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Commentary

Health Research Needed to Resolve Scientific Issues Surrounding Drinking Water Disinfection

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Introduction

Disinfection of drinking water will most likely continue in the United States in order to prevent exposure to microbial pathogens that can cause infectious disease. However, the emergence of concerns over possible toxicological effects, including cancer, mutagenicity, cardiovascular disease, and reproductive effects, may require that we alter or change the disinfection techniques used in this country. Before we change these practices, we must assess the spectrum of possible health effects and determine the level of risk posed by exposure to chemicals in drinking water, including the disinfectants themselves and the disinfection by-products. This will require a continuing research program to develop the scientific data necessary to resolve these issues. In this paper, I will discuss the microbiological, chemical, toxicological, and epidemiological research that is needed to address these issues.

Microbiological Research

The concerns over the risks of infectious disease are not behind us. We must continue to develop methods to measure pathogens in our environment, particularly newly identified bacteria, viruses, and parasites. These methodologies then need to be applied to determine the occurrence of these pathogens in water supplies and their survival after disinfection, particularly with chloramine and ozone. A first step in this area may be to collect and analyze the data on microbial survival through the various combinations of treatment and disinfectant techniques used in the Jefferson Parish pilot plant or a similar facility. If the survival data are not adequate for various pathogens, the new data must be developed.

Knowing the occurrence and survival of microbial pathogens through various treatment regimens is only the first step in developing disinfection techniques to control infectious disease. We also need to define quantitatively the health significance of exposure to these pathogens through studies such as determination of minimum infective doses in either laboratory animal models or human volunteers.

There also should be a requirement to monitor the effectiveness of disinfection practices. Since it would be impractical to monitor each and every pathogen, research to develop a quantitative, health-related microbial indicator for drinking water should be undertaken. It may also be possible to approach this research problem using epidemiological techniques. A health-related indicator may be valuable to determine the required level of residual disinfectants to maintain the quality of water in the distribution system and to deal with the rising concerns over potential pathogen regrowth on point-of-use filtration devices.

Chemical Research

Substantial new research is needed to assess the long-term human health risk posed by drinking water disinfectants. In the area of chemistry, two major questions must be addressed. First, research to identify the major disinfection by-products should continue. Second, a methodology must be developed to produce representative concentrates from water samples. These concentrates would then be used in toxicological testing to assess the risk from exposure to complex mixtures.

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Toxicological Research

Once chemicals of concern have been identified in drinking water, toxicological testing must be performed to assess their human health risk. This area poses several important research problems. First, in the near-term, research should continue to develop dose-response data in order to supply the EPA regulatory offices with the data they need to develop Acceptable Daily Intakes (ADIs) and Recommended Maximum Contaminant Levels (RMCLs). These data should include all possible endpoints, i.e., not just cancer. In this area of research, questions about the proper protocols for conducting bioassays and how to determine whether the data obtained from these tests indicate a human health problem should be resolved. For example, data from several studies presented at this symposium suggest that the vehicle corn oil enhances the toxicity of many chlorinated compounds. The mechanism by which this enhancement takes place must be studied and understood. Without such an understanding, the applicability of data from bioassays using corn oil as the vehicle for risk assessment would have to be seriously questioned.

One of the most interesting research problems raised during this symposium is the relevance of short-term *in vitro* and *in vivo* mutagenicity and carcinogenicity assays for risk assessment. Can tests, such as the Ames test and various *in vitro* cytogenetic assays, be used in risk assessment or are they limited to use as screening tools? To answer this question, we need to better understand the mechanisms that cause the observed effects in these assays and relate these mechanisms to mechanisms of disease in whole animals and humans.

Research is also needed (1) to determine how whole animal protective and repair mechanisms can be accounted for in *in vitro* bioassays, and (2) to validate the hypothesis on which the use of initiation and promotion assays is based. This may entail determining if various lesions and measures in these assays are predictive of the effects observed in whole animals and humans. Without answering these basic biological questions, it will be very difficult to define the possible health risks from exposure to complex mixtures in drinking water or even to identify the most toxicologically significant disinfection by-products.

All too often, cancer is the major concern associated with environmental pollution. Research must be conducted to investigate other toxicological endpoints, including reproductive effects, cardiovascular disease, renal toxicity, and effects on the endocrine system. In the area of reproductive effects, the haloacetonitriles studies should be followed up, and effects of trichloracetonitrile at doses lower than 15 mg/kg should be determined. This information is vital for setting reasonable drinking water standards for these compounds.

In the area of cardiovascular disease, the studies presented by Dr. Nathaniel Revis on atheriosclerotic plaque formation in pigeons should be repeated in order to verify the data. Human clinical studies will also be valuable to further define the risk of cardiovascular disease from disinfectants. Expanding clinical studies to include other disinfectants, other water contaminants, and additional health endpoints may be an appropriate route to follow in the future.

In the area of the renal and endocrine systems, research should continue to determine the potential effects and the level of risk from exposure to both the drinking water contaminants and the disinfectants themselves.

Consideration should also be given to studying toxic effects on the immune and nervous systems. These body systems are involved in detecting early exposures and potential effects on the body. They also trigger and direct the body's defense mechanisms. Studies in this area may lead to tools to detect and define environmental exposure to toxic substances and identify early signs of toxicity.

Epidemiological Research

Finally, there is a role for epidemiology in defining potential risks in drinking water disinfectants. The preliminary epidemiological studies linking drinking water disinfectants to bladder cancer and colon cancer, need to be confirmed. Results observed in human clinical and epidemiological studies may provide the best data for risk assessment and may serve to confirm the observations in animal studies.

Conclusion

As a result of the societal and political system we live under, the EPA Office of Drinking Water (ODW) must often request scientists to make regulatory recommendations and decisions with insufficient data. We as scientists must assist ODW in this effort and provide the leadership to determine how best to assess public health risks using the data that are available. We must also identify any deficiencies in both the data and the methodologies used to obtain the data, and we must conduct research to resolve these deficiencies. That, I think, is the most important charge for our future research efforts.