1925

Water should be clear, colorless, odorless, pleasant to the taste, and should not contain an excessive amount of soluble mineral substances nor of any chemicals used in treatment.

1943

(a) Water shall have no objectionable taste or odor, and shall not contain an excessive amount of soluble mineral substances, nor excessive amounts of any chemicals used in treatment.

(b) Salts of barium hexavalent chromium, heavy metal glucosides, or other substances with deleterious physical effects shall not be allowed in the water supply system.

1946

(a) See item (a) under 1943 U.S.P.H.S. Standards above.

(b) Salts of barium, hexavalent chromium, heavy metal glucosides, or other substances with deleterious physiological effects shall not be added to the system for water treatment purposes.

1962

Drinking water shall not contain impurities in concentrations which may be hazardous to the health of consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effect, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the customer. Drinking water should contain no impurity which would cause offense to the sense of sight, taste or smell.

Table B-1 Historical Physical and Chemical Standards: U.S.

	U.S.P.H.S. 1925 mg/l#		U.S.P.H.S. 1943 mg/l#		U.S.P.H.S. 1946 mg/l#		U.S.P.H.S. 1962 mg/l#	
	Recommended Limit[1]	Maximum Allowable[2]	Recommended Limit[1]	Maximum Allowable[2]	Recommended Limit[1]	Maximum Allowable[2]	Recommended Limit[1]	Maximum Allowable[2]
Physical Characteristics								
Color	10-20[a]		20[a]		20[a]		15[a]	
Odor	none		unobjec-tionable		unobjec-tionable		unobjec-tionable	
Taste	pleasant							
Turbidity	5-10[b]		10[b]		10[b]		5[b]	
Inorganic Substances								
Ammonia								
Arsenic				0.05		0.05	0.01	0.05
Barium								1.0
Cadmium								0.01
Calcium								
Carbon Dioxide, Free								
Chloride	250		250		250		250	
Chromium						0.05		0.05
Chromium (Cr^{+6} only)								
Copper		0.2	3.0		3.0		1.	
Cyanide							0.01	0.2
Fluoride				1.0		1.5	0.8-1.7[d]	1.4-2.4[d]
Hydrogen Sulfide								
Iron	0.3		0.3[q]		0.3[q]		0.3	
Lead		0.1		0.1		0.1		0.05
Magnesium	100		125		125			

Table B-1 Historical Physical and Chemical Standards: U.S. (Continued)

Inorganic Substances (cont'd.)	U.S.P.H.S. 1925 mg/l[w] Recommended Limit[1]	U.S.P.H.S. 1925 mg/l[w] Maximum Allowable[2]	U.S.P.H.S. 1943 mg/l[w] Recommended Limit[1]	U.S.P.H.S. 1943 mg/l[w] Maximum Allowable[2]	U.S.P.H.S. 1946 mg/l[w] Recommended Limit[1]	U.S.P.H.S. 1946 mg/l[w] Maximum Allowable[2]	U.S.P.H.S. 1962 mg/l[w] Recommended Limit[1]	U.S.P.H.S. 1962 mg/l[w] Maximum Allowable[2]
Magnesium & Sodium Sulfate								
Manganese			0.3[q]		0.3[q]		0.05	
Murcury								
Nitrate							45	
Oxygen, Dissolved (Minimum)								
Selenium				0.05		0.05		0.01
Silver								0.05
Sulfate	250		250		250		250	
Total Hardness								
Total Solids	1,000		500-1,000		500-1,000		500[e]	
Zinc		5.0	15		15		5	
Caustic Alkalinity	none							
Normal Carbonate Alkalinity			120		120			
pH Range								
Phenolthalein Alkalinity			see (s)		see (s)			
Residual Alkilinity (Min.)	≤ 10[u]							
Sodium & Potassium Carbonates	50[r]							
Total Alkalinity			see (t)		see (t)			
Organic Substances								
Alkyl Benzene Sulfonates							0.5	
Carbon Chloroform Extract							0.2	
Phenolic Compound (as Phenols)			0.001		0.001			

Table B-1 Historical Physical and Chemical Standards: W.H.O. (Continued)

Physical Characteristics	W.H.O. International 1958			W.H.O. International 1963			W.H.O. European 1961	
	Permissible[3]	Excessive[3]	Maximum Allowable[2]	Maximum Acceptable[3]	Maximum Allowable[3]	Maximum Allowable[2]	Recommended Limit[5]	Tolerance Limit[2]
	Other Substances[4] mg/l[#]		Toxic Substances	Other Substances[4] mg/l[#]		Toxic Substances	Other Substances mg/l[#]	Toxic Substances
Color	5[a]	50[a]		5[a]	50[a]			
Odor	unobjectionable	-		unobjectionable	-			
Taste		-			-			
Turbidity	5[b]	25[b]		5[b]	25[b]			
Inorganic Substances								
Ammonia							0.5	
Arsenic			0.2			0.05		0.2
Barium						1.0		
Cadmium						0.01		0.05
Calcium	75	200		75	200			
Carbon Dioxide, Free							0[p]	0[p]
Chloride	200	600		200	600		350	200-600
Chromium								
Chromium (CR^{+6} only)			0.05			0.05		0.05
Copper	1.0	1.5		1.0	1.5		0.05[l]	
Cyanide			0.01			0.2		0.01
Fluoride		1.0-1.5[h]			1.0-1.5[h]		1.5	
Hydrogen Sulfide								
Iron	0.3	1.0		0.3	1.0		0.1[m]	
Lead			0.1			0.05		0.1[n]
Magnesium	50	150		50	150		30[o]	

