

Drinking Water Contamination and Its Effects on Human Health

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BACKGROUND AND EXTENT OF PROBLEM:

Importance of Water to Human Health and Survival

Water is essential for survival.¹ It has been stated that our existence is “intimately connected with the quality of water available to us.”¹ According to F. Batmanghelidj, MD, author of “Your Body’s Many Cries for Water”, “25% of the human body is made up of solid matter while the remaining 75% is water.”¹ Therefore, if our bodies are not continuously supplied with water, our bodies become dehydrated and the vital organs will deteriorate until they are no longer viable for human life.¹

Water also acts as a purifier in our bodies. If enough water isn’t consumed, one is unable to properly flush out their kidneys and/or liver, and the colon is unable to expel bowels properly and completely thus keeping unhealthy toxins in the body.² The longer the waste remains in the body, the more time the body has to reabsorb the toxins back into the bloodstream.² As a result, the toxins are able to make its way through the human body causing poisoning and spreading infections.²

How Safe is Our Drinking Water?

“Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity.” -Kofi Annan, UN Secretary-General

According to medical experts, an individual needs to consume at least 2 liters of water daily for basic survival.³ “The health and livelihood of Americans depends on the availability of a safe drinking water supply.”⁴ Unfortunately, drinking water in the United States is susceptible to toxins. As the human population and development in modern technology increases, the risk for water contamination also increases.⁵ Examples of water contamination sources include animal and human waste, chemicals disposed of improperly, and landfills.⁵ If not treated for properly, drinking water can pose a severe health risk for humans.

TOXICOLOGY:

According to a report by Time Magazine, “over 4,000 chemicals have been found in our drinking water.”¹ Furthermore, approximately 18 billion pounds of pollutants and chemicals are released into the atmosphere, soil, and groundwater in the United States

¹ Routledge and Stewart (1998)

² Global Healing Center [GHC] (1998-2010)

³ de Kok, Guidotti, Kjellstrom & Yassi (2001)

⁴ Grantham, Hairston, & McFarland (2010)

⁵ Environmental Protection Agency [EPA]

every year.¹ Though the Environmental Protection Agency placed more than 60 safety standards for the drinking water supply, they report that about 50% of all municipal water supplies in the United States violate Federal health standards.¹ As a result, over 120 million people have been affected with numbers continuing to grow.¹

Pathogens

It is believed that many of the diseases associated with water contamination are caused by pathogens.³ Pathogens spread by water leading to the spread of diseases.³ Examples of pathogens are bacteria, viruses, and parasites.³ Pathogens are considered to be “communicable” because “they have the ability to spread from one person to another by way of contaminated water and/or other vectors.”³ The most common diseases spread through water are diarrheal diseases; examples include cholera, typhoid, paratyphoid, salmonella, giardiasis, and cryptosporidiosis.³

Many pathogens arise from animal and human feces and from insufficient water supply.³ Pathogen related diseases could also be spread by person-to-person contact, aerosols, and food intake.³ This causes the bacteria causing the disease to buildup over time causing an infected person to contaminate the water supply and therefore continuing the spread of disease.³ For example, a survey from 1999-2000 reported 39 disease outbreaks associated with drinking water, many of which were associated to public drinking water supplies.⁵ The largest recorded outbreak of waterborne disease in the United States dates back to 1993 in Milwaukee, Wisconsin—an outbreak of cryptosporidiosis infected more than 400,000 people and lead to at least 50 deaths.⁵

Pathogens are classified according to “the various aspects of the environment that human intervention can alter.”³ They include the following:

- **Waterborne Diseases:** Waterborne diseases “arise from the contamination of water by human and/or animal body excretions infected by pathogenic viruses or bacteria, which are directly transmitted when the water is consumed or used for food preparations.”³ Examples of waterborne diseases include cholera, typhoid, and cryptosporidiosis.³
- **Water-Privation Diseases:** Water-Privation diseases are “affected by the quantity of water.”³ The disease is spread through (infected) person-to-person contact or through contact with infected materials.³ Poor personal hygiene is a common factor leading to water-privation diseases.³
- **Water-Based Diseases:** In water-based diseases, “water provides the habitat for intermediate host organisms in which parasites are able to pass part of their life cycle and later their infective larval forms in water are passed on the humans.”³
- **Water-Related Diseases:** In water-related diseases, water provides a “home for insects.”³ Examples of these types of diseases include malaria, dengue and yellow fever.³
- **Water-Dispersed Infections:** In these types of infections, “pathogens are able to

proliferate in freshwater and enter the body through the respiratory tract.”⁵

Chemicals

Many of the water that we drink contain toxic chemicals.³ These chemical substances that are found in water is due to natural processes or human activities.³ Examples of the most common chemicals found in water include the following:

