Farm wastewater modeling shows footbaths are source of antimicrobial resistance

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New research has mapped wastewater flows on farms and revealed where spikes in antibiotic resistant bacteria in slurry occur, showing that water from copper and zinc footbaths used by dairy animals can cause

fluctuations.

Researchers from the University of Nottingham developed mathematical models and conducted on-farm research to explore the impact of wastewater flows and management practices on antimicrobial resistance (AMR) in slurry. The research is the first to investigate the effects of farm layout, the farm practices associated with different areas of the farm, and the impact these may have on the emergence and spread of AMR across the farm.

Temporal fluctuations in cephalosporin-resistant Escherichia coli were observed and attributed to farm activities, specifically the disposal of spent copper and zinc footbath into the slurry system. The results have been published in *npj Antimicrobials and Resistance*.

The results highlight farm-specific opportunities to reduce AMR pollution, beyond antibiotic use reduction, including careful disposal or recycling of waste antimicrobial metals.

Dairy slurry, if not properly stored, can be a source of environmental contamination with antimicrobial resistant genes and bacteria, which could eventually get into the human population through water or crops.

Previous modeling research from the University of Nottingham showed that slurry tanks that were left alone without further waste added for at least 60 days reduced the spread of antibiotic resistant bacteria (ARB) as the bacteria died in the hostile environment. Researchers also noticed that there were times when there were spikes in cephalosporin-resistant Escherichia coli.

"What we initially found was that the slurry tank wasn't as scary a place as we thought for the spread of antimicrobial resistant genes and, in fact, if left alone for a period of time, the bacteria would die in such a hostile

environment. However, what was also interesting was that we were seeing fluctuations in a particularly problematic drug-resistant bacteria called Escherichia coli.

"When we investigated this further in this research using computer modeling and on farm research we saw that there was a direct correlation between the emptying of the water from the Zinc and copper footbaths into the slurry tank and a spike in the presence of Escherichia coli," said Dov Stekel, Professor of Computational Biology in the School of Biosciences at the University of Nottingham.

In addition to antibiotics, other antimicrobials such as metals (copper and zinc) and other chemicals (e.g., formalin, disinfectants) are widely used across farms globally, particularly in footbaths to prevent lameness in livestock.

"Metals and other antimicrobial agents (such as formalin and glutaraldehyde) are known to have a co-selective effect on antibiotic resistance, meaning that ARBs could persist in the slurry even after the antibiotics have degraded," said Dr. Jon Hobman, Associate Professor of Microbiology, School of Biosciences.

Professor Stekel added, "Mapping the antibiotic resistant bacteria in this way allows us to understand its precise source and importantly its route through the farm. We hope this information will lead to wastewater management practices that can be developed to mitigate this."

Engineers at the University of Nottingham have started investigating how to remove copper and zinc from cattle footbath wastewater and found that layered double hydroxides successfully removed copper and zinc from cattle footbath. This was the first successful investigation into the removal of copper and zinc from a commercially available cattle footbath powder mix solution.

More information: Henry Todman et al, Modelling the impact of wastewater flows and management practices on antimicrobial resistance in dairy farms, *npj Antimicrobials and Resistance* (2024). DOI: 10.1038/s44259-024-00029-4