Table B-1 Historical Physical and Chemical Standards: W.H.O. (Continued)

Inorganic Substances (Cont'd.)	W.H.O. International 1958			W.H.O. International 1963			W.H.O. European 1961	
	Permissible[3]	Excessive[3]	Maximum Allowable[2]	Maximum Acceptable[3]	Maximum Allowable[3]	Maximum Allowable[2]	Recommended Limit[5]	Recommended Limit[5]
	Other Substances[4] mg/l[f]		Toxic Substances	Other Substances[4] mg/l[f]		Toxic Substances	Other Substances	Toxic Substances mg/l[f]
Magnesium & Sodium Sulfate	500	1,000		500	1,000			
Manganese	0.1	0.5		0.1	0.5		0.1	
Mercury								
Nitrate		50-100[i]			45[i]		50	
Oxygen, Dissolved (Minimum)							≥ 5	
Selenium			0.05			0.01		0.05
Silver								
Sulfate	200	400		200	400		250	
Total Hardness							2-10[k]	
Total Solids	500	1,500		500	1,500			
Zinc	5.0	15		5.0	15		5.0	
Caustic Alkalinity								
Normal Carbonate Alkalinity								
pH Range	7.0-8.5	6.5-9.2		7.0-8.5	6.5-9.2			
Phenolthalein Alkalinity								
Residual Alkalinity (Min.)								
Sodium & Potassium Carbonates								
Total Alkalinity								
Organic Substances								
Alkyl Benzene Sulfonates				0.5	1.0			
Carbon Chloroform Extract				0.2	0.5			
Phenolic Compound (as Phenols)	0.001	0.002		0.001	0.002		0.001	

Table B-1 Historical Physical and Chemical Standards (Continued)

[1]Should not be exceeded if other more suitable supplies are available.
[2]Presence in excess of the concentrations quoted constitute grounds for rejection of the supply.
[3]These limiting concentrations are indicative only and can be disregarded in specific instances.
[4]Substances that may affect the potability or acceptibility of water or may affect health if present in excessive amounts.
[5]If present in piped supplies in excess of quoted concentrations, whatever practicable steps should be taken to adjust the concentrations.
[#]Units are milligrams per liter unless otherwise noted

[a]platinum-cobalt scale
[b]turbidity units
[c]threshold odor number
[d]Recommended limits and maximum allowable average concentrations vary inversely with mean annual temperatures - see separate section on fluoride standards.
[e]for total dissolved solids
[f]Monthly average, an average of up to 5 turbidity units may be allowed if disinfection is not hindered.
[g]Average for 2 consecutive days.
[h]The effective limit should be based on the total daily flouride intake of individuals in the area.
[i]If the nitrate content exceeds the quoted limit, the population should be warned of potential dangers and/or should be informed of other safer sources for infant feeding.
[j]If less than 250 mg/l sulfate present, magnesium up to 150 mg/l may be allowed.
[k]measured in milliequivalents per liter (mEq/l)
[l]3.0 mg/l after 16 hours' contact with new pipes
[m]As water enters distribution system. In certain small installations up to 0.3 mg/l may be permitted.
[n]0.3 mg/l after 16 hours' contact with new lead pipes
[o]If less than 250 mg/l sulfate present, magnesium up to 125 mg/l may be allowed.
[p]for aggressive carbon dioxide
[q]Standard is for iron and manganese together.
[r]Calculated as normal calcium carbonate.
[s]If chemically treated, 15 mg/l plus 0.4 times the total alkalinity (calculated as $CaCO_3$).
[t]If chemically treated, should not exceed hardness by more than 35 mg/l (calculated as $CaCO_3$).
[u]If treated with an aluminum compound.
[v]Concentrations > 0.2 mg/l necessitate further analysis to determine the causative agent

Table B-2 Current Physical and Chemical Standards

	World Health Organization					1975 USEPA
	1970 European		1971 International			
	Recommended Limit[1]	Tolerance Limit[2]	Highest Desirable	Maximum Permissible	Upper Limit	Maximum Permissible[3]
Physical Characteristics	Other Substances[4] mg/l	Toxic Substances[5]	Other Substances[4] mg/l		Toxic Substances mg/l	
Color			5[a]	50[a]		
Odor			unobjectionable	unobjectionable		
Taste						
Turbidity			5[b]	25[b]		1[b,c], 5[b,d]
Inorganic Substances						
Ammonia	0.05					
Arsenic		0.05			0.05	0.05
Barium		1.0				1.
Cadmium		0.01			0.01	0.010
Calcium			75	200		
Carbon Dioxide, Free	0[e]					
Chloride	200-600		200	600		
Chromium						0.05
Chromium (CR^{+6} only)		0.05				0.05
Copper	0.05[f]		0.05	1.5		
Cyanide		0.05			0.05	
Fluoride	1.0-1.7[g]			0.8-1.7[g,h]		1.4-2.4[g]
Hydrogen Sulfide	0.05					
Iron	0.1[i]		0.1	1.0		
Lead		0.1[j]			0.1	0.05
Magnesium	30[k]		30[l]	150		

