HEALTH EFFECTS OF CHEMICAL CONTAMINATION OF DRINKING WATER SUPPLIES

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Summary

Drinking water contains chemicals that are present naturally and as a consequence of contamination from agriculture, from industry and human habitation. Some chemicals arise as a consequence of drinking water treatment and some can be leached from materials that come into contact with drinking water, including distribution and storage within buildings. There is often a perception that many chemicals in drinking water will cause effects on health. However, while high concentrations of many chemicals can cause adverse health effects if individuals are exposed over a long period, there is little credible evidence that the low concentrations that are usually found in drinking water cause such effects. There is clear evidence that a small number of naturally occurring chemicals, particularly arsenic and fluoride, are a cause of human health effects. Nitrate, primarily from agriculture has been shown to cause methemoglobinemia or blue-baby syndrome in bottle-fed infants in the presence of microbial contaminants. The guidelines and standards for drinking water quality provide an important benchmark for controlling chemical contamination to ensure that health effects do not occur. The development of water safety plans helps to ensure that all hazards will be identified and the potential risks assessed and controlled.

1. Introduction

Safe and acceptable drinking water is an essential requirement for public health. While microbial contaminants are a major consideration, chemical contaminants can also be very important under some circumstances, e.g. arsenic, fluoride.

All water contains chemicals from natural sources but many waters also contain chemicals that are present as a consequence of human activity. These can arise from agricultural activity, from discharges from industrial establishments and as a consequence of the general use of a wide range of chemicals in industry or domestic settings. We as humans contribute significant amounts of chemicals into the environment because of our modern lifestyle and also because of the sheer density of population. Although there are potentially many chemicals that can occur in drinking water, they have to overcome a number of barriers so that they are usually only present in very small quantities and there is often uncertainty as to whether they constitute any risk to humans. There is always a danger that the misplaced perception that particular chemicals in drinking water are a significant risk to health, even when they are not, will result in resources being diverted from where they can have the biggest positive impact on public health to solving less important problems that are highlighted by the media and have raised public concern. It is, therefore, most important that proper evaluations are carried out and that the true impact on health is understood. That there are problems in some areas and under specific circumstances cannot be denied but it is important to recognize that such problems and threats do not apply to all drinking water. WHO considers that the greatest threat to drinking water is from pathogens but that chemicals may also be important. However, these need to be identified on a supply by supply basis under the hazard identification, risk assessment and risk management approach called water safety plans (WSPs).

As analytical techniques have developed and as our understanding of water contamination has increased, more and more substances have been detected at lower and lower concentrations, commonly referred to as micropollutants. Now we can detect quite esoteric substances at concentrations of less than a nanogram per liter, or less than 1 one thousand millionth of a gram per liter. This can create considerable concern in the minds of consumers if taken out of context but it has the potential to be a very powerful source of knowledge that can help us to not only understand how and with what water can become contaminated but also help us to find better ways of protecting drinking water sources and treating drinking water. It is also a vital part of enabling us to determine the health risks of such chemicals and setting the priorities for dealing with them.

Much of the research and knowledge is directed at micropollutants found in developed countries but there is still a need to consider how chemicals impact on populations in developing countries where resources are often very limited and people may be at their most vulnerable. While microbiological quality is the first priority for such countries, particularly in rural areas, chemicals can also be extremely important. These mostly arise from natural sources and our knowledge of many naturally occurring chemicals is still relatively limited. Under such circumstances identifying what may be in the water source can frequently be very difficult due to lack of capability to analyze such waters. While the consequences of microbial contamination are quickly and fairly easily identified, chemical contamination is usually much more insidious with effects not seen

until the source has been in use for a considerable period, usually many years. In addition there are well established and robust methods for protecting drinking water from microbial contamination while removal of chemical contaminants is often much more difficult and requires greater effort. An additional issue for industrial, and some agricultural, contaminants is the problem of spills, particularly to surface water, but also sometimes to groundwater. This can lead to unusually high concentrations of contaminants in source waters that can be a threat to health even following short-term exposure. Some of these may not be present at sufficiently high concentrations to cause adverse health effects but they may impact on the acceptability of drinking water to consumers. Prevention and management of spills is a key part of the Water Safety Plan approach to assuring safe drinking water that has been introduced by WHO in the Guidelines for Dinking-water quality and encompassed in the IWA Bonn Charter. This approach, which is not just directed at chemicals, is discussed below.

