IMPERIAL LAIDLAW SCHOLARS

Temperature-Dependent Degradation of Amoxicillin and Ciprofloxacin in the River Thames

Hao Yin Bon[1,2]
Valerie Soo[1]
Lari Warshong[1]
[1]Department of Adult Infectious Diseases
[2]Department of Life Sciences

Introduction

Environmental Pollutants: Antibiotics enter aquatic systems (e.g., River Thames) via municipal wastewater, agricultural runoff, and sewage overflows[1].

Target Antibiotics:

- Amoxicillin (AMX): Broad-spectrum antibiotic accounting for up to 40% of UK prescriptions[2].
- Ciprofloxacin (CIP): Fluoroquinolone frequently detected in global water samples[3].

Study Aim: Evaluate the abiotic degradation kinetics of AMX and CIP in wastewater to determine if sub-lethal concentrations persist and drive antimicrobial resistance (AMR).

Results

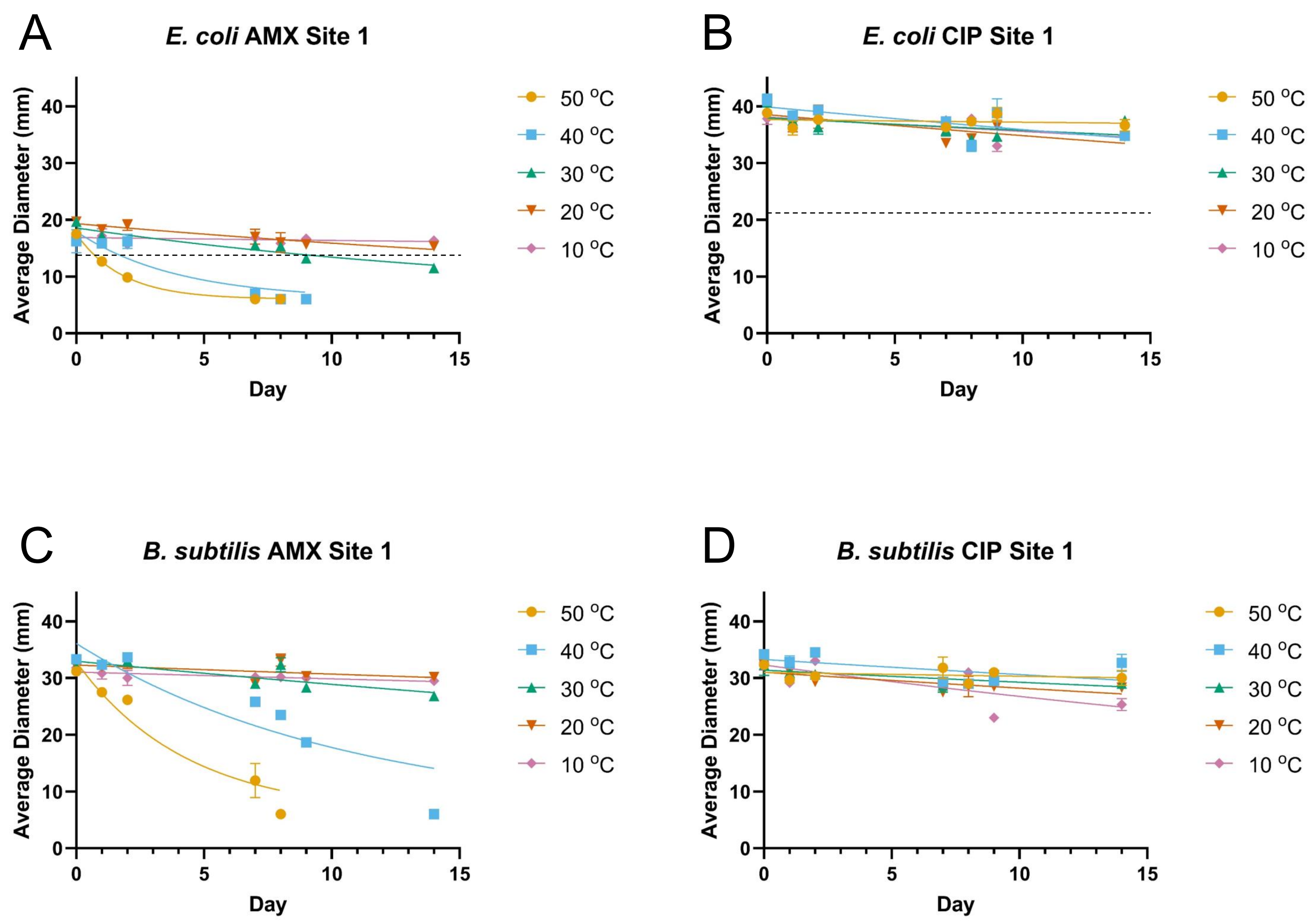


Figure 1. Antibiotic degradation kinetics in Site 1 across varying temperatures. Zones of inhibition over time for *E. coli* (A: amoxicillin; B: ciprofloxacin) and *B. subtilis* (C: amoxicillin; D: ciprofloxacin). Error bars indicate ± SD of technical replicates. Dotted lines denote resistance breakpoints derived from EUCAST (A) and CLSI (B). No MIC breakpoints were available for *B. subtilis*.

