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pH in Drinking-water

Revised background document for development of
WHO *Guidelines for Drinking-water Quality*

Preface

One of the primary goals of WHO and its member states is that "all people, whatever their stage of development and their social and economic conditions, have the right to have access to an adequate supply of safe drinking water." A major WHO function to achieve such goals is the responsibility "to propose regulations, and to make recommendations with respect to international health matters ...."

The first WHO document dealing specifically with public drinking-water quality was published in 1958 as *International Standards for Drinking-water*. It was subsequently revised in 1963 and in 1971 under the same title. In 1984–1985, the first edition of the WHO *Guidelines for Drinking-water Quality* (GDWQ) was published in three volumes: Volume 1, Recommendations; Volume 2, Health criteria and other supporting information; and Volume 3, Surveillance and control of community supplies. Second editions of these volumes were published in 1993, 1996 and 1997, respectively. Addenda to Volumes 1 and 2 of the second edition were published on selected chemicals in 1998 and on microbial aspects in 2002. The third edition of the GDWQ was published in 2004 and the first addendum to the third edition was published in 2005. The second addendum to the third edition will be published in 2008.

The GDWQ are subject to a rolling revision process. Through this process, microbial, chemical and radiological aspects of drinking-water are subject to periodic review, and documentation related to aspects of protection and control of public drinking-water quality is accordingly prepared/updated.

Since the first edition of the GDWQ, WHO has published information on health criteria and other supporting information to the GDWQ, describing the approaches used in deriving guideline values and presenting critical reviews and evaluations of the effects on human health of the substances or contaminants examined in drinking-water. In the first and second editions, these constituted Volume 2 of the GDWQ. Since publication of the third edition, they comprise a series of free-standing monographs, including this one.

For each chemical contaminant or substance considered, a lead institution prepared a health criteria document evaluating the risks for human health from exposure to the particular chemical in drinking-water. Institutions from Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Poland, Sweden, United Kingdom and United States of America prepared the documents for the third edition and addenda.

Under the oversight of a group of coordinators, each of whom was responsible for a group of chemicals considered in the GDWQ, the draft health criteria documents were submitted to a number of scientific institutions and selected experts for peer review. Comments were taken into consideration by the coordinators and authors. The draft documents were also released to the public domain for comment and submitted for final evaluation by expert meetings.

During the preparation of background documents and at expert meetings, careful consideration was given to information available in previous risk assessments carried out by the International Programme on Chemical Safety, in its Environmental Health Criteria monographs and Concise International Chemical Assessment Documents, the International Agency for Research on Cancer, the Joint FAO/WHO Meetings on Pesticide Residues, and the Joint FAO/WHO Expert Committee on Food Additives (which evaluates contaminants such as lead, cadmium, nitrate and nitrite in addition to food additives).

Further up-to-date information on the GDWQ and the process of their development is available on the WHO Internet site and in the current edition of the GDWQ.

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The WHO coordinator was Dr J. Bartram, WHO Headquarters. Ms C. Vickers provided a liaison with the International Programme on Chemical Safety, WHO Headquarters. Mr Robert Bos, Public Health and Environment Programme, WHO Headquarters, provided input on pesticides added to drinking-water for public health purposes. Ms Penny Ward provided invaluable administrative support. Ms Marla Sheffer of Ottawa, Canada, was responsible for the scientific editing of the document.

Many individuals from various countries contributed to the development of the GDWQ. The efforts of all who contributed to the preparation of this document are greatly appreciated.

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1. GENERAL DESCRIPTION

The pH of a solution is the negative common logarithm of the hydrogen ion activity:

$$pH = -\log (H^+)$$

In dilute solutions, the hydrogen ion activity is approximately equal to the hydrogen ion concentration.

The pH of water is a measure of the acid–base equilibrium and, in most natural waters, is controlled by the carbon dioxide–bicarbonate–carbonate equilibrium system. An increased carbon dioxide concentration will therefore lower pH, whereas a decrease will cause it to rise. Temperature will also affect the equilibria and the pH. In pure water, a decrease in pH of about 0.45 occurs as the temperature is raised by 25 °C. In water with a buffering capacity imparted by bicarbonate, carbonate and hydroxyl ions, this temperature effect is modified (APHA, 1989). The pH of most drinking-water lies within the range 6.5–8.5. Natural waters can be of lower pH, as a result of, for example, acid rain or higher pH in limestone areas.

2. ANALYTICAL METHODS

The pH of an aqueous sample is usually measured electrometrically with a glass electrode. Temperature has a significant effect on pH measurement (ASTM, 1976; HMSO, 1978; APHA, 1989).

3. RELATIONSHIP WITH WATER QUALITY PARAMETERS

The pH is of importance in determining the corrosivity of water, but the relationship with a number of other parameters is complex. Natural waters contain gases, colloidal matter and a variety of electrolyte and non-electrolyte material, and these, together with pH, determine the extent of corrosion in a system. However, in general, the lower the pH, the higher the potential level of corrosion (Langelier, 1946; McClanahan & Mancy, 1974; Nordberg et al., 1985; Murrel, 1987; Stone et al., 1987; Webber et al., 1989).

4. *HEALTH EFFECTS OF pH*

The effects of acids and alkalis depend on the strength of the acid or alkali and the concentration. Strong concentrated acids or alkalis are corrosive, whereas dilute and weak acids and alkalis are not corrosive. pH alone is not the primary determinant of adverse effects, and in water, acids and alkalis are normally extremely dilute. The pH of stomach fluid, which contains hydrochloric acid, is between 1.0 and 3.5, with a mean of approximately 2.0, and there is a range of commonly encountered foods that are also of low pH. These include lemon juice, with a pH of 2.4, and vinegar, with a pH of 2.8. Because these are weak acids, they pose no threat to health from their consumption. A direct relationship between human health and the pH of drinking-water is impossible to ascertain, because pH is so closely associated with other aspects of water quality, and acids and alkalis are weak and usually very dilute. However, because pH can affect the degree of corrosion of metals as well as disinfection efficiency, any effect on health is likely to be indirect and due to increased ingestion of metals from plumbing and pipes or inadequate disinfection.

5. CONCLUSIONS

Although pH usually has no direct impact on water consumers, it is one of the most important operational water quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. For effective disinfection with chlorine, the pH should preferably be less than 8.0. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Failure to do so can result in the contamination of drinking-water and in adverse effects on its taste, odour and appearance.

The optimum pH will vary in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system, but is often in the range 6.5–9.5. Extreme pH values can result from accidental spills, treatment breakdowns and insufficiently cured cement mortar pipe linings.

It is not considered to be necessary to propose a health-based guideline value for pH.

6. REFERENCES

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