

## Food Microscopy

### (An Annotated Bibliography)

#### PART IIG. MAJOR INGREDIENTS: WATER

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The microscopy of water includes such topics as the examination of natural and municipal water supplies, water conditioning and treatment problems, water in food products, ice crystals, boiler deposits and scale, and the effects of various waters on dental enamel.

Many textbooks on the microscopy of drinking water have been published over the years and helpful papers can be located through *Water Pollution Abstracts*. The microscopical examination of water supplies may involve the identification of particulate matter (inorganic and organic) or of animal and vegetable life, including bacteria. The optical microscope, in conjunction with membrane filters, has been much used in these studies, and increasing use of the electron microscope is apparent, particularly for bacteriological examination. Both instruments are widely used in the control and development of water treatment for re-cycling. Immobilised or bound water in foods has also been investigated by electron microscopy.

The nucleation and growth of ice crystals in water, aqueous solutions and biological systems, including food, have been extensively studied and the development of snow and frost crystals is also of interest in connection with frozen products and cold storage. The growth of scale in boilers and pipes is sometimes a problem in the food industry and many different inorganic salts of Ca, Mg, Pb, Si and Sr have been identified in these deposits by microscopy and x-ray diffraction. Extravagant claims have been made for magnetic water treatment in the prevention of boiler scale, but these have not been substantiated.

Several electron microscopical studies of human dental enamel have been reported, and the effect on enamel of sodium fluoride in water supplies have been investigated.

The following references provide an introduction to these various aspects of water microscopy.

#### References

1. Hassall, A. H., "A Microscopic Examination of the Water Supplied to the Inhabitants of London", Highley, London, 1850.
2. MacDonald, J. D., "A Guide to the Microscopical Examination of Drinking Water", Churchill, London, 1875.
3. Hirt, L., "Über die Principien und die Methoden der Mikroskopischen Untersuchung des Wassers", Z. Biol., 1879.