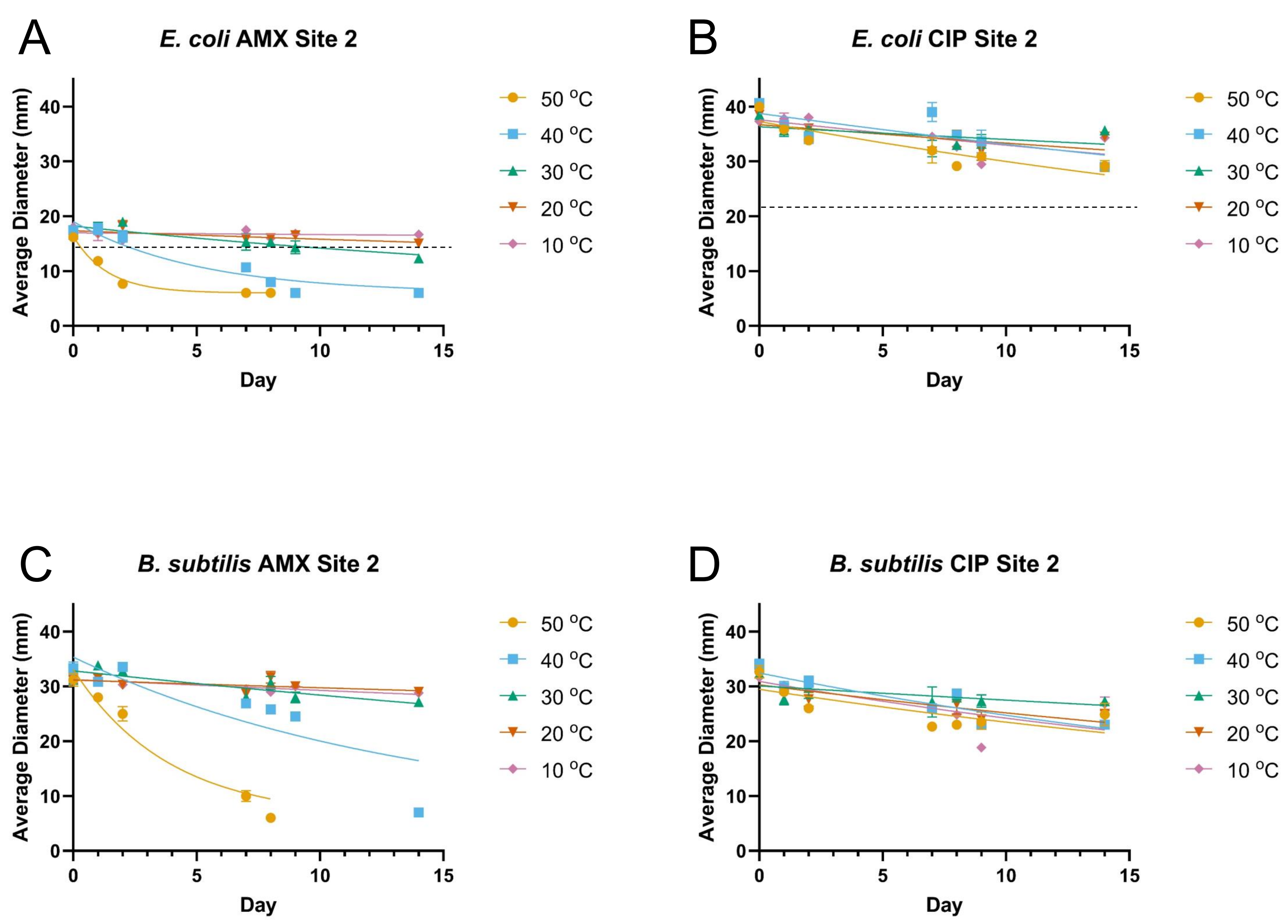
