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Examination of Water for Pollution Control

A REFERENCE HANDBOOK

IN THREE VOLUMES

VOLUME 3
Biological, Bacteriological and Virological Examination

Edited by

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Cover: Biological sampling (photo WHO/M. Jacot). Colonies of faecal streptococci (courtesy of Karin Ormerod, Norwegian Institute of Water Research, Oslo); human adenovirus (courtesy of Robert W. Horne, John Innes Institute, Norwich, U.K.)

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PREFACE

The older industrialized countries experienced gross pollution of water, air and soil for many years before either the political will or the technical means existed for effective control. Nevertheless, in some of these countries, substantial steps were being taken to carry out improvements as early as the beginning of the century and in the field of water pollution, for example, many biological treatment plants still in operation were constructed over half a century ago.

Countries which have experienced rapid industrialization more recently have had more technical experience to draw on, but have often had to face pressures to maintain or improve the quality of the environment in a much shorter time.

During the last few years, there has been an increasing realization that water resources are limited and must be conserved, leading to the necessity for stringent quality control.

Many of the communicable diseases having the greatest impact on mankind are waterborne, and a permanent reduction in morbidity and mortality can most effectively be achieved by providing safe drinking-water and satisfactory sanitation. It is the ambitious target of the International Drinking-Water Supply and Sanitation Decade that such facilities will be available for all communities in the world by 1990. This programme fits well into the World Health Organization's increased emphasis on the preventative approach to health care. The investment will be largely wasted unless it embodies the development of systematic water quality surveillance.

In addition to the long-standing problem of microbiological pollution, the introduction to the environment of an increasing range of chemicals has led to the need for ever more complex technologies for surveillance and control.

Effective water quality management involves systematic programmes of sampling and analysis of rivers, lakes and groundwater and all stages of waste treatment. Proven and harmonized procedures must be adopted if results are to be reliable, reproducible and comparable.

The present Handbook has been developed by the WHO Regional Office for Europe with these objectives in mind. It has involved the active cooperation of many institutions and over 250 scientists in 31 countries, over a period of 10 years. It is primarily intended for routine use in relation to process control and surveillance programmes, but it is hoped that it will also be useful both for research and in training laboratories.

Many countries share common water resources and an increasing number of countries are now adopting similar systems of pollution monitoring and control, through various forms of international agreements. It has been the intention of all concerned in the development of the Handbook that its adoption should help such cooperation by facilitating the harmonization of sampling and analytical procedures throughout the world.

On behalf of WHO, I should like to thank all concerned in its production.

J. IAN WADDINGTON
Director, Promotion of Environmental Health,
WHO Regional Office for Europe

CONTENTS OF OTHER VOLUMES

NOTE ON TERMINOLOGY

WHO policy in respect of terminology is to follow the official recommendations of authoritative international bodies such as the International Union of Pure and Applied Chemistry (IUPAC) and the International Organization for Standardization (ISO). Every effort has been made in this publication to comply with such recommendations.

Nearly all international scientific bodies have now recommended the use of the SI units (*Système international d'Unités*) developed by the Conférence générale des Poids et Mesures (CGPM),[a] and the use of these units was endorsed by the Thirtieth World Health Assembly in 1977. In almost all cases, only SI units are used in this publication. However, the use of the curie (Ci) instead of the becquerel (Bq) has been retained in radiological texts (1 mCi = 37 MBq).

As the base unit "amount of substance", the CGPM has adopted the mole. As a result, the variable units "equivalent" and "normality" are inconsistent with the international system. Confronted with this problem, the 29th IUPAC General Assembly in 1977 officially abandoned the use of " equivalent " and " normality " and approved a new terminology to replace them. Subsequently a joint IUPAC–ISO *ad hoc* group made detailed recommendations for implementing this new terminology. A new physical quantity named " equivalent entity " has been defined, and since it is a physical quantity and not a unit, the fact that it may vary according to the particular reaction in which an acid, a base, or an oxidizing or reducing agent participates is of no consequence.

The unit in which equivalent entity is expressed is the mole, or an appropriate multiple or submultiple. Concentrations of acids, bases, and oxidizing or reducing agents are therefore expressed in $mol \cdot m^{-3}$ or an appropriate multiple or submultiple, such as $mol \cdot l^{-1}$ or $mmol \cdot l^{-1}$. These units replace " normality " as well as such units as $mEq \cdot l^{-1}$.

[a] An authoritative account of the SI system entitled "The SI for the Health Professions" has been prepared by the World Health Organization and is available, through booksellers, from WHO sales agents, or direct from Distribution and Sales Service, World Health Organization, 1211 Geneva 27, Switzerland.

EXAMPLES

1. Acid–base reaction

In the reaction

$$H_2SO_4 + 2NaOH = Na_2SO_4 + 2H_2O$$

$\frac{1}{2}$ mole of H_2SO_4 is equivalent to 1 mole of NaOH, i.e., the equivalent entities are ($\frac{1}{2}$ H_2SO_4) and (NaOH). The substance concentration of sulfuric acid is written as $c(\frac{1}{2}\ H_2SO_4)$, e.g. $c(\frac{1}{2}\ H_2SO_4) = 0.1\ \text{mol} \cdot l^{-1}$, instead of H_2SO_4, 0.1N solution.

2. Redox reaction

In the reaction

$$5FeSO_4 + KMnO_4 + 4H_2SO_4 = \tfrac{1}{2}K_2SO_4 + MnSO_4 + 5/2Fe_2(SO_4)_3 + 4H_2O$$

each reacting entity of ($5FeSO_4$) is equivalent to one of $KMnO_4$ at the equivalence point. Five electrons are transferred in the reaction:

$$MnO_4^- + 8H^+ + 5e^- = Mn^{2+} + 4H_2O$$

$$5Fe^{2+} = 5Fe^{3+} + 5e^-$$

and the equivalent entities of iron(II) sulfate and potassium permanganate are ($FeSO_4$) and (1/5 $KMnO_4$). The substance concentration of potassium permanganate is therefore written as $c(1/5\ KMn0_4)$, e.g. $c(1/5\ KMnO_4) = 0.1\ \text{mol} \cdot l^{-1}$, instead of $KMnO_4$, 0.1N solution.

It should also be noted that all substance concentrations are expressed in the form $\text{mol} \cdot l^{-1}$, $g \cdot l^{-1}$, $mg \cdot kg^{-1}$, etc., the denominator being always the litre or the kilogram. Such expressions as p.p.m., %(w/v), and g% are no longer in conformity with the recommendations of international scientific organizations.

It will be noted that when the new definition of equivalent entity as a quantity (rather than unit) is used, there is no change in the numerical values traditionally associated with the concept of " normality ".