Table B-2 Current Physical and Chemical Standards (Continued)

Inorganic Substances (Cont'd.)	World Health Organization 1970 European Recommended Limit[1] Other Substances[4] mg/l[5]	World Health Organization 1970 European Tolerance Limit[2] Toxic Substances	World Health Organization 1971 International Highest Desirable Other Substances[4] mg/l[5]	World Health Organization 1971 International Maximum Permissible Other Substances[4] mg/l[5]	World Health Organization 1971 International Upper Limit Toxic Substances mg/l	1975 USEPA Maximum Permissible[3]
Manganese	0.05		0.05-	0.5		
Mercury					0.001	0.002
Nitrate	50-100			45[m]		45
Oxygen, Dissolved (Minimum)	≥ 5					
pH			7.0-8.5-	6.5-9.2		
Selenium		0.01			0.01	0.01
Silver						0.05
Sulfate	250		200	400		
Total Hardness	2-10[n]		2[n]	10[n]		
Total Solids			500	1500		
Zinc	5.0		5.0	15		
Organic Substances						
Anionic Detergents	0.2		0.2	1.0		
Carbon Chloriform Extract	0.2-0.5					
2,4-D[o]						0.1
Endrin[p]						0.0002
Lindane[q]						0.004
Methoxychlor[r]						0.1
Mineral Oil			0.01	0.30		
PAH[s]	0.0002			0.0092		

Table B-2 Current Physical and Chemical Standards (Continued)

	World Health Organization						1975 USEPA
	1970 European		1971 International				
	Recommended Limit[1]	Tolerance Limit[2]	Highest Desirable	Maximum Permissible	Upper Limit	Maximum Permissible[3]
	Other Substances[4] mg/l[5]	Toxic Substances	Other Substances[4] mg/l[5]		Toxic Substances mg/l	
Organic Substances (Cont'd.)						
Phenolic Compounds (as Phenols)	≥0.001					
Toxaphene[t]						0.005
2, 4, 5-TP Silvex[u]						0.01

[1] If present in piped supplies in excess of quoted concentrations, whatever practicable steps should be taken to adjust the concentrations.
[2] Presence in excess of concentrations quoted constitute grounds for rejection of the supply.
[3] If limits exceeded, public and State must be notified.
[4] Substances that may affect the potability or acceptability of water, or may affect health if present in excessive amounts.
[5] Units are milligrams per liter, except for pH and where otherwise noted.

[a] Platinum-cobalt scale.
[b] Turbidity units (TU).
[c] Monthly average, an average up to 5 TU may be allowed if disinfection is not hindered.
[d] Average for 2 consecutive days.
[e] For aggressive CO_2.
[f] 3.0 mg/l after 16 hours' contact with new pipes.
[g] Recommended limits and maximum allowable mean concentrations vary inversely with mean annual temperature - see section on fluoride standards.
[h] The effective limit should be based on the total daily fluoride intake of individuals in the area.
[i] As water enters distribution system. In certain small installations up to 0.3 mg/l may be permitted.

Table B-2 Current Physical and Chemical Standards (Continued)

[j] 0.3 mg/l after 16 hours' contact with new lead pipes.
[k] If < 250 mg/l sulfate present, magnesium up to 125 mg/l may be allowed.
[l] If < 250 mg/l sulfate present, magnesium up to 150 mg/l may be allowed.
[m] If the nitrate content exceeds the quoted limit, the population should be warned of potential dangers and/or should be informed of the safer sources for infant feeding.
[n] Measured in milliequivalents per liter.
[o] 2,4 - Dichlorophenoxyacetic acid.
[p] 1,2,3,4,10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5, 8-dimethano napthalene.
[q] 1, 2, 3, 4, 5, 6-hexachlorocyclohexane, gamma isomer.
[r] (1, 1, 1-Trichloroethane). 2, 2-bis (p-methoxyphenyl).
[s] Polynuclear aromatic hydrocarbons; the limit is based on the concentration of six representative PAH compounds: fluoranthene; 3, 4-benzfluoranthene; 11, 12-benzfluoranthene; 3, 4-benzpyrene; 1, 12-benzperylene; indeno (1, 2, 3-ed) pyrene.
[t] $C_{10}H_{10}Cl_q$ - Technical chlorinated camphene, 67-69 percent chlorine
[u] 2, 4, 5-Trichlorophenoxypropionic acid.