- **Arsenic:** Arsenic is a naturally occurring metal found in all lead, copper, and gold ores.³ The Environmental Protection Agency has set the “acceptable standard for arsenic at 10 parts per billion in tap water,” however many areas exceed this limit.² The International Academy for Research on Cancer (IARC) classifies arsenic as a Category I carcinogen.² Other health risks at high levels include vascular disease, liver disease, skin lesions, and neurological disorders.³
- **Fluoride:** Fluoride is a natural occurring chemical found in foods and water.³ Fluoride is an essential element due to its importance in bone and tooth structure and growth.³ However, at high levels, fluoride can be toxic.³
- **Chlorine:** Chlorine is often added to water in order to kill bacteria.² If consumed in high amounts, chlorine can be toxic and cause sufficient cell damage in the human body.²
- **Iodine:** Unlike some other chemicals, insufficient levels of iodine can cause lead to severe health problems such as the enlargement of the thyroid gland, mental retardation, and cretinism.³ “Water is one of the main sources of dietary intake of iodine.”³
- **Nitrates:** Pesticides, nitrogenous fertilizers, and manure are the common sources of the presence of nitrates in water.³ High levels of nitrate in water can lead to blood poisoning and eventually death.³

ENVIRONMENTAL HEALTH RISK ASSESSMENT:

“The quality of water should under no circumstances be degraded to the recommended level from a better level.” –The World Health Organization

Water is susceptible to various toxic pathogens and chemicals. Therefore, it is of extreme importance that the quality of water is tested through frequent monitoring.³

The quality of drinking water can be determined by its appearance, taste, and odor.³ Fecal organisms have been deemed as a popular organism to monitor in water because of its ability to be present in high numbers in the feces of humans and animals and because of its ability to be easily detected.³ E.Coli has been identified as a major indicator fecal organism present in drinking water.³ According to standards set by the World Health Organization, no drinking water should contain E.Coli in any 100 mL sample.³

Scientists are constantly researching how various contaminants affect drinking water and how these contaminants affect individuals.⁶ They continuously study how toxic substances affect a community in order to determine the relationship between “exposure to a contaminant and a health effect.”⁶ Through research and investigation, scientists are also able to determine at what level is a pathogen and chemical toxic or not.⁶ The “acceptable daily intake” (ADI) is used to estimate risk for those toxic chemicals in which little to no adverse effects on health are observed.³ The acceptable daily intake is “a safety net when exposed to certain toxic chemicals.”⁶ It should also be noted that carcinogens are unable to be calculated by the acceptable daily intake because they are “genotoxic chemicals, have no detectable threshold for consumption, and may be harmful at any level of exposure.”³ The acceptable daily value is calculated by:

$$\text{ADI} = \text{NOAEL or LOAEL/UF}^3$$

- **NOAEL** = no-observed-adverse-effect level³
- **LOAEL** = lowest-observed-adverse-effect level³
- **UF** = uncertainty factor³

Once the acceptable daily intake is calculated, the guideline value (GV) is determined:

$$\text{GV} = \text{ADI} * \text{BW} * \text{P/C}^3$$

- **BW** = body weight (60 kg for adults, 10 kg for children, 5 kg for infants)³
- **P** = fraction of the ADI allocated to drinking water³
- **C** = daily drinking water consumption (2L for adults, 1L for children, 0.75L for infants)³

IMPACT ON POPULATIONS:

Unfortunately, our drinking water is not as safe as we think. Drinking water is contaminated with toxic pathogens and chemicals; at last count over 4,000 chemicals have been found.¹ Sources of water contaminants include human and animal fecal wastes, improper disposal of chemicals, natural occurring floods and other disastrous events, and use of agricultural products such as pesticides and fertilizers.⁵

Water becomes contaminated when it comes in contact with these toxic pathogens and chemicals.⁵ The most common type of water contamination is through human and animal feces.⁷ Some countries, such as the United States have the means to safely dispose of these types of pathogens, however other countries, such as China and India are not able to properly dispose of the feces in a safe manner.⁷ As a result, the

⁶ Herman and Zaslow (1996)

⁷ National Resources Defense Council [NRDC] (1998)

feces enter the water supply and spread through the population through person-to-person contact.⁷ Infections caused by pathogens are diarrheal diseases such as E. coli, giardia and the typhoid fever.⁷ Some populations are more susceptible to water-contamination diseases more than other populations.⁵ For example, children and infants are vulnerable to pathogen related diseases because their immune systems are not fully developed and strong enough to fight off the toxic contaminants and the resulting infections.⁷ Statistics show that more than 2 million children die from diarrheal diseases each year with 90% of these children being under 5 years of age.⁷ Other populations that are prone to diarrheal diseases include cancer patients, HIV/AIDS patients, transplant patients, the elderly, and pregnant women (including their unborn child).⁷