4. Rafter, W. G., "The Microscopical Examination of Potable Water", Van Nostrand, New York, 1888.
5. Mez, C., "Mikroskopische Wasseranalyse", Springer, Berlin, 1898.
6. Kenwood, H. R., "Public Health Laboratory Work (Chemistry)", Lewis, London, 1925.
7. Fair, G. M., and Whipple, M. C., "The Microscopy of Drinking Water", Wiley, New York, 4th Edition, 1927.
8. Hastings, A. B., "Biology of Water Supply", British Museum (Natural History). Economic Series, No. 7A, London, 1937.
9. Partridge, E. P., "Some Applications of the Polarising Microscope to Water Conditioning Problems", *Proc. Am. Soc. Testing Materials*, 1937, 37, Pt. II, 600.
10. Partridge, E. P., Scott, R. K., and Morrison, P. H., "Diagnosis of Water Problems at Limbo Station", *Am. Soc. Testing Materials*, Preprint 94, 1943, *Wat. Pollut. Abstr.*, 1943, 16, 955.
11. Tomlinson, T. G., "Animal Life in Percolating Filters: Identification of Flies, Worms and Some Other Common Organisms", DSIR Water Pollution Research, Tech. Paper No. 9, H.M.S.O., London, 1946.
12. De Bernard, W. W., and Baylis, J. R., "New Vistas in Water Quality Research", *Engng News Rec.*, 1948, 140, 639; *Wat. Pollut. Abstr.* 1949, 22, 711.
13. Thresh, J. C., Beale, J. F., and Suckling, E. V., "The Examination of Waters and Water Supplies", Blakiston, Philadelphia, 6th Edition, 1949.
14. Baylis, J. R., "Use of Electron Microscope in Water Treatment Control", *J. Am. Water Works Assoc.*, 1950, 42, 66; *Wat. Pollut. Abstr.*, 1950, 23, 809.
15. Scott, D. B., Picard, R. G., and Wyckoff, R. W. G., "Studies of the Action of Sodium Fluoride on Human Enamel by Electron Microscope and Electron Diffraction", *Pub. Hlth Rep. Wash.*, 1950, 65, 43; *Wat. Pollut. Abstr.*, 1950, 23, 1163.
16. Anon., "Water Supply Sanitation", *Engng News Rec.*, 1951, 146, 101; *Wat. Pollut. Abstr.*, 1951, 24, 1560.
17. Clegg, L. F. L., "Sampling and Bacteriological Testing of Water Supplies", *Lab. Practice*, 1952, 1, 162.
18. Nakaya, U., "Snow Crystals: Natural and Artificial", Harvard U.P., Oxford U.P., 1954.
19. Lackey, J. A., "Microscopic Examination in Determination of Water Quality", Paper, Am. Public Health Assoc., 83rd Annual Meeting, Nov. 1955.
20. Little, K., "Electron Microscope Studies on Teeth", *J. Dental Res.*, 1955, 34, 778.
21. Vaughan, J. C., and Scarce, L., "The Identification of Lactose Presumptive Organisms in the Chicago Water Supply", *Pure Water*, 1955, 7, 5; *Wat. Pollut. Abstr.*, 1956, 29, 651.
22. Ware, G. C., "Bacteriological Examination of Polluted Water and Sewage Effluents", *Lab. Practice*, 1955, 4, 444.
23. Ministry of Health, "The Bacteriological Examination of Water Supplies", Report No. 71, H.M.S.O., London, 1956.
24. Wallis, T. E., "Calcium Carbonate in the Scale from Water", *J. R. micr. Soc.*, 1956, 76, 1.
25. Luyet, B. J., "An Analysis of the Notions of Cooling and of Freezing Velocity", *Biodynamica*, 1957, 7, 293.
26. Luyet, B., and Rapatz, G., "An Automatically Regulated Refrigeration System for Small Laboratory Equipment and a Microscope Cooling Stage", *Biodynamica*, 1957, 7, 337.
27. Rapatz, G., and Luyet, B., "Apparatus for Cinemicrography During Rapid Freezing", *Biodynamica*, 1957, 7, 346.
28. Wallis, T. E., "Analytical Microscopy", "Scale", Churchill, London, 1957, p. 130.
29. Little, K., "Electron Microscope Studies on Human Dental Enamel", *J. R. micr. Soc.*, 1958, 78, 58.
30. Taylor, E. W., "The Examination of Waters and Water Supplies", Churchill, London, 1958 (Revised 7th Edn. of Thresh, Beale and Suckling, Reference 14, above).
31. Vaughan, J. C., and Scarce, L., "The Electron Microscope as an Aid in Water Quality Research and Control", *Public Works*, 1958, 89, (12), 96; *Chem. Abstr.*, 1959, 53, 20635e.
32. Baylis, J. R., and Scarce, L., "Public Health Hazards of Microbial Pollution of Water", No. 6. Electron Microscope Method. Proc. Rudolf's Research Conf. Rutgers State Univ. June, 1961, 285-351; *Wat. Pollut. Abstr.*, 1962, 35, 1719.
33. Frank, R., "Electron Microscopy and Electron Diffraction of Dental Crystalline Fragments", Proc. Congr. European Org. Res. Fluorine Dental Caries Prevention, 4th Malmö, 134-142; *Chem. Abstr.*, 1961, 55, 27581h.
34. Pfefferkorn, G., and Vhal, J., "Electron Optical, Comparative Microscopic and X-ray Investigation of Oxide Layers Produced on Steam Boiler Tubes", *Korrosion*, 1961, 15, 55; *Chem. Abstr.*, 1963, 58, 8775.
35. Bentley, W. A., and Humphreys, W. J., "Snow Crystals", Dover Publications, New York; Constable, London, 1962.
36. Black, A. P., and Smith, A. L., "Determination of the Mobility of Colloidal Particles by Microelectrophoresis", *J. Am. Water Works Assoc.*, 1962, 54, 926.
37. Garnett, W. J., "Fresh Water Microscopy", Constable London, 1962.
38. Little, K., "The Matrix in Caries-Resistant Teeth", *J. R. micr. Soc.*, 1962, 82, 199.
39. Latham, J., "Symposium on Ice Crystals and Ice Nucleation", Berkeley, California, 1963; *Br. J. appl. Phys.*, 1963, 14, 825.