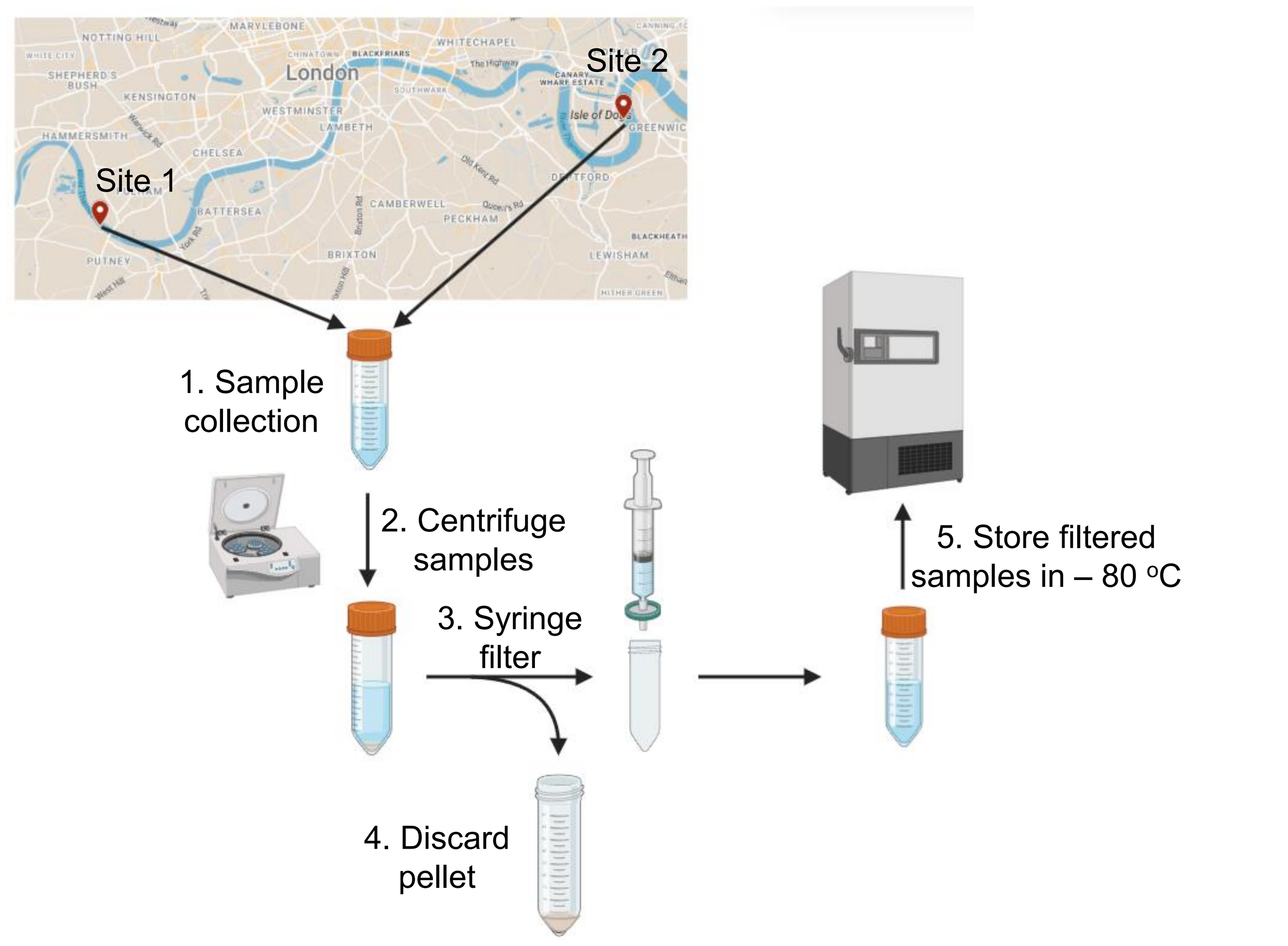