A number of chemical contaminants and constituents can impact on the acceptability of water to consumers by adversely affecting taste, odor and color. Under such circumstances, consumer confidence in the supply may be damaged and this may be very difficult to re-establish. Even more important, taste, odor and discoloration or turbidity may lead to consumers turning away from microbiologically safe water supplies to sources that are more acceptable aesthetically but which are less safe. This may also apply to some sources with significant chemical contamination such as with arsenic, fluoride or nitrate.

WHO has considered a significant number of potential chemical contaminants and has developed guideline values while a number of countries have developed standards for additional substances. These guidelines and standards provide a sound basis for protecting public health and judging the potential risks of chemical contaminants for health.

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Biographical Sketches

John Fawell has a first degree in applied biology and has a Diploma in Toxicology of the Royal College of Pathologists. He has worked in research and consultancy in the water industry since 1979 when he joined the Water Research Centre (WRc) in the UK as toxicologist. He was involved in a wide range of research into drinking water contaminants and their significance for health. He became head of toxicology and led research programs on mutagenicity of drinking water concentrates and the significance of organic micropollutants in drinking water. He became one of the coordinators of the World Health Organisation Guidelines for Drinking Water Quality in 1988 and has remained one of the coordinating committee and closely involved in the evolution and development of the Guidelines. He eventually became chief scientist of the National Centre for Environmental Toxicology at WRc with an expanded research and advisory program, and finally chief scientist of WRc-NSF. He joined Warren Associates in 2000 to establish a new environment and health division and became an independent consultant in 2003, providing support to governments and the water industry on issues of drinking water quality, including policy. In this role he has carried out studies for regulators, water suppliers and industry on a range of topics including risk assessments of specific substances and reviews of contaminants such as pharmaceuticals and research on the potential health effects of disinfection by-products. He has also worked extensively on Water Safety Plans and their introduction.

Employment record

- 2003 to date Independent consultant
- 2000-2003 Environment Director Warren Associates (later FaberMaunsell)
- 1998-2000 Chief scientist WRc-NSF
- 1993-1998 Chief scientist National Centre for Environmental Toxicology, WRc
- 1980-1993 Head of toxicology WRc
- 1979-1980 Toxicologist Water Research Centre
- 1976-1979 Scientist in charge, pathology RHM Research
- 1970-1976 Contract toxicology research – quantitative pathology

Mrs. Hulsmann is an Environmental Engineer (MSc) specialized in drinking water supply and EU water legislation. As such, she has extensive experience with water quality studies and water quantity studies, as well as with design and operation of treatment plants for the production of potable water. Mrs. Hulsmann is an expert on national and international standards for the Quality of Water intended for human consumption. She has worked at university level, at water supply companies, at water research institutes and at private consulting companies. She worked in various countries, including Indonesia, Vietnam, Romania, United Kingdom and Belgium. She has obtained a Ph.D. in Mathematics and Sciences from the University of Amsterdam. Her most recent experience relevant to this project are two consecutive three year contracts providing technical and scientific support to DGENV of the European Commission, both during the preparation and adoption of the new Drinking Water Directive and currently the implementation in the new Member States, the organization of a European Seminar on the revision of the Drinking Water Directive and the Service Contract on the Standardised Reporting Directive, processing and interpretation of the three annual returns from the Member States. Through her international work she has connections with drinking water experts and regulators in all 25 Member States of the European Union as well as in other countries

both inside and outside Europe. Dr. Hulsmann is coordinator of the European Technology Platform on Water Supply and Sanitation WSSTP.

Employment record

- 2000 to date Principal Scientific Officer Kiwa Water Research
- 1992-2000 Senior Adviser Haskoning Consulting Engineers and Architects
- 1989-1991 Consulting EngineerSelf employed
- 1987-1989 Senior Adviser WRc Engineering U.K./contract research DoE
- 1982-1986 Senior Adviser Kiwa Consultancy and Research
- 1978-1982 Research Scientist University of Amsterdam
- 1976-1978 Junior Researcher Rotterdam Municipal Water Company