Table B-3 Current Raw Water Quality Standards

Physical Characteristics	FWPCA Criteria 1968[1,5] Permissible[4]	FWPCA Criteria 1968[1,5] Desirable[4]	WHO International - 1963[2] Maximum Allowable	NAS-NAE Criteria - 1972[3,5] Recommended Limit
Color	75[a]	10[a]	300[a]	75[a]
Odor		~0	-	~0
Turbidity		~0[b]	-	
Inorganic	mg/1	mg/1	mg/1	mg/1
Alkalinity	30-500			
Ammonia (as N)	0.5	< 0.01	0.41	0.5
Arsenic	0.05	0	0.05	0.1
Barium	1.0	0		1.0
Boron	1.0	0		
Cadmium	0.01	0	0.01	0.010
Chloride	250	< 25		250
Chromium			0.05	0.05
Chromium (VI)	0.05	0		
Copper	1.0	0	1.5	1
Dissolved Oxygen	≤ 4[c], ≤ 3[d]	~ saturated		
Fluoride	0.8-1.7[g]		1.5	1.4-2.4[h]
Iron	0.3[e]	~0	50	0.3[i]
Lead	0.05	0	0.05	0.05
Magnesium & Sodium Sulfate			1000	
Manganese	0.05[e]	0	5[f]	0.05[i]
Mercury				0.002
Nitrate (as N)			10	10
Nitrate & Nitrite (as N)	10	~0		
Nitrite (as N)				1
pH	6.0-8.5	-	-	5.0-9.0
Selenium	0.01	0	0.01	0.01
Silver	0.05	0	-	
Sulfate	250	< 50	-	250
Total Dissolved Solids	500[e]	< 200[e]	1500	
Total Nitrogen[j]	-	-	1	
Uranylion	5	0	-	
Zinc	5	~0	1.5	5

Table B-3 Current Raw Water Quality Standards (Continued)

Organic	FWPCA Criteria 1968[1,5] Permissible[4]	FWPCA Criteria 1968[1,5] Desirable[4]	WHO International - 1963[1] Maximum Allowable	NAS-NAE Criteria - 1962[3,5] Recommended Limit
Alkyl Benzene Sulfonates			0.5	
Carbon Alcohol Extract				1.5[m]
Carbon Chloroform Extract	0.15	< 0.04	0.5	0.3[m]
Cyanide	0.20	0	0.2	0.2
MBAS[k]	0.05	~0		0.5
Oil & Grease	~0	0	1	~0
Pesticides:				
Aldrin	0.017	0		0.001
Chlordane	0.003	0		0.003
DDT	0.042	0		0.05
Dieldrin	0.017	0		0.001
Endrin	0.001	0		0.0005
Heptachlor	0.018	0		0.0001
Heptachlor Epoxide	0.018	0		0.0001
Lindane	0.056	0		0.005
Methoxychlor	0.035	0		1.0
Organic Phosphates & Carbamates	0.01[1]	0		0.1
Toxaphene	0.005	0		0.005
Herbicides:				
2,4-D				0.02
2,4,5-T				0.002
2,4,5-TP				0.03
2,4-D+2,4,5-T+2,4,5-TP	0.1	0		0.03
Phenolics (as Phenols)	0.001	0	0.002	.001
Biological Oxygen Demand			6	
Chemical Oxygen Demand			10	
Radioactivity	pCi/1	pCi/1	pCi/1	pCi/1
Gross alpha			0.5[n]	
Gross beta	1,000	< 100	5[n,o]	1,000[p]
Radium-226	3	< 1		
Strontium-90	10	< 2		

Table B-3 Current Raw Water Quality Standards (Continued)

	FWPCA Criteria 1968[1,5]		WHO International - 1963[1]	NAS-NAE Criteria - 1972[3,5]
	Permissible[4]	Desirable[4]	Maximum Allowable	Recommended Limit
Bacteriological	in 100 ml[q]	in 100 ml[q]	MPN/100 ml	MPN/100 ml[r]
Coliforms	10,000	< 100	0-50, 000[s]	20,000
Fecal Coliforms	2,000	< 20		2,000

[1]Surface water criteria for public water supplies.
[2]Standards of quality for water sources.
[3]NAS-NAE Committee on Water Quality Criteria for public water supply sources.
[4]The number 0 is used in place of the original term - "absent"; approximately (~) 0 in place of "virtually absent."
[5]It is assumed that the following treatment, and no more, is used: coagulation (< 50 mg/l alum, ferric sulfate or copper as with alkali addition, but without coagulant aids or activated carbon, sedimentation (≤ 6 hrs.), rapid sand filtration (≤ 3 gal/sq ft/min) and disinfection with chlorine (without consideration to concentration or form of chlorine residual).

[a]Platinum cobalt scale.
[b]Turbidity units.
[c]Monthly mean.
[d]Individual sample.
[e]Filterable.
[f]Assuming ammonia content is < 0.5 mg/l.
[g]Limits vary with average temperature; are upper limits in 1962 USPHS Standards, see section on fluorides.
[h]Limits vary with average temperature; are identical to 1975 EPA limits, see section on fluorides.
[i]Soluble.
[j]Exclusive of nitrate.
[k]Methylene blue active substances.
[l]As parathion in cholinesterase inhibition.
[m]As measured by the Low-Flow Sampler.
[n]If exceeded, radiochemical analysis is required.
[o]Excluding potassium-40, and if lead-210 and radium-228 are virtually absent.
[p]The amount of radioactivity detected in a water source should not be greater than can be reduced by the selected treatment process to values which fall within the limits established for drinking water.
[q]Monthly arithmetic average.
[r]Geometric mean density.
[s]Different treatment processes are recommended for intervals within this range.

