# Environmental Health Criteria 17

# MANGANESE

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World Health Organization

IPCS INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

# ENVIRONMENTAL HEALTH CRITERIA 17

# MANGANESE

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NOTE TO READERS OF THE CRITERIA DOCUMENTS

While every effort has been made to present information in the criteria documents as accurately as possible without unduly delaying their publication, mistakes might have occurred and are likely to occur in the future. In the interest of all users of the environmental health criteria documents, readers are kindly requested to communicate any errors found to the Division of Environmental Health, World Health Organization, Geneva, Switzerland, in order that they may be included in corrigenda which will appear in subsequent volumes.

In addition, experts in any particular field dealt with in the criteria documents are kindly requested to make available to the WHO Secretariat any important published information that may have inadvertently been omitted and which may change the evaluation of health risks from exposure to the environmental agent under examination, so that the information may be considered in the event of updating and re-evaluation of the conclusions contained in the criteria documents.

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ENVIRONMENTAL HEALTH CRITERIA FOR MANGANESE

A WHO Task Group on Environmental Health Criteria for Manganese met in Geneva from 22 to 26 September 1975. Dr B. H. Dieterich, Director, Division of Environmental Health, opened the meeting on behalf of the Director-General. The Task Group reviewed and revised the second draft Of the criteria document and made an evaluation of the health risks from exposure to manganese and its compounds.

The first and second drafts of the criteria document were prepared by Dr P. S. Elias of the Department of Health and Social Security, London, England. The first draft was based on national reviews received from the national focal points for the WHO Environmental Health Criteria Programme in Bulgaria, Japan, New Zealand, the United Kingdom, the USA, and the USSR. The second draft was prepared according to comments received from national focal points in Canada, Chile, Czechoslovakia, Greece, Japan, Netherlands, New Zealand, Poland, Sweden, the USA, and the USSR; and from the Commission of the European Communities, the Food and Agriculture Organization of the United Nations, the Ethyl Corporation, the

International Union of Biological Sciences, the International Union of Pure and Applied Chemistry, the United Nations Economic Commission for Europe, and the World Meteorological Organization. Dr P. S. Elias and Dr I. C. Munro, Bureau of Chemical Safety, Department of National Health and Welfare, Ontario, Canada, assisted the Secretariat in the preparation of a third draft, which was distributed for comments to the Task Group members. Additional comments on this draft were received from Dr R. J. M. Horton, US Environmental Protection Agency, Research Triangle Park, USA, and Professor M. Piscator, the Karolinska Institute, Stockholm, Sweden. Following the recommendations made by a WHO Consultative Group on the application of environmental health criteria, Bilthoven, Netherlands, 2-5 May 1977, a final draft was prepared by Dr H. Nordman, Institute of Occupational Health, Helsinki, Finland, taking into consideration the comments of members of the Task Group and of Professor P. S. Papavasiliou, the New York Hospital Centre-Cornell Medical Center, New York, USA, and Professor M. Piscator.

The collaboration of these institutions, organizations, and individual experts is gratefully acknowledged. The Secretariat wishes to thank, in particular, Dr P. S. Elias, Dr. I. C. Munro, and Dr H. Nordman for their help in the various phases of preparation of the document.

This document is based on original publications listed in the reference section but much valuable information was also obtained from publications reviewing and evaluating the essentiality and toxicity of manganese, including those by Cotzias (1958, 1962), Stokinger (1962), Schroeder et al. (1966), Suzuki et al. (1973a, 1973b, 1973c), WHO (1973), WHO Working Group (1973), US Environmental Protection Agency (1975), International Agency for Cancer Research (1976), and Saric (1978). Owing to unforseen circumstances, it has not been possible to update the document beyond 1978.

Details of the WHO Environmental Health Criteria Programme, including some terms frequently used in the documents, can be found in the general introduction to the Environmental Health Criteria Programme published together with the environmental health criteria document on mercury (Environmental Health Criteria 1, Mercury, Geneva, World Health Organization, 1976) and now available as a reprint.

Financial support for the publication of this criteria document was kindly provided by the Department of Health and Human Services through a contract from the National Institute of Environmental Health Sciences, Research Triangle Park, North Carolina, USA -- a WHO Collaborating Centre for Environmental Health Sciences.

# 1. SUMMARY AND RECOMMENDATIONS FOR FURTHER STUDIES

## 1.1 Summary

### 1.1.1 Analytical methods

Numerous analytical methods are available for the quantitative determination of manganese in environmental media and biological samples. The method the most frequently used is atomic absorption spectroscopy, which appears to be sufficiently sensitive for most analytical purposes. The way in which biological and environmental samples are procured and stored, prior to analysis, has an important bearing on the accuracy and validity of the results. For example, in air sampling, it is important to ensure that respirable particulate matter is collected. In the collection of biological samples with a low manganese content, contamination may constitute a major difficulty.

### 1.1.2 Sources and pathways of exposure

Manganese is one of the more abundant elements in the earth's crust and is widely distributed in soils, sediments, rocks, water, and biological materials. The major sources of man-made environmental pollution by manganese arise in the manufacture of alloys, steel, and iron products. Other sources include mining operations, the production and use of fertilizers and fungicides, and the production of synthetic manganese oxide and dry-cell batteries. Organomanganese fuel additives, though only a minor source at present, could significantly increase exposure, if they come into widespread use. Average manganese concentrations[a] in soils range from about 500 to 900 mg/kg and concentrations in sea water range from 0.1 to 5 µg/litre. Surface waters may have a manganese content of 1-500 µg/litre, but in areas where high concentrations of manganese occur naturally, levels may be considerably higher. Average manganese levels in drinking water range from 5 to 25 µg/litre.

Manganese is present in all foodstuffs, usually at concentrations below 5 mg/kg. However, concentrations in certain cereals, nuts, and shellfish can be much higher, exceeding 30 mg/kg in some cases. Levels in finished tea leaves may amount to several hundred mg/kg.

Manganese has been found in measurable quantities in practically all air samples of suspended particulate matter. Annual average levels in ambient air in unpolluted urban and rural areas vary from 0.01 to 0.07 µg/m$^3$. However, in areas associated with the manganese industry,

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[a] Throughout the document, the term concentration refers to mass concentration, unless otherwise stated.

annual averages may be higher than 0.5 µg/m$^3$, and have occasionally exceeded 8 µg/m$^3$. About 80% of the manganese in suspended particulate matter is associated with particles having a mass median equivalent diameter (MMED)[b] of less than 5 µm, i.e., particles within the respirable range. This association with small particles favours the widespread airborne distribution of manganese.

### 1.1.3 Essentiality of manganese

Manganese is an essential trace element for both animals and man. It is necessary for the formation of connective tissue and bone, and for growth, carbohydrate and lipid metabolism, the embryonic development of the inner ear, and reproductive functions. Some