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OPERATION AND CONTROL OF WATER TREATMENT PROCESSES

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PREFACE

The problem of supplying adequate amounts of safe water for distribution to the public does not end with the construction of waterworks. Many water-borne epidemics of disease have been traced to defects in the operating procedures used in water treatment plants, and it is self-evident that the level of operating skill and practice is of great public health significance. It is in recognition of the need for a practical and authoritative text or guide on water treatment which will encourage better plant operation that this monograph is published by WHO.

The text deals specifically with the operation and control of water treatment processes designed to produce water for domestic purposes; it does not deal with the treatment of water for industrial use.

Recognition is given to the limits of effectiveness of the various processes, which impose a restriction on the quality and character of raw waters capable of being treated in an effective, reliable and reasonably economical manner. Water treatment is the third aspect of the cycle comprising (a) sewage and waste treatment, (b) self-purification in streams and in ground waters, and (c) water treatment. Too much reliance cannot be placed on any one of these aspects of the cycle from sewage to potable water and then to waste water; therefore water-supply officials should work closely with water-pollution-control authorities, to the end that the natural water resources of concern to them are not polluted to such a degree that self-purification and water treatment processes cannot produce potable water in a reliable and economical manner.

This monograph brings together a body of recent information on water treatment and control for the benefit of officials, including public health officials, who are concerned with maintaining a suitable system of controls. Its primary purpose, however, is to serve the needs of plant superintendents, operators and laboratory personnel, and the style of presentation has been adapted to those groups. Sufficient theory is presented to provide a basic understanding of the processes described, but the main emphasis is on practical operating problems. Designers will find much of value to them, but the approach used has been not to present standards of design, but rather to reveal how to get the most from a plant already built.

In addition to sources and references given in the text, the author has made extensive use of his "Water Supply Control", "Guides to the Design of Water Treatment Plants" and "Water Analytical Procedures", which were prepared for limited use and are not suitable for general distribution.

A preliminary text was drafted by Mr Cox in 1961 and was issued as a mimeographed document. This text was circulated to 36 experts in different parts of the world for their comments and suggestions. The replies received have greatly assisted in amending and revising the original text. A list of reviewers will be found on page 379. WHO appreciates the contributions received from these reviewers and expresses its sincere thanks to them.

INTRODUCTION

Water treatment involves physical, chemical and biological changes that transform raw waters into potable waters. The treatment processes used in any specific instance must depend on the quality and nature of the raw water. Thus many well waters are of satisfactory physical and chemical quality and require treatment only by chlorination to protect against known or potential bacteriological pollution. At the other extreme are those mineralized raw waters subject to serious pollution by sewage and industrial wastes, which require all the resources of water treatment to yield an attractive water of safe sanitary quality.

The quality of raw water supplies is affected by a multiplicity of factors, and each source of supply must be evaluated on an individual basis. It is therefore essential that basic criteria for a water supply should be established before a purification scheme is developed; only then can a system be designed that will guarantee the safety of the users.

Water treatment processes may be simple in nature, like sedimentation, or may involve very complex physicochemical changes, as with coagulation. These complexities may be further obscured by factors not disclosed by water analysis. Thus the alum dose required to coagulate a given water having a certain turbidity, colour, pH and alkalinity differs from the alum dose required for another water having the same apparent qualities. Fortunately these difficulties can be minimized by the trial-and-error procedure of the " jar test ", in which the effective coagulant dose is determined by observing results secured in jars or beakers with graduated doses of alum. Even then the most effective dose with a litre of water under the conditions surrounding the jar test will differ from that most effective on a plant scale. Experience will disclose, however, the adjustments needed to translate the results of jar tests into plant practice.

Any review of laboratory manuals, such as *International Standards for Drinking-Water* (World Health Organization) or *Standard Methods for the Examination of Water and Waste Water* (American Public Health Association), will disclose the complexity of the laboratory procedures, their limitations and the extent of the facilities involved. Those who supervise plants frequently will not have such complete facilities, or the training and

experience necessary for their proper use; they must, perforce, use the more simple tests. These simplified tests are referred to in this monograph where specific processes are discussed, and the section on Laboratory Procedures describes each test for the guidance of those to whom only limited equipment is available. The selection of the simplified tests was based on the factors mentioned in the introduction to that section. It should be noted that other laboratory equipment may be used, following the specific directions for its use; but it would not be practicable in this monograph to describe all the different equipment and kits available in various countries. Specifically developed equipment of this nature often provides for convenient and simplified water analysis suitable for use in the field and for plant control.

It should be realized that the compromises involved in using simplified tests are intended to facilitate the laboratory control of water treatment plants and hence serve as tools of the operators. More technical and official control of the quality of water for public consumption should be provided by health departments having jurisdiction, as these agencies normally have the more elaborate facilities necessary, staffed by chemists, biologists and engineers. This independent appraisal of the quality of delivered water should not be interpreted as placing the operation and control of treatment plants necessarily under health departments; the basic responsibility rests with the water department.

Automation has been extended to water treatment equipment and is being improved. At first glance automation might seem to be the solution to problems of operation when trained personnel are not available. Unfortunately, automatic devices usually are costly and complex and hence cannot be maintained by unskilled personnel; furthermore, in many countries such devices must be imported. Therefore the only automatic devices discussed in this monograph are chemical feeders and chlorinators controlled by metering devices; float-operated switches; and rate controllers.

Many of the references are to practice in the USA. An effort has been made, however, to include practice followed in other countries, as, for example, in the text on filter-washing practice.

The objective of water treatment being the production of potable water, it follows that the measures of accomplishment are the numerical norms of physical, chemical and bacteriological quality of potable water. Reference is made to *International Standards of Drinking Water* (World Health Organization) for guidance as to water quality; see also Chapter 9.

Units of measurement are given in US and metric values (Annex 3 gives conversion factors). *Note that measurements in gallons refer to the US unit unless the UK gallon is specified.*