Table B-4 Current and Historical Radiological Standards

			WHO				
			International			European	
	USPHS 1962[1] Limit[2] pCi/l	USEPA 1975* Maximum Permissible Level[6] pCi/l	1958 Recommended Limit[3,4] pCi/l	1963 Maximum Acceptable Limits[3,4] pCi/l	1971 Recommended Limit[3,5] pCi/l	1961 Recommended Limit[3,4] pCi/l	1970 Recommended Limit[3,5] pCi/l
Gross alpha activity	-	-	1	-	3	1	3
Gross alpha activity (including Ra^{226} but excluding radon & uranium)	-	15	-	-	-	-	-
Gross beta activity	-	-	10	-	30	10	30
Gross beta concentration (in the absence[a] of Sr^{90} and alpha emitters)	1000	-	-	1000	-	-	-
Radium-226	3	-	-	10	-	-	-
Radium-226 & Radium-228	-	5	-	-	-	-	-
Strontium-90	10	8[c]	-	30	-	-	-
Tritium	-	20,000[c]	-	-	<1000[b]	-	<1000[b]

*It is also required that the average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year. The concentration of Strontium-90 and Tritium causing 4 mrem dose equivalents are listed (see above table). The concentration of other man-made radionuclides causing 4 mrem dose equivalents shall be calculated on the basis of a 2 liter/day drinking water intake using the 168 hour data listed in "Maximum Permissible Body Burden & Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure". If 2 or more radionuclides are present, the sum of their annual dose equivalent shall not exceed 4 mrem/year.

[1]Earlier USPHS Standards and the 1914 Treasury Department Standard do not mention radioactivity.

[2]If these concentrations are exceeded, a water supply shall be approved by the certifying authority if surveillance of total intakes of radioactivity from all sources are within the limits recommended by the Federal Radiation Council for control action.

[3]If these levels are exceeded, determination of the nature of the radionuclides present will be necessary before deciding on the safety of the water. (The 1970 & 1971 WHO Standards specify procedures for radioanalysis.) These figures include both naturally occurring radioactivity and that from effluents and fall out.

Table B-4 Current and Historical Radiological Standards (Continued)

[4] in drinking water for lifetime use for large populations.

[5] applicable to the mean of all the activity measurements during a 3-month period.

[6] If exceeded, the State and the public must be notified.

[a] In the 1962 USPHS Standards absence is specified to mean a negligibly small fraction of the specific limits, where the limit for unidentified alpha emitters is taken as the listed limit for Radium-226.

[b] If detected at levels ≤1000 pCi/l the appropriate authorities should be consulted.

[c] Average annual concentration assumed to produce a total body or organ dose of 4 mrem/year.

