# Water, Cancer and Public Health

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## 1. Introduction

Whereas the access to unpolluted water is one of the requirements of human health, water is an excellent solvent and potentially a means for human exposure to a large number and variety of carcinogens.
Water quality is influenced by seasons, geology and discharges of agriculture and industry.
The major waterborne exposures are: disinfection (chlorination) by-products; nitrate; arsenic and other metals; chemicals from human commerce (including volatile organics and contaminated water from hazardous waste sites); asbestos; radio-nuclides; and fluoride.
Drinking water may contain a variety of potentially carcinogenic agents, including chlorination by-products (1), resulting from the interaction of chlorine with organic chemicals whose level determines the concentration of by-products. Moreover, drinking water may serve as a route of exposure for contaminants suspected or recognized as carcinogens in other exposure media such as asbestos and arsenic. Such contaminants may not be carcinogenic when ingested or may cause cancer in different organs than inhalation, requiring their evaluation specifically as waterborne agents.
Drinking water also may contain contaminants or unique mixtures to means such as disinfection by products.

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Whereas the evidence for an association between chlorination by-products and cancers in organs other than the bladder is inconclusive as some of them are considered possible human carcinogens because of evidence of carcinogenicity in experimental systems (2).

Among the many halogenated compounds that may be formed, trihalomethanes are those most commonly found. Trihalomethanes include chloroform, bromodichloromethane, chlorodibromomethane and bromoform. Brominated by-products are formed after the reaction of chlorinated by-products with bromide, which is present at low levels in drinking water.

Several other groups of pollutants of drinking water have been investigated as possible sources of cancer risk in human beings (3,4). They include organic compounds derived from industrial, commercial and agricultural activities and in particular from waste sites, nitrites & nitrates, radionuclides and asbestos.

Most of the studies were based on ecological comparisons and did not provide a quantitative risk estimate.

Epidemiologic studies suggest that drinking water contaminants such as chlorination by-products, arsenic, and radionuclides are implicated in causing human cancer. Nitrate also may be carcinogenic, based on our knowledge of its mechanism. Microbiological contamination of water is controlled by disinfection methods based on oxidants like chlorine, hypochlorite, chloramine, chlorine dioxine and ozone.

Many drinking water contaminants are not amenable to toxicologic evaluation as carcinogens, either because suitable animal models are unavailable (e.g., arsenic) or because the contaminant occurs as a complex mixture with a chemical composition that varies temporarily and from place to place (e.g., disinfection by products).

The only source of information for quantitative risk assessment in these cases is epidemiologic data, occasionally with support from metabolic or biomarker studies. Populations exposed to certain water contaminants can be enormous with large attributable risks.

Presently, the EPA regulates more than 40 different contaminants that are known or suspected to cause cancer. These contaminants are called carcinogens and it is assumed that no concentration in drinking water is safe. However, the EPA must decide what level of risk is acceptable for regulation. Scientists, therefore, focus on the relationship between concentration in drinking water and the risk of causing a specified number of cancer cases in a specified population size during the course of a lifetime. For many carcinogens, the concentration causing no more than one cancer per million people is typically in the range of a few parts per billion.

The types and quantities of carcinogens present in drinking water at the point of consumption will differ depending on whether they result from contamination of the source water, arisen as a consequence of treatment processes, or enter as the water is conveyed to the user. Source-water contaminants of concern include arsenic, asbestos, radon, agricultural chemicals, and hazardous waste. Among these, the strongest evidence for a cancer risk involves arsenic, which is linked to liver, lung, bladder, and kidney cancers. The use of chlorine for water treatment to reduce the risk of infectious disease may account for a substantial portion of the cancer risk associated with drinking water. The by-products of chlorination are associated with increased risk of bladder and rectal cancer, possibly accounting for 5000 cases of bladder cancer and 8000 cases of rectal cancer per year in the United States. Fluoridation of water has received great scrutiny but appears to pose little or no cancer risk. Further research is needed to identify and quantify risks put forward by contaminants from drinking-water distribution pipes, linings, joints, and fixtures and by biologically active micro pollutants, such as microbial agents.

