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What's in your Water can be Bad for your Health?

Robert Clegg, Akshay Sethi and Rajat Sethi*

California Health Sciences University, College of Pharmacy, Clovis, California, USA

Waterborne diseases are caused by pathogenic microorganisms and chemical pollutants that are often transmitted in contaminated fresh water. As a result, most Water Borne Disease Outbreaks (WBDOs) occur during bathing, washing, drinking and the preparation and consumption of food that has been contaminated [1]. Although the United States has historically had some of the safest drinking water in the world, waterborne contaminants are not always eliminated by treatment processes and still find their way into drinking water sources [2]. According to research presented at the International Conference on Emerging Infectious Diseases, hospitalizations for three of the most common pathogenic waterborne diseases alone – Legionnaires' disease, cryptosporidiosis, and giardiasis – cost the U.S. healthcare system upward of $539 million annually [3]. In the U.S primary responsibility for the detection and investigation of WBDOs falls on local, state and regional public health departments which, in turn, voluntarily report their findings to the U.S. Centers for Disease Control and Prevention (CDC). In a collaborative effort, the CDC and the U.S. Environmental Protection Agency (EPA) then monitor microbial- and chemical-specific WBDOs nationwide [2]. Under the Surface Water Treatment Rule of 1989, all public community and non-community water systems that use surface-water or groundwater sources must be filtered and maintain a disinfectant residual in their distribution system [4]. According to the CDC (1998), there must be two criteria present for a waterborne event to be defined as a WBDO: (a) two or more individual must experience a similar illness after ingesting or exposure to recreational water sources; and (b) epidemiological evidence links the probable illness to the source of water in question.

While several factors contribute to the risk of exposure to chemical-related waterborne disease, a number of published studies point toward climate as a primary culprit for such outbreaks. Since climate ultimately controls outside water temperature and the frequency and intensity of precipitation, the increased risk for pollutant-specific human disease is significantly affected by local conditions, such as regional water capacities and sewage treatment practices. Moreover, changes in volume and composition of runoff from watershed development and coastal urbanization may lead to chemical leaching which can result in drinking and recreational water contamination. Other climate-specific environmental changes, including excessive rainfall and flooding may also affect the distribution and concentration of chemical contaminants such as arsenic, fluoride and nitrates [5].

According to the American Chemistry Council (2003), between 1991 and 2000, 16% of the reported WBDOs in the U.S. resulted from chemical contaminants [2]. Oxygenates such as ethanol are synthetic chemicals added to gasoline to increase its octane level and reduce the emission of airborne pollutants such as carbon monoxide. Most oxygenates are comprised of either alcohol or ether and, while liquid at room temperature, they are readily soluble in water. Oxygenates that get into the soil as the result of gasoline spills, underground storage leaks or improper disposal are often carried into groundwater that is used as a drinking water source [6]. Acetaldehyde, which is often used as an intermediate in the synthesis of other chemicals, is a colorless, flammable liquid that is mixable in water. It is considered a Group B2 human carcinogen and may be formed from the breakdown of ethanol in the body [7]. While a majority of the harmful exposures to acetaldehyde result from inhalation of ambient air with harmful concentrations of the chemical, due to its water solubility, there remains the risk of waterborne exposures as well. Trimethyltin chloride (TMT) is a colorless to sand-like solid chemical that contains a strong, often unpleasant odor. Cited on the Hazardous Substance List by the EPA and U.S. Department of Transportation (DOT), TMT is used primarily to control bacteria, fungus and insects in the preservation of wood, leather, textiles and paint products. Harmful exposure to TMT often results from inhalation or dermal contact with the chemical, although it has also been widely detected in aqueous environments [8].

Research has linked waterborne chemical contaminants such as ethanol, acetaldehyde and TMT to cardiovascular abnormalities. For instance, Reimers et al. utilized zebra fish embryos to link ethanol or acetaldehyde exposure to developmental toxicity [9]. In the early stages of embryogenesis, a 45-hour exposure of waterborne ethanol concentration of 340 μM resulted in 50% mortality (LC_{50}). While exposure to both ethanol and acetaldehyde negatively impacted embryonic development, a number of reproducible endpoints, including axial malformations and blistering, otolith defects and pericardial edema were present. In another study, Chen et al., also utilized zebra fish embryos and exposed them to concentrations of TMT ranging from 8-96 hours post-fertilization (hpf) [10]. While the mortality rate in 50% of the embryos (LC_{50}) at 96 hpf occurred at TMT concentration levels at 8.2 μM and malformations in 50% (EC_{50}) was 2.8 μM, pericardial edema was the predominant response observed in the surviving embryos. In addition, non-invasive monitoring indicated that TMT exposure resulted in "distinct disarrangements in the vascular system". Further analysis using Ingenuity Pathway Analysis (IPA) found that TMT exposure in 459 transcripts revealed a nearly two-fold increase ($p<0.05$) in the number of physiological anomalies, including metabolic and cardiovascular disease.

Much of the statistical data derived from national surveillance systems fail to illustrate the true incidence of chemical-specific waterborne disease outbreaks [2]. Often, persons who experience illness from chemical contaminants do not seek immediate medical attention. Among those individuals who decide to seek treatment for their illness,

***Corresponding author:** Rajat Sethi, Chair of Pharmaceutical and Biomedical Sciences and Director of Research California Health Sciences University, College of Pharmacy, Clovis, California, USA, Tel: 559-272-8107; E-mail: rsethi@chsu.org

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medical professionals are required to report all diagnosed cases of waterborne disease to state health departments. The problem lies with the actual reporting of such cases to the CDC. Currently, reporting of waterborne disease cases by state health departments to the CDC is voluntary. Research shows that there are a number of reasons that explain the reasoning behind underreporting of waterborne chemical poisonings to the CDC. First, most chemical exposures of a waterborne nature often occur in private residences, thereby affecting a relatively small number of individuals. Such exposures, often the result of leaching of a specific chemical (e.g., copper) into a plumbing system, will not raise any red flags for public health officials. Second, it is difficult to link chemical exposure from drinking water illness because nonspecific symptoms cannot always be associated to a specific chemical. Third, mechanisms in the existing surveillance system to report WBDOs caused by chemical poisonings are not as advanced as those that result from infectious agents (CDC, 1998). Under existing reporting practices, unless diagnosed cases result in a large outbreak, the data specific to WBDOs will continue to be limited. Therefore, immediate efforts need to focus on improving not only the detection of potential chemical-specific WBDOs, but the sensitivity of existing surveillance activities and assessing the burden of water-related chemical exposures and their impact on public health.

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