Table B-5 -- DRINKING WATER STANDARDS Comparison

CHEMICAL, PHYSICAL AND RADIOLOGICAL STANDARDS	WHO Recommended Standards (International Std. 1971 Edition)	European Standards 1970 Edition	Japan (1968)	India (1973)	India Recommended (1973)	Yugoslavia (Temporary 1971)	USSR 1973 (Last Rev. 1971-72)	Israel (1974)	Germany (1973)	Poland	Sweden (1969)	Bulgaria (updated in Romanian Summary)	USA 1973 Interim (2) USA 1962 (1)	Switzerland	Canada	Korea	Australia - Criteria	Quebec	Philippines (1963)	France
Radioactivity. α activity β activity	3 pCi/l 30 pCi/l	3-10 pCi/l 30-100 pCi/l		10.9 10.8	3 pCi/l 30 pCi/l		$.2\times10^{-9}$ μg/l 1×10^{-10} c/l	3 pCi/l					3 pCi/l 10 pCi/l				3 pCi/l 30 pCi/l			
pH	6.5-9.2		5.8-8.6	6.5-9.2	6.5-9.2	6.5-9.2	6.5-8.5	6.5-9.5		6.5-9.0	6.0-8.0	6.5-8.5		6.5-8.5	6.5-8.3		6.5-6.9		6.5-9.2	
Total Hardness (meq/l) 1 meq/l = 50 mg/l as $CaCO_3$	2-10	2-10	6	12	12	12	10			7		9		6	10	6	10			6
Chlorides (as Cl)	600 mg/l	600	200	1000	1000	800	300	600		215	25/250	250	250(2)	330	250	150	600	250	600	250
Depending on temperature, Fluoride (as F)	0.6-1.7 mg/l	0.7-1.7	0.8	2.0	1.5	8.0	0.7-1.5	1.4-1.7	1.5	1.0	1.5	0.7-1.0	1.4-2.4(1)	1-1.5	1.2-1.4	1.0	1.5	1.6	1-1.5	1.0
Nitrate (as NO_3)	45 mg/l	100	45	50	45	100	45	90	90		30	30	45(1)	45	45	45	45		50	44
Copper (as Cu)	1.5 mg/l	.05-3 for new pipe	1.0	3.0	1.5	3.0	1.0	1.4		1.0	1.0	0.2	1.0(1)	1.0	1.0	1.0	0.3	0.3	1.5	1.0
Iron (as Fe)	1 mg/l	0.3	0.3	1.0	1.0	1.0	0.3	1.0		0.3	0.2	0.2	0.3(2)	0.5	0.3	0.3	0.3	0.3	1.0	0.2
Manganese (as Mn)	0.5 mg/l	0.05	0.3	0.5	0.5	0.5	0.1			0.1	0.05	0.1	0.05(2)	0.3	0.05	0.3	0.1	0.3	0.5	0.1
Zinc (as Zn)	15 mg/l	5.0	1.0	15.0	15.0		5.0	15.0	2.0	5.0	5.0	3.0	5.0(2)	15.0	5.0	1.0	5.0	15.0	15.0	
Magnesium (as Mg)	150 mg/l	30 or up to 125 if 250 mg/l HCO_3		150	150			150				50		125	150		150	125	150	125
Sulfate (as SO_4)	400 mg/l	250		400	400	600	500	400	240	150	25/250	250	Being studied	250	500	800	250	250	400	250
Phenolic compounds (as phenol) (mg/l)		.001	.305	.002	.002	.002		.002		17.0		.001		.001	.002	.005	.001	.001	.001	0
Color (platinum-cobalt scale)	50 units		5°			50	20	50	20		10	15		20	15	2	15	20		
Turbidity (T.u.)	25 T.u.		2°			30 T.u.	1.5 mg/l	25 T.u.	3 mg/l silica scale			30 T.u.	1-5 T.u.(1)	5	5	2	5	5		
Taste	Should be unobjectionable		not to be abnormal			not objectionable	2 units	not objectionable						not objectionable	not objectionable	none	not objectionable			
Odor	"		"			"	"	"	3°			2		"	4 T.O.N.	none	"			
Arsenic (as As)	.05 mg/l	0.05	0.05	0.2	0.05	0.05	0.05	0.05	0.04	0.05	.01/.05	0.05	0.05(1)	0.05	0.05	0.05	0.05		0.2	0.05
Cadmium (as Cd)	.01 mg/l	0.01	0.01		0.01	0.05		0.01	0.005		0.01	0.05	0.01(1)		0.01		0.05		0.01	
Cyanide (as Cn)	.05 mg/l	0.05	0	0.01	0.05	0.20		0.05	0.05		.01/.2	0.01	0.01(2)	0.2	0.2		0.2		0.01	
Lead (as Pb)	0.1 mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.04	0.1	.02/.05	0.10	0.05(1)	0.05	0.05	0.1	0.05	0.1	0.1	0.1
Mercury (as Hg)	001 mg/l		0		.001			0.01	.004		.001/.005		.002(1)				.002			
Selenium (as Se)	.01 mg/l	0.01		0.05	0.01	0.05	.002	0.01	.008		.01/.05	0.05	0.01(1)	0.01	0.01		0.01		0.05	0.05
Polycyclic aromatic hydrocarbons	.0002 mg/l	.0002			.0002				.00025											
Chromium	0.05 mg/l	0.05	0.05	0.05	0.05	0.05		0.05	0.05		0.02	0.05	0.05(1)	0.05	0.05	0.05	0.05	0.05	0.05	
Beryllium Molybdenum Strontium Boron (mg/l)							.0002 .5 2.0	1							1		1		1	

