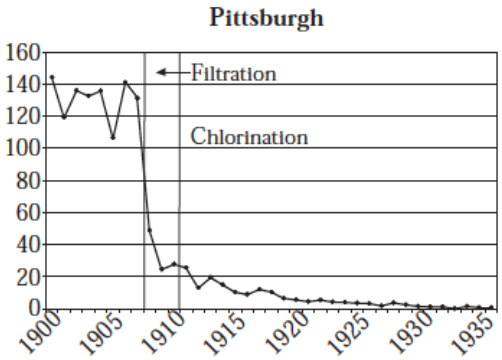
Hi Ann,

The question of whether or not drinking water is safe is difficult to answer and requires an understanding of risk. Whether or not an individual deems the water safe depends on the risk tolerance of the individual.

To put drinking water safety into a historical perspective, it is best to start with the benefits that drinking water treatment has provided to society. In the late 1800s and early 1900s, communities began to treat drinking water by filtration and chlorine disinfection. The public health benefits of drinking water filtration and disinfection cannot be understated. One of my favorite papers, published in 2005 by a research group from Harvard University estimated these public health benefits. Based on the Harvard analysis, the introduction of drinking water filtration and chlorination between 1900 and 1936 led to:

- Nearly 50% of total mortality reduction
- About 75% infant mortality reduction
- Nearly two thirds of child mortality reduction

Prior to the introduction of drinking water filtration and chlorination, the probability of dying in any given year from typhoid fever alone, ranged from about 300-1,400 per million people depending on the US city, in which people resided. Here is an example figure for the city of Pittsburgh:



Mortality from typhoid fever per 100,000 people on the y-axis, calendar year on the x-axis. Note: A value of 140 means that for every 100,000 people, 140 people died of typhoid fever; this is equivalent to 1,400 deaths per million people or an **annual** risk of 1,400 in a million). *Source:* Cutler, D. and Miller, G. The role of public health improvements in health advances: The twentieth-century United States. Demography, Volume 42-Number 1, February 2005: 1–22.

In 1974, with the advent of new, sensitive analytical measurement techniques, researchers showed that drinking water disinfection with chlorine produces disinfection by-products that are toxic. In the US, these disinfection by-products are regulated through the Safe Drinking Water Act. The first regulation covering disinfection by-products was passed by Congress in 1979, and the most recent update, the Stage 2 Disinfectants/Disinfection By-products Rule was promulgated in 2006. These rules, along with other surface water treatment rules, seek to balance microbial risk by stipulating how drinking water providers disinfect their water (i.e.

provide sufficient disinfection) with chemical risk by stipulating maximum contaminant levels for disinfection by-products. Example disinfection by-products are the trihalomethanes (regulated at 80 ppb) and the haloacetic acids (regulated at 60 ppb). The health risk associated with disinfection by-products is expressed by the excess **lifetime** cancer risk, which, for trihalomethanes, can be in the range of 10 in a million to 100 in a million. This balancing act between microbial and chemical risk management means that we cannot have water that has no risk associated with it.

In general, when the EPA sets maximum contaminant levels (i.e. drinking water standards) for contaminants that are likely human carcinogens, the levels are set such that the excess **lifetime** cancer risk is in the range of 1 in a million to 100 in a million. That is considered to be an acceptable risk. For 1,4-dioxane, which is an unregulated contaminant, the 1 in a million excess lifetime cancer risk is associated with a 1,4-dioxane concentration of 0.35 ppb. Thus, if 1,4-dioxane is at a level of 1.2 ppb in Wilmington drinking water, then the excess lifetime cancer risk is ~3 in a million. While some might argue that this is an acceptable risk level, it is in my opinion an unnecessary additional risk. Also, according to the NC stream water quality standard, the 1,4-dioxane concentration in a drinking water supply (before treatment) should be <0.35 ppb. That is why my research group has worked together with DEQ to characterize 1,4-dioxane concentrations in the Cape Fear River watershed and to identify the wastewater discharges that contribute to the elevated 1,4-dioxane concentrations in the Cape Fear River basin. Our goal is to reduce the quantity of 1,4-dioxane that is being discharged by industries into municipal sewer systems that are located in the headwater region of the Cape Fear River.

Because EPA has insufficient toxicity data on GenX and the other perfluoroalkyl ether carboxylic acids (PFECAs) we have found in the Cape Fear River and in Wilmington drinking water, excess lifetime cancer risk calculations cannot be made. However, EPA issued a lifetime health advisory level for two perfluoroalkyl acids, perfluorooctanoic acid (C8 or PFOA) and perfluorooctane sulfonate (PFOS) in May 2106. The sum concentration of PFOA and PFOS in drinking water should not exceed 70 ng/L (or parts per trillion, ppt). Relative to the 2016 health advisory level, the average concentration of GenX we measured in 2013 in the raw water of the Sweeney water treatment plant was 9 times higher. Of greater concern to me was our 2014 observation that other PFECAs were present at levels that greatly exceeded those of GenX. It took some time to confirm the molecular structures of the other PFECAs, and their identity was first published in a peer-reviewed paper that appeared in the journal Environmental Science and Technology in September 2015. As we showed in our 2016 paper that appeared in the journal Environmental Science and Technology Letters, two of these additional ethers are not practically removable by granular activated carbon (GAC) adsorption (a fact ignored by the Brockovich expert).

When people express their wish for safer water from their utility, what we need to consider in the end is: What additional cost are people willing to pay in form of a higher water bill to lower the risk? Also, the affordability of water is an important topic. If water is too costly, it can become unaffordable for some.

Using insufficient water for personal hygiene and bathing because the water is unsafe (or perceived to be unsafe) can also lead to increased risk of disease, which has been documented in Flint, Michigan, during their water crisis.

Finally, I think the risk associated with the ingestion of contaminants in drinking water needs to be put into perspective with other activities that we engage in and that carry risk, such as driving a car, eating unhealthy food, insufficient exercise, etc.

Best regards,
Detlef