Antimicrobial Resistance in Drinking Water Systems

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Future Challenges in Drinking Water Systems

1. Changes in environmental conditions (e.g. increase in temperature and changes in rainfall pattern)
2. New or increasing levels of contaminants in water bodies
3. Mixing of water from low quality sources (e.g. water re-use) due to water stress

All of these will force water companies to modify the way they deliver water
New & Increasing Levels of Contaminants

WHAT’S MAKING THE PROBLEM WORSE?

GLOBAL A failure to address the problem of antibiotic resistance could result in:

10m deaths by 2050
Costing £66 trillion

http://www.bbc.co.uk/guides/z8kkcdm
Indiscriminate use of antibiotics and inadequacy of wastewater treatment result in accumulation of antibiotics in surface waters.


Recent water quality reports highlight increasing accumulation of macrolides (e.g. azithromycin, clarithromycin and erythromycin), which eventually end up in the drinking water in the UK.
This release of antibiotics within the urban water environment can select for antibiotic resistance bacteria (ARB).

The generation of ARB and antibiotic resistance genes (ARGs), reduces the therapeutic potential of antibiotics against pathogens.
Microorganisms in Water Distribution Systems

**BIOFILM:** microorganisms attached to a surface or/and to each other and surrounded by an extracellular polymeric matrix (EPS) and with particles trapped in it.

Problems

- **Reservoirs of opportunistic pathogens and AMR**
- Changes in water quality (odour, taste, discolouration, etc.)
- Affects hydrodynamic parameters (e.g. clogging, hydraulic resistance)
- Corrosion
Several disinfectant and resistance mechanisms were identified preferentially within biofilms, including genes associated with the prevention and repair of radical-induced damage and antibiotic resistance.

**Beta-lactamase** (Beta-lactamase class C and other penicillin binding proteins)

**BETA-LACTAM ANTIBIOTICS**

- Penicillins
  - Narrow-spectrum penicillins
  - Penicillinase-resistant penicillins (Antistaphylococcal penicillins)
  - Extended-spectrum penicillins
- Cephalosporins
  - First generation cephalosporins
  - Second generation cephalosporins
  - Third generation cephalosporins
  - Fourth generation cephalosporins
- Monobactams
- Carbapenems
- Beta-lactamase inhibitors

Douterelo et al., 2018. Environmental Science: Water Research & Technology 4,12, 2080-2091.
ARBs favoured by chlorination

- **Disinfection** can exert **selective pressure** and increase the transfer of antibiotic resistant genes (ARGs) to pathogens.

- **Disinfection** may promote **horizontal gene transfer** (movement of genetic information from a donor to an unrelated recipient), from environmental ARB to pathogens.

- Disinfectants and their **by-products** may induce genetic mutations on bacteria, which can confer resistance to antibiotics.

Global Monitoring of Antimicrobial Resistance Based on Metagenomics Analyses of Urban Sewage

Preventing AMR

Treatment

Treatment is an essential tool for managing AMR risk associated with water and sanitation.

- Advanced oxidation processes (AOPs) such as combinations of ozone, UV and hydrogen peroxide appear promising for the destruction of ARGs and minimizing AMR risk.

Literature data on the removal of tetracycline resistant bacteria (FC: fecal coliforms, HB: heterotrophic bacteria, ENT: enterococcus) and ARGs during conventional and advanced treatment processes (hatched fields indicate different results from literature; NR: not reported).

https://doi.org/10.1016/j.scitotenv.2019.05.315
AMR Materials for Water Infrastructure

Song et al., 2015. Journal of Dental Research 94 (8) 1027-1034
Probiotic Approach

- Adding microbes or manipulating the conditions in drinking water systems to select for beneficial microbiomes.
- Research to understand how engineering may select for a desirable microbiome.
- The use of a probiotic approach has the potential to exclude undesirable or pathogenic members of microbial communities in drinking water systems, avoiding chemical treatments.

Research Needs

- Underpin the creation of a framework for the surveillance and reporting of AMR in water systems.
- Support options for waste treatment practices to minimise emergence, transmission and/or exposure risk of ABR in the environment.
- Consider the implications of socio-economic factors and climate change (e.g. water scarcity, reuse, etc) on the sustainability and efficacy of strategies to reduce the impact of the water industry practices on AMR.
One Water

Holistic approach for water management
Integrate the regimes and mechanisms that govern water use, water quality and land use to better protect the integrity of our aquatic systems, while meeting human needs.
Bacterial Resistance to Antibiotics can be Reversible

If the pressure of antibiotics on the microbes decreases "the resistance is reversible and the bacteria tend to lose them"

A better use of antibiotics- not prescribing unnecessary ones and choosing those that have the least ecological impact reduces infections by multiresistant bacteria.

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Thank you