Table B-5 (cont.) -- DRINKING WATER STANDARDS

Comparison

BACTERIOLOGICAL STANDARDS	Total plate count	Coliforms
WHO Recommended Standards (International, 3rd Edition)		1. Water entering distribution system: Chlorinated or otherwise disinfected supplies - 0/100 ml; non-disinfected supplies E. coli 0/100 ml; coliform 3/100 ml occasionally. 2. Water in distribution system: 95% of samples in a year - 0/100 ml coliform; E. coli - 0/100 in all samples; no sample greater than 10 coliform/100 ml; coliform not detectable in 100 ml of any two successive samples. 3. Individual or small community supplies: less than 10/100 ml coliform; 0/100 ml E. coli in repeated samples.
European Standards 1970 Edition		E. coli - 0/100 ml Coliform - 95% of samples - 0/100 ml. No sample to exceed 10/100 ml. No successive samples to be positive
Japan (1966)	100	Coliform - not to be detected
India (1973)		Coliform - 0-1.0/100 ml permissive 10-100/100 ml excessive but tolerated in absence of alternative, better source 8-10/100 ml acceptable only if not in successive samples 10% of monthly samples can exceed 1/100 ml
India Recommended (1975)		E. coli - 0/100 ml Coliform - 10/100 ml in any sample, but not detectable in 100 ml of any two consecutive samples or more than 50% of samples collected for the year.
Tanzania (Temporary 1974)		Non-chlorinated piped supplies: 0/100 ml coliform - classified as excellent; 1-3/100 ml coliform - classified as satisfactory; 4-10/100 ml coliform - classified as suspicious; 10/100 ml coliform - classified as unsatisfactory; one or more E. coli/100 ml classified as unsatisfactory. Other supplies: WHO Standards to be aimed at.
USSR 1973 (Gost 2874-73)	100/ml	Coliform not more than 3/litre on membrane filters Coli litre with enriched media not less than 300
Israel (1974)	1000/ml	Faecal coli - 0/100 ml Coliform - not more than 2/100 ml
Germany (1975)		
Poland	25/ml	For systems serving at least 50,000 people - coli titre not lower than 100 (coli index 10/l) For systems serving less than 50,000 people - coli titre not lower than 50 (coli index 20/l)
Sweden (1969)		
Bulgaria (quoted in Tanzanian summary)		
USA 1975 Interim (1) USA 1962 (2)		Coliform shall not be present in (a) more than 60% of the portions in any month; (b) five portions in more than one sample when less than five are examined/month; or (c) five portions in more than 20% of the samples when five or more samples examined/month.
Thailand	500/ml	Coliform - 2.2/100 ml E. coli - 0/100 ml
Canada		Coliforms - Acceptable - at least 85% of the samples in any 30-day period to be negative. None of samples positive should have MPN greater than 4/100 ml. Maximum permissible - at least 90% of samples in any 30-day period to be negative. None of the positive samples should have MPN greater than 10/100 ml.
Korea		
Australia - Criteria		Coliforms - 0/100 ml in at least 95% of samples for the year. No sample to contain more than 10/100 ml. Coliforms not to be detected in any two consecutive 100 ml samples. Faecal coliforms - 0/100 ml
Qatar		Coliforms 0/100 ml if present in two successive 100 ml samples, gives grounds for rejection of supply.
Philippines (1963)		Coliforms - Not more than 10% of 10 ml portions examined shall be positive in any month. Three or more positive 10 ml portions shall not be allowed in two consecutive samples; in more than one sample per month when less than 20 samples examined; or in more than 5% of the samples when 20 are examined per month.
France		E. coli - 0/100 ml Strep. faecalis - 0/50 ml

Compiled by Harold E. Shipman, Consultant to the World Bank Water Supply Staff Training Course 1977

U.S. Environmental Protection Agency Regulations - 1975

World Health Organization Standards

International

1958

1963

1971

(a) The presence of barium, beryllium, cobalt, molybdenum, nitroloacetate, thiocyanate, tin, uranium, and vanadium in drinking water should be controlled.

(b) Care should be taken to ensure that chemicals, especially new chemicals, used in water treatment do not entail a toxicity hazard.

(c) Attention should be paid to the possible presence of pesticide residues in water supplies.

European

1961

Attention should be paid to the concentration of synthetic detergents in piped supplies of drinking water.

1970

(a) The presence of mercury, tin, vanadium, beryllium, molybdenum, silver, uranium, and thiocyanate in drinking water should be controlled.

(b) See item (b) under 1971 International Standards above.

(c) See item (c) under 1971 International Standards above.

Fluoride Standards

The recommended control limits for fluoride in the 1962 USPHS, 1975 USEPA, 1970 European, and 1971 International Standards vary with the average maximum temperature in the area. All the fluoride standards are based on those recommended in the 1962 USPHS Standards. These are presented in (the table below).

Annual average of maximum daily air temperatures[a]		Recommended control limits Fluoride concentrations in mg/l		
Degrees Celsius	Degrees Fahrenheit	Lower	Optimum	Upper
10.0-12.0[b]	50.0-53.7[b]	0.9	1.2	1.7
12.1-14.6	53.8-58.3	0.8	1.1	1.5
14.7-17.6	58.4-63.8	0.8	1.0	1.3
17.7-21.4	63.9-70.6	0.8	0.9	1.2
21.5-26.2	70.7-79.2	0.7	0.8	1.0
26.3-32.5	79.3-90.5	0.6	0.7	0.8

[a]All except the 1975 EPA Regulations specify that this should be based on temperature data obtained over a minimum of 5 years.

[b]No lower limit in this temperature range in the 1975 EPA Regulations.

The 1962 USPHS Standards state that the presence of fluoride in average concentrations greater than two times the optimum values in the above table constitute grounds for the rejection of the supply.

The 1975 EPA Regulations only specify maximum permissible levels for fluoride, these are also two times the optimum values in the above table.

The 1970 European and 1971 International Standards only specify the lower and upper control limits in the above table.

Frequency of Physical and Chemical Examination

U.S. Treasury Department Standards - 1914

-none-

U.S. Public Health Service Standards

1925

Ordinarily, sample evidence that the water is acceptable in appearance, taste and odor will be sufficient; and detailed analysis will be required only when there is some presumption of unfitness by reason of physical or chemical characteristics.

1943

(a) Ordinarily, analytical evidence that the water satisfies the physical standards (see Table 1), and the standards for lead, fluoride, arsenic and selenium (see Table 1); and simpel evidence that it is acceptable for taste and odor will be sufficient.

(b) Ordinarily, analysis for these substances need be made only semi-annually, unless there is some presumption of unfitness because of these elements, in which case examinations for these should be more frequent.

1946

(a) Same as item (a) above with the addition of hexavalent chromium to the list of chemicals.

(b) See item (b) above.

(c) In cases where such substances are not likely to be present in the water supplies, semi-annual examinations may be unnecessary.