40. Mason, B. J., Bryant, G. W., and Van Den Heuvel, A. P., "The Growth Habits and Surface Structure of Ice Crystals", *Phil. Mag.*, **8**, 505.
41. Minenko, V. I., Romas'ko, S. D., and Bilyach, L. I., "The Control of Magnetic Water Treatment", *Teploenergetika*, 1963, **10**, (9) 48; *Chem. Abstr.*, 1964, **60**, 304e.
42. Hendey, N. I., "An Introductory Account of the Smaller Algae of British Coastal Waters", Part V, Bacillariophyceae (Diatoms), Ministry of Agriculture, Fisheries and Food, Fishery Investigations, Series IV, H.M.S.O., London, 1964.
43. Herlihy, E. P., "London Drinking Water", *J. Quekett Micr. Club.*, 1964, **29**, 303.
44. Hallet, J., "Nucleation and Growth of Ice Crystals", in Rey, L., "Advances in Freeze-Drying", Hermann, Paris, 1966, pp. 21-38.
45. Hoffman, R., and Gross, L., "Microstructures of Dental Enamel Observed with Differential Interference Reflected Light Microscope", *Nature*, 1966, **212**, 992.
46. Procter, N. A. A., and Taylor, G. H., "Microscopical Techniques for Studying Boiler Deposits", *J. R. micr. Soc.*, 1966, **85**, 283.
47. Walker, M. I., "The High-Speed Photomicrography of Fresh-Water Protozoa", *Phot. J.*, 1966, **106**, 333.
48. Schwartz, G. I., "Life in a Drop of Water", Doubleday, New York, 1968.
49. Hallett, J., "Nucleation and Growth of Ice Crystals in Water and Biological Systems", *Recent Adv. Food Sci.*, 1968, **4**, 23.
50. Ling, G. N., "Physical State of Water in Biological Systems", *Food Technol.*, 1968, **22**, 1254.
51. Luyet, B. J., "The Formation of Ice and Physical Behaviour of the Ice Phase in Aqueous Solutions and in Biological Systems", *Recent Adv. Food Sci.*, 1968, **4**, 53.
52. Eisenberg, D., and Kauzmann, W., "The Structure and Properties of Water", Oxford U.P., London, 1969.
53. Gomis, C. G., and Pascual, J. A., "Substances Transported by the Water of the River Ebro. Their Study by the Electron Microscope", *Agua Suppl.*, 1959, (5), 59; *Wat. Pollut. Abstr.*, 1970, **43**, 160.
54. Horne, R. A., "Marine Chemistry: The Structure of Water and the Chemistry of the Hydrosphere", Wiley, Chichester, 1969.
55. Jones, H. C., Roth, I. L., and Sanders, W. M., "Electron-microscopic Study of a Slime Layer", *J. Bact.*, 1969, **99**, 316; *Wat. Pollut. Abstr.*, 1970, **43**, 43.
56. Millipore, "Microbiological Analysis of Water", Application Report AR-81, 1969.
57. Fletcher, N. H., "The Chemical Physics of Ice", Cambridge Monographs on Physics, Cambridge U.P., New York, 1970.
58. Halden, W. S., "Water Treatment and Examination", A successor to "The Examination of Waters and Water Supplies", by Thresh, J. C., Beale, J. F., and Suckling, E. V. (Reference 14 above), Churchill, London, 1970.
59. APHA, AWWA, and WPCF, "Standard Methods for the Examination of Water and Waste Water", American Public Health Assoc. Washington, Thirteenth Edition, 1971.
60. Ciacco, L. L., (Ed.), "Water and Water Pollution Handbook", Dekker, New York, 4 volumes, 1971-73.
61. Cunningham, H. M., and Pontefract, R., "Asbestos Fibres in Beverages and Drinking Water", *Nature*, 1971, **232**, 332.
62. Minton, A. P., "Relations Between Crystal Structure, Molecular Electronic Polarizability and Refractive Properties of Ice I", *J. Phys. Chem.*, 1972, **76**, 886.
63. Cunningham, H. M., and Pontefract, R. D., "Asbestos Fibres in Beverages, Drinking Water and Tissues: Their Passage through the Intestinal Wall and Movement Through the Body", *J. Assoc. Off. Anal. Chem.*, 1973, **56**, 976; *Food RA Abstr.*, 1973, **26**, (4749).
64. Hobbs, P. V., "Ice Physics", Oxford U.P., London, 1975.
65. Powrie, W. D., and Tung, M. A., "Electron Microscopy in the Study of Immobilised Water", in Duckworth R. B. (Ed.), "Water Relations of Foods", Academic Press, London, 1975.
66. Biddle, P., and Miles, J. H., "Characterisation of Particulate Material in Very Pure Waters", *J. Microscopy*, 1976, **107**, 93.
67. Flickinger, J., and Stanbridge, J., "Identification of Fibrous Material in Two Public Water Supplies", *Environ. Sci. Technol.*, 1976, **10**, 102.
68. Murr, L. E., and Kloska, K., "The Detection and Analysis of Particles in Municipal Water Supplies by Transmission Electron Microscopy", *Wat. Res.*, 1976, **10**, (5), 469.
69. Werner, D. (Ed.), "The Biology of Diatoms", Botanical Monographs, vol. 13, Blackwell, Oxford, 1977.