

Science for Environment Policy

Disease-causing bacteria made more resilient by standard water disinfection practices

Halogenated nitrogenous disinfection by-products (N-DBPs) in water increase bacterial resistance to antibiotics, new research shows. The study found that a strain of bacteria which can cause disease in humans, *Pseudomonas aeruginosa*, increased its resistance to a range of different antibiotics by an average of 5.5 times after the bacteria were exposed to chemicals which form as by-products of common water treatment procedures. The results highlight the risks to public health which these currently unregulated by-products may cause.

Chlorine, chloramine and other disinfectants are added to drinking water to kill harmful microbes, such as those responsible for dysentery and typhoid. One side effect is that these disinfectants react with organic material present in the water — such as algae, [dissolved nitrogen compounds](#) and microscopic organic matter from wastewater — to create disinfection by-products (DBPs). Guideline values have been established for a number of chlorination by-products in the World Health Organisation guidelines. However, this study focused on nitrogenous-DBPs (N-DBPs), a sub-category of DBPs which are currently not regulated, but have been shown by recent research to be substantially more toxic to cells and their genetic information than the regulated DBPs at the same concentrations.

Previous studies on mammals have demonstrated that N-DBPs have direct carcinogenic effects, but this is the first study to look into the wider health implications of their mutagenic effects on bacteria, and whether their presence can increase the development of bacterial antibiotic resistance.

The researchers primarily studied effects on the bacterium *Pseudomonas aeruginosa*, a waterborne, opportunistic pathogen that can cause ear infections, skin rash, and even fatal illness in people with weakened immune systems. Liquid samples of the bacteria were exposed to differing concentrations of three N-DBPs — bromoacetamide (BACAm), trichloroacetonitrile (TCAN) and tribromonitromethane (TBNM) — for 24 hours.

These affected bacteria were then plated on petri dishes with five different antibiotics: gentamicin, polymyxin, tetracycline, ciprofloxacin, and rifampin, respectively. After a 48-hour incubation period, colonies of bacteria were counted and compared to a control culture of *Pseudomonas aeruginosa* to determine their antibiotic resistance. It was found that the N-DBP induced bacteria have a resistance which was on average 5.5 times stronger across all of the tested antibiotics than the control group.

The authors suggest that one of the main drivers for this increase in resistance is a strengthening of the generic mechanism which bacteria use to rid themselves of toxins (antibiotics are toxic from the perspective of bacteria) which is called the efflux pump. This was tested by observing the effects of efflux pump inhibitors on mutated bacteria, which made them significantly more susceptible to antibiotics again, and by gene analysis, which showed changes in the part of genetic code responsible for the efflux pump systems. This mechanism is also responsible for the development of multidrug antibiotic resistance.

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Induction of bacterial antibiotic resistance by mutagenic halogenated nitrogenous disinfection byproducts. *Environmental Pollution* 205 (2015): 291-298. DOI

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The bacteria *E. coli* was also tested to see if N-DBP exposure may impact other species of environmental bacteria, and showed a similar increase in antibiotic resistance. As both *P.aeruginosa* and *E.coli* are the indicators of pathogens in water, the researchers suggest that the effects observed in the study could be common for many strains of bacteria found in water.

Due to the regulation of DBPs, alternative disinfectants — such as chloramine in place of chlorine — have started to be used to reduce quantities of these regulated DBPs. However, these alternatives can produce greater levels of N-DBPs, and an increasing number have been shown to be mutagenic. High N-DBP levels could lead to a significant public health risk, especially in big cities, because the huge scale of water supplies and water treatment facilities would expose the residents to tens of millions of antibiotic resistant bacteria per day. More research is needed to clearly define what levels of N-DBPs are safe to minimise antibiotic resistant mutations in bacteria, and in turn what policies need to be created to monitor and regulate N-DBP concentrations in water supplies.