1962

The frequency and manner of sampling shall be determined by the Reporting Agency and the Certifying Authority.

Normally, samples from representative points in the distribution system should be examined for physical characteristics (see Table 1) one or more times a week.

Normally, analysis for chemical substances (see Table 1) need be made only semiannually unless there is some presumption of unfitness because of the presence of undesirable substances, in which case determinations for the substance should be more frequent, and an exhaustive sanitary survey should be made to determine the source of pollution.

Where the concentration of a substance is not expected to increase in processing and distribution, compliance of the source water with the standards may be sufficient.

In cases where certain substances are likely to be consistently absent from a water supply, or below levels of concern, semiannual examination for these may be omitted.

U.S. Environmental Protection Agency Regulations - 1975

Turbidity:

Samples from representative entry points to the distribution system shall be analyzed for turbidity at least once a day.

(A) Sampling and analysis for inorganic chemicals:

Community water systems using surface water sources - at yearly intervals
Community water systems using only ground water sources - at three-year intervals.
Non-community water systems (for nitrate only*) - frequency determined by State.

(B) Sampling and analysis for organic chemicals:

Community water systems using surface water sources - frequency determined by State in no event less than at three-year intervals.
Community water systems using only ground water sources - frequency determined by State.

In addition, there are requirements for record maintenance and routine reports to the State of the results of analyses. Specific requirements regarding resampling and notification of the public and State, in the event that a maximum contaminant level is exceeded, are also laid down. These have been omitted here to maintain brevity.

Table B-6 -- W.H.O. Standards: Frequency of Chemical and Physical Examination

Type	Minimum Frequency				
	International			European	
	1958	1963	1971	1961	1970
(1) Examination for toxic substances (see Table 1)	once every 3 months	once every 3 months	once every year	once every year	once every year
(2) Complete chemical examination:					
(a) if < 50,000 inhabitants served	once every 3 months	once every 3 months	once a year	once a year	once a year
(b) if = 50,000 inhabitants served	twice a year	twice a year	once a year	once a year	once a year
(3) Short chemical examination*:					
(a) if < 50,000 inhabitants served	-	-	once a month	once a month	once a month
(b) if = 50,000 inhabitants served	-	-	twice a year	twice a year	twice a year

All 5 sets of standards recommend:

a) The frequency of examinations for toxic substances should be increased when subtolerance levels are known to be present in the source of supply, or such potential pollution exists.

b) More frequent examination may be required for control of water treatment processes.

c) For new or proposed sources frequent examination for toxic substances and general chemical analysis will be required, depending on local conditions.

*examination for: appearance, color, odor, taste, temperature, methyl orange alkalinity, oxidizability, ammonia, nitrite, chloride, and free and total residual chlorine in chlorinated water.

Sampling Schedules for Radiological Examination

U.S. Public Health Service Standards - 1962[a]

The frequency of sampling and analysis for radioactivity shall be determined by the Reporting Agency and Certifying Authority after consideration of the likelihood of significant amounts being present.

Quarterly samples composited over a period of three months are recommended when concentrations of Ra^{226} or SR^{90} may vary considerably. Samples for determination of gross activity should be taken and analyzed more frequently.

U.S. Environmental Protection Agency Regulations - 1975

The regulations regarding monitoring frequency are extensive; some of the more important requirements are summarized below.

Monitoring frequency for gross alpha particle activity, radium-226 and radium-228:

At least once every 4 years following procedures prescribed in the Regulations. When ordered by the State, more frequent monitoring shall be conducted in the vicinity of operations which may contribute alpha particle radioactivity to either ground or surface water sources, or if other processes may increase the concentration of radioactivity in finished water.

Monitoring frequency for man-made radioactivity:

At least every 4 years for surface water, following procedures presented in the Regulations. At the discretion of the State, supplies using only ground water may be required to monitor man-made radioactivity. Source waters contaminated by effluent from nuclear facilities shall be monitored quarterly for gross beta particle and iodine-131 radioactivity, and annually for strontium-90 and tritium. Procedures for these are specified in the Regulations.

Specific requirements regarding resampling and notification of the public and the State, in the event that a maximum contaminant level is exceeded, are also laid down.

---

[a]USPHS Standards prior to 1962 do not mention radioactivity.

World Health Organization

A. International Standards

1958

Samples should be collected at consumers' taps, sources of supply, and relevant points throughout the system. Frequence of sampling is not mentioned.

1963

Samples from consumers' taps, sources of supply, and relevant points throughout the system should be collected and examined as frequently as possible.

Daily sampling is recommended for detection of gross beta concentration.

Samples should be collected daily, or less frequently if necessary, for the determination of Sr^{90} or Ra^{226} activity; these samples may be composited over a period no longer than three months before examination.

1971

The frequency of sampling and choice of methods used should take into account the fluctuation of observed activity levels of radionuclides in the water, the vicinity of major sources of radiopollution, and the risk of contamination.

Where it is suggested that tritium (^{3}H) from effluents or fall out may be present in the water, examinations for this radionuclide should be carried out.

B. European Standards

1961

Samples both from sources of supply and distribution system should be collected.

Recommended frequency of sampling is same as that for chemical examination.

1970

See 1971 International Standards.