## 2. Water and cancer risks

Several other groups of pollutants of drinking water have been investigated as possible sources of cancer risk in human beings. They include organic compounds derived from industrial,

commercial and agricultural activities and in particular from waste sites, nitrites & nitrates, radio-nuclides and asbestos.
Most of the studies were based on ecological comparisons and did not provide a quantitative risk estimate. Several cancer sites were analysed in many studies and selective reporting of positive results, resulting in an over-estimate of the risk, is a possibility. An increased risk of stomach cancer has been repeatedly reported in areas with high nitrate levels in drinking water. Moreover, studies are available on the association between nitrate level in drinking water and risk of non-Hodgkin lymphoma in the USA. Weisenburger (5) found a higher rate of lymphoma in eastern counties of Nebraska with more than 20% of wells with nitrate levels exceeding the standard as compared to counties with less than 10% of such wells. In a case–control study in the same region, Ward et al (6) found an increased risk for high cumulative intake of nitrates in drinking water. A case–control study of bladder cancer reported an association with high nitrate level in drinking water (7).
Finally, two ecological studies from the USA reported an increased risk of leukaemia in adults among residents in areas with elevated levels of radium in drinking water (8,9). Another study reported a similar association between radon levels and childhood leukaemia (10).
One more focus concerns about the potential for micro pollutants to cause cancer: cancer risks may emerge from the micro pollutants and microbial contaminants that can enter our drinking water supply, involving compounds that mimic naturally occurring, biologically active molecules.
Biologically active micro pollutants or endocrine disrupters appear to have the ability to disturb normal intercellular communications. For example, evidence from wildlife biologists, toxicologists, endocrinologists, and epidemiologists demonstrate the potential for estrogenic effects of environmental contaminants amongst human beings (11,12).
Metabolites of DDT are estrogenic in vivo and have been associated with the development of breast cancer in epidemiologic studies (13,14). Nonyl-phenol, a common chemical surfactant, increases proliferation in breast tumor cell

cultures (15).

Because of the complex mixture of contaminants, examining cancer risks for each individual compound may not give a complete picture of cancer risks associated with drinking water. An alternative approach is to look at the geographic distribution of neoplasms that might be associated with drinking water. These include cancer of the gastrointestinal tract and bladder cancer (i.e., neoplasms of the mucosal epithelium).

Bacteria, parasites, and viruses appear sporadically in most water supplies. The possibility that currently unidentified pathogens in drinking water can cause cancer should not be overlooked.

Microbial contaminants also have carcinogenic potential. For example, Schistosoma haematobium is waterborne, although it is not transmitted by drinking water and has been linked to cancer of the urinary bladder (16).

Helicobacter pylori (H. pylori) is an example of a recently emerged pathogen that may be transmitted through water (17). Infection with H. pylori is widespread throughout the world and is strongly associated with gastroduodenal diseases, including chronic gastritis, peptic ulcers and duodenal ulcers and gastric cancer (18). Regarding the role of water in the transmission of this disease has been frequently reported in the Epidemiological Literature Association between the presence of Helicobacter in water and prevalence of H. pylori in the population (19, 20). There is a strong link between H. pylori infection and gastric cancer in many countries; nevertheless, there is a large variability in the incidence of gastric cancer and H. pylori serumprevalence seen among many Asian countries. For example, the prevalence of H. pylori infection is higher in India and Bangladesh but low gastric cancer rates have been reported. Factors that may influence the aetiology of gastric cancer include the genetic diversity of the infecting H. pylori strains and differences in the host genetic background in various ethnic groups. These factors, in addition to environmental factors, such as personal hygiene and dietary habits, reflect the multi- factorial aetiology of gastric cancer (21).