Chemical toxins, pesticides, and fertilizers are also sources that contaminate drinking water. In underdeveloped countries, such as Bangladesh, India, China, Taiwan, and Nepal, people drink water from “arsenic-laced” wells on a daily basis.⁷ Examples of health risks that are caused by chemical contamination of drinking water include skin lesions, vascular and cardiac problems, and cancer of the bladder, lungs, or skin, liver and kidney damage, damage to the nervous system, suppression of the immune system, and birth defects.⁷

APPROACHES TO RESOLVE PROBLEM AND PROTECT HUMAN HEALTH:

In 1974, Congress passed the Safe Drinking Water Act (SDWA) in order to protect the public health by “regulating the nation’s public drinking water supply and protecting sources of drinking water.”⁵ Important concepts of the Safe Drinking Water Act are:

- “Authorizes EPA to set enforceable health standards for contaminants in drinking water.”⁵
- “Requires public notification of water systems violations and annual reports (Consumer Confidence Reports) to customers on contaminants found in their drinking water.”⁵
- “Establishes a federal-state partnership for regulation enforcement.”
- “Includes provisions specifically designed to protect underground sources of drinking water.”⁵
- “Requires disinfection of surface water supplies, except those with pristine, protected sources.”⁵
- “Establishes a multi-billion-dollar state revolving loan fund for water system upgrades.”⁵
- “Requires an assessment of the vulnerability of all drinking water sources to contamination.”⁵

Monitoring Drinking Water

The most effective way to protect the quality of drinking water is through consistent and constant monitoring of the drinking water supply.³ Before distributing water, it is important to verify that the quality of water meets the standards of safe drinking water.³ It is also important to ensure that there is sufficient supply of water to meet the demands of the population.³ Finally, it is important to know where the water is coming from before distribution.³ For example, if the water is coming from a well, one should verify the location and construction of the well; making sure that the well and its water is protected from surface drainage and flooding.³ It is also important to keep any source of drinking water isolated from human activities and garbage.³

Treating Drinking Water

Proper treatment and handling of drinking water is essential not only for the quality of water but also for human health.³ The type of treatment depends on several factors: the quality of the original source of water, the number of people to whom the water will be served, and the point of origin for the water.³

For drinking water that does not require much treatment or will be served to a small population (such as to individuals within the same household), water can be treated by water purification filters and disinfecting tablets.³ Water can also be boiled to remove pathogens—studies show that boiling water for one minute can remove most or all pathogenic contaminants.⁵ However, there have been warnings placed for boiling water containing lead and nitrate.⁵ Boiling water that contains lead and nitrate actually increases its concentration and therefore poses as a greater risk for infection and poisoning.⁵ It is important to keep in mind that boiling water cannot be used to remove chemical toxins.³ Boiling water can also be expensive, especially in places where fuel is limited and the population is high.³

In water distribution centers, 4 different methods are used to treat drinking water: flocculation, sedimentation, filtration, and disinfection:³

- **Flocculation:** The process of flocculation involves removing dirt and other particles that are suspended in the water.⁵ This is achieved by adding aluminum and iron salts to the water; these salts form sticky particles, which attract the particles to be removed.⁵
 - **Sedimentation:** Once the particles are removed by flocculation, they naturally settle out of the water.⁵
 - **Filtration:** Filtration is used to remove particles such as clays, organic matter and, chemicals, and precipitates out of the water.⁵ The process of filtration purifies the quality of drinking water and thus decreasing the chances of contamination.⁵
- Disinfection:** The process of disinfection is one of the most popular and

advanced treatment method of the 20th century.⁵ Disinfection occurs before water has a chance to enter the distribution center to ensure that the water is free from toxins.⁵ Effective and efficient sources of disinfectants include chlorine, chlorinates, and chlorine dioxides.⁵

According to researchers, not all organisms and contaminants found in drinking water are harmful as long as they do not exceed safety values established by the World Health Organization.³ Therefore, contaminants should be removed when absolutely necessary.⁵ It is important to keep in mind that removing contaminants is costly; the more toxins that need to be removed, the more expensive the cost will be.⁵ It is also important to remember that removing contaminants does not secure increased safety of human health.⁵

RESEARCH NEEDS:

Given that the most common source of drinking water contamination is due to pathogenic and chemical particles, it has been advised that scientists focus on counting the number of particles found in drinking water.⁸ Research has shown that counting particles can show changes in the quality of water which can allow scientists to identify when it is necessary to remove to particles and what particles pose the greatest threats to human health.⁸ Particle counting can also help scientists determine what removal and treatment methods are necessary in order to insure the safety of drinking water.⁸

CONCLUSION:

Water is the essence of basic survival. Without it, life on Earth would cease to exist. In order to ensure that human life continues to exist, we must work together and do our part to improve the quality of drinking water. Researchers must do their part in the laboratory to come up with treatment methods to improve the quality of drinking water. When the quality of drinking water is good, human health is also good.

⁸ Water Research Foundation (2000)

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