GENERAL REMARKS

In this fifty-second volume of *IARC Monographs*, evaluations are made of the evidence in relation to the carcinogenicity of chlorinated water supplies, of chemical by-products of the chlorination of drinking-water, of some other chemicals found in drinking-water and of cobalt and cobalt compounds. By-products of the chlorination process found in chlorinated drinking-water that have been evaluated previously in this series are listed in Table 1.

Table 1. Organic compounds formed during chlorination of drinking-water supplies that have been evaluated in the *IARC Monographs*

Compound	Year	Degree of evidence for carcinogenicity[a]		Overall evaluation of carcinogenicity to humans[a]
		Human	Animal	
Acetaldehyde	1987	I	S	2B
Chloroform	1987	I	S	2B
2,4-Dichlorophenol (see Chlorophenols)	1986	L	-	2B
Formaldehyde	1987	L	S	2A
2,4,6-Trichlorophenol	1987	L	S	2B
Pentachlorophenol	1990	I	S	2B

[a]I, inadequate evidence; S, sufficient evidence; L, limited evidence; ND, no data; see pp. 30-33 of the Preamble for definitions of these classifications.

Chlorinated drinking-water

The maintenance of an adequate supply of unpolluted water is a requirement for both human health and good environmental quality. Our demands upon the planet's water are great, and in some regions dangerously so. Water is taken for drinking, irrigation and industry and is returned as industrial discharge, agricultural run-off and microbiologically contaminated, treated or untreated sewage. Water quality varies according to these discharges, the seasons and the geology of an area. The most critical characteristic of water for human health is its microbiology.

The microbiological quality of water can be controlled effectively by disinfection methods, which normally involve the introduction of chemical oxidants to the water supply. Chemicals used on a substantial scale as disinfectants are chlorine, hypochlorite, chloramine, chlorine dioxide and ozone. Chlorination is almost universally accepted as the method of choice for purifying water supplies. It was first used on a continuous basis for this purpose at the beginning of the twentieth century. It is also used for sewage treatment in a few countries. Since some water suppliers have difficulty in maintaining acceptable water quality, particularly with regard to taste and odour, chlorine may be used in combination with ozone, chlorine dioxide, ammonia and activated charcoal. These treatments are sometimes followed by dechlorination, for example with sulfur dioxide.

There are substantial and irrefutable benefits of disinfection of water supplies by chlorination. Any major change to these programmes would need to be evaluated fully as to its costs and benefits with regard not only to the need to maintain microbiological safety but also to the possible long-term adverse effects of alternatives to chlorination. Nonetheless, it is now known that the interaction of chlorine with naturally occurring humic and fulvic acids in water supplies results in the formation of by-products such as trihalomethanes, halogenated acids and aldehydes, some of which are either known or suspected carcinogens. Other compounds that occur at much lower concentrations include substances that are mutagenic primarily in bacterial and in-vitro systems but have not been demonstrated to produce cancer in man or experimental animals.

The investigation of possible risks of cancer from consuming chlorinated drinking-water in human populations is difficult. There are a number of methodological obstacles. Chlorination may produce quite different profiles of chemical by-products in different areas. Characterization of a person's water consumption is complicated by the fact that in some parts of the world people change residence during life, and the nature of their domestic water source changes in consequence. Furthermore, people may consume water not only at home but also at work and in other places, and may drink unchlorinated water, bottled water, boiled water and other liquids, which will greatly influence their exposure to chlorination by-products. Exposure to constituents of water other than by ingestion—by inhalation or skin absorption—may also occur. Even if associations can be demonstrated between human cancer risk and exposure to residential chlorinated water supplies, they may be due to other constituents of the water that is chlorinated or to particular characteristics of the populations who live in areas served by chlorinated water supplies.

Evaluation of chlorinated water for carcinogenicity in experimental animals is similarly challenging. Indeed, few studies have yet been conducted in which the

effects, if any, of constituents of chlorinated water have been compared with those of constituents of water from the same supply collected before chlorination.

This volume includes monographs related to the chlorination rather than other methods of disinfection of water, because, firstly, chlorination is the most commonly used disinfection process, and, secondly, potentially carcinogenic by-products have been measured in chlorinated water (although not uniquely so, as they have also been identified in water disinfected by other methods).

Cobalt and cobalt compounds

Some explanation is necessary with regard to the inclusion of a monograph on cobalt and cobalt compounds in this volume. It was originally prepared for inclusion in Volume 49 of the *Monographs* (*Chromium, Nickel and Welding*); however, during the preparation of that meeting, it became clear that there would be insufficient time to consider this topic adequately. Consequently, it was decided to postpone the evaluation of cobalt and cobalt compounds until the earliest convenient *Monographs* meeting, which was the present one.

Cobalt has widespread and important uses, particularly in alloys with chromium, nickel and several other metals, and it is therefore a component of some industrial environments. Alloys that contain cobalt in combination with chromium, molybdenum, nickel, tungsten and other metals are commonly used in orthopaedic prostheses and in other implanted medical or dental devices. Since, on a worldwide basis, hundreds of thousands of patients receive such implants each year, concern has arisen about the potential carcinogenic hazards of wear particles and of cobalt and other metals that are gradually solubilized from the surface of implants.

Cobalt is a component of an essential micronutrient, vitamin B_{12} (cyanocobalamin), which is synthesized by certain microorganisms and ingested in the diet of humans and animals. Since the kinetics and metabolism of vitamin B_{12} are distinct from those of other cobalt compounds, however, it was decided not to consider vitamin B_{12} itself. Similarly, except for cobalt naphthenate, which is widely used industrially, other organic cobalt compounds have not been considered.