Recent studies have shown that drinking water bio-films may act as a reservoir for H. pylori which raises new concerns about the

role of bio-films as vectors for pathogens like Helicobacter pylori (22, 23).
Water pollution may pose cancer risks other than the direct, toxic effects of exposure to contaminated water. Causal links for the effects described below have not been clearly established but they are plausible and should be considered in evaluating cancer risks from drinking water.
In viewing the public health's importance of a sound epidemiologic database it is surprising to realize how limited is the body of well-conducted and informative human studies.
Epidemiologic evaluation of most drinking water contaminants is complicated by several factors. Biologic mechanisms of carcinogenic action for most contaminants are poorly understood.
Most chemically-induced cancer is preceded by decades of incubation or latency and the need to estimate contaminant levels in case-control studies can lead to misclassification of exposure that can decrease the strength of observed associations. These and other methodological problems are slowly giving the way to improvements in studies designed to increase the precision of relative risk estimates. Improvements include more accurate historical modelling of exposure as well as incorporation of biomarkers.

## 3. Water sanitation impact on public health

The public health impact of small risk elevations among large exposed populations can be substantial and toxicologic data may not be appropriate for quantitative risk assessment of complex mixtures or of chemicals with no acceptable animal models for carcinogenesis.
The weight of evidence suggests that chlorination by-products provoke substantial cancer risks that should be reduced. A growing body of evidence supports the possibility that arsenic in drinking water may also carry unacceptable cancer risks. The cancer risks from radon and asbestos in drinking water are less substantial but may require remediation where local conditions

dictate. The available evidence does not support assertions of cancer risks associated with fluoridation of drinking water.

For most other compounds existing in drinking water the most probable cancer risks are not clear. Hazardous waste and pesticides may contaminate waters locally and regionally, but the probability of cancer risk is difficult to quantify. Nitrates are more widespread contaminants and more closely linked to human cancer, but evidence is incomplete. Contamination during drinking-water distribution may pose cancer risks but the epidemiologic evidence is extremely limited. Less conventional cancer risk factors, such as biologically active micro pollutants and pathogens, introduce the possibility of risk at present only but may emerge as important carcinogens in the future.

Cancer-prevention strategies must focus on source-water purity. In particular, strong source-water protection efforts provide a barrier to emerging cancer risks that have not been identified or fully characterized.

Furthermore, failure to protect source water purity will necessitate more extensive water treatment and, in most cases, heavier chlorination. Drinking-water treatment technologies should be evaluated with extreme care and should be revaluated on a regular basis. The concept of continuous quality improvement should be fully integrated into drinking-water treatment and should include ongoing efforts to raise, evaluate, and implement new treatment technologies. More cost-effective methods for monitoring drinking-water quality need to be aggressively developed.

As it has been noticed, often in processes of water treatment aspects of the toxicological and eco -toxicological effects with phenomena of bioaccumulation, bio magnification in the medium and long term are neglected. Sanitation preventive measures require strong disinfection treatments in order to eliminate or reduce the pollution load due to pathogens that cause the so-called "primary pollution." The next step is the treatment with chemical disinfectants with a consequent "secondary pollution" due to the formation of by-products (DBP), responsible for health risks related to these products. The goal in water management is a balance between the infection and

toxicological risks which inevitably sees both public and environmental health experts seriously involved therein.

## 4. Conclusion

One of the primary objectives is to provide suitable information for the political community and administrative support for the management and control of health risks potentially produced by a given human activity. The criteria for an objective assessment of potential risks for health problems must be seen in a very broad range of terms. A higher level of health protection is obtained by considering the urban sanitation as a whole. The old logic of giving priority to pathogenetic and etiological aspects of urban hygiene rather than general ones, must be given up. It is given more attention to the disease rather than other aspects such as those involved in the onset of the disease; the different aspects should not be individually considered, but integrated with each other. It is necessary to overcome the old logic in which the formulation of appropriate criteria for quality healthcare should be based on a set of data provided with "safety factors" able to allow the extrapolation of experimental data at a level that can be considered adequately protective for the Environment and Public Health: drinking-water research should be a priority.

The relationship between human activities and ecosystem dynamics must be such to allow human being's life to continue, people to meet their needs so that changes made to ecosystems from human activities do not overstep the limit of the carrying capacity (24).

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