Figure 2. Antibiotic degradation kinetics in Site 2 across varying temperatures. Error bars indicate ± SD of technical replicates. Dotted lines denote resistance breakpoints derived from EUCAST (A) and CLSI (B).

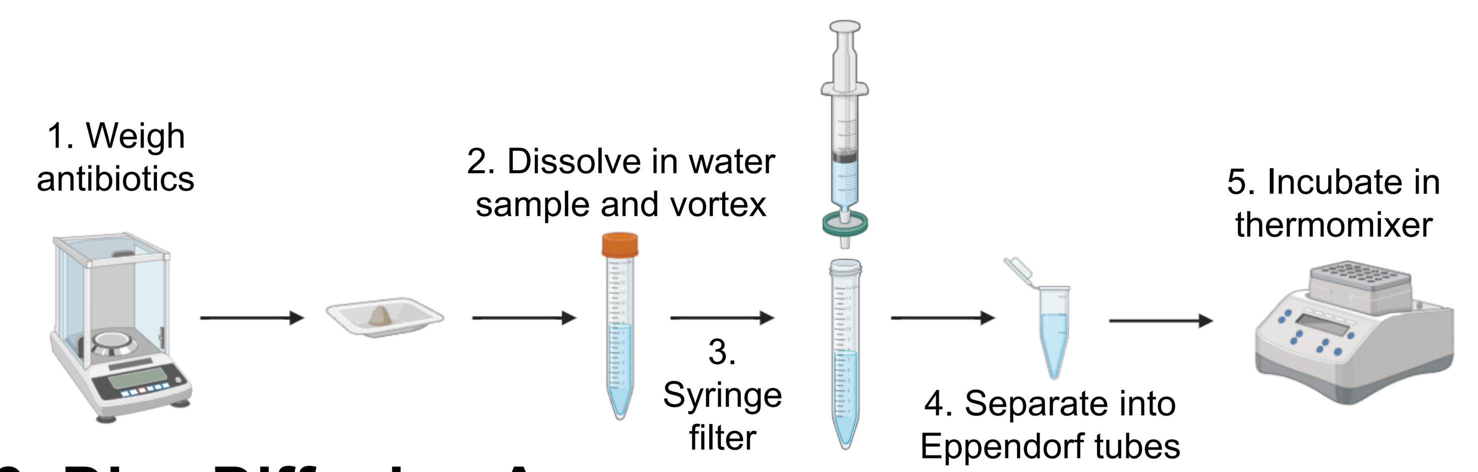
- **Temperature Dependency:** Both antibiotics showed accelerated degradation at higher temperatures (40°C-50°C). Significant differences observed between all temperature groups.
- **Antibiotic Stability:** CIP was more stable than AMX across all conditions, reaching a maximum reduction of only 40% by Day 14, compared to the 100% reduction observed for AMX (Figure 3. C and D).
- **Site Variations:** Site 2 consistently demonstrated faster degradation rates than Site 1 at elevated temperatures (e.g., 50°C at Day 2 for AMX). Significant differences observed between non-linear regression curves of two sites in 12/20 temperatures.

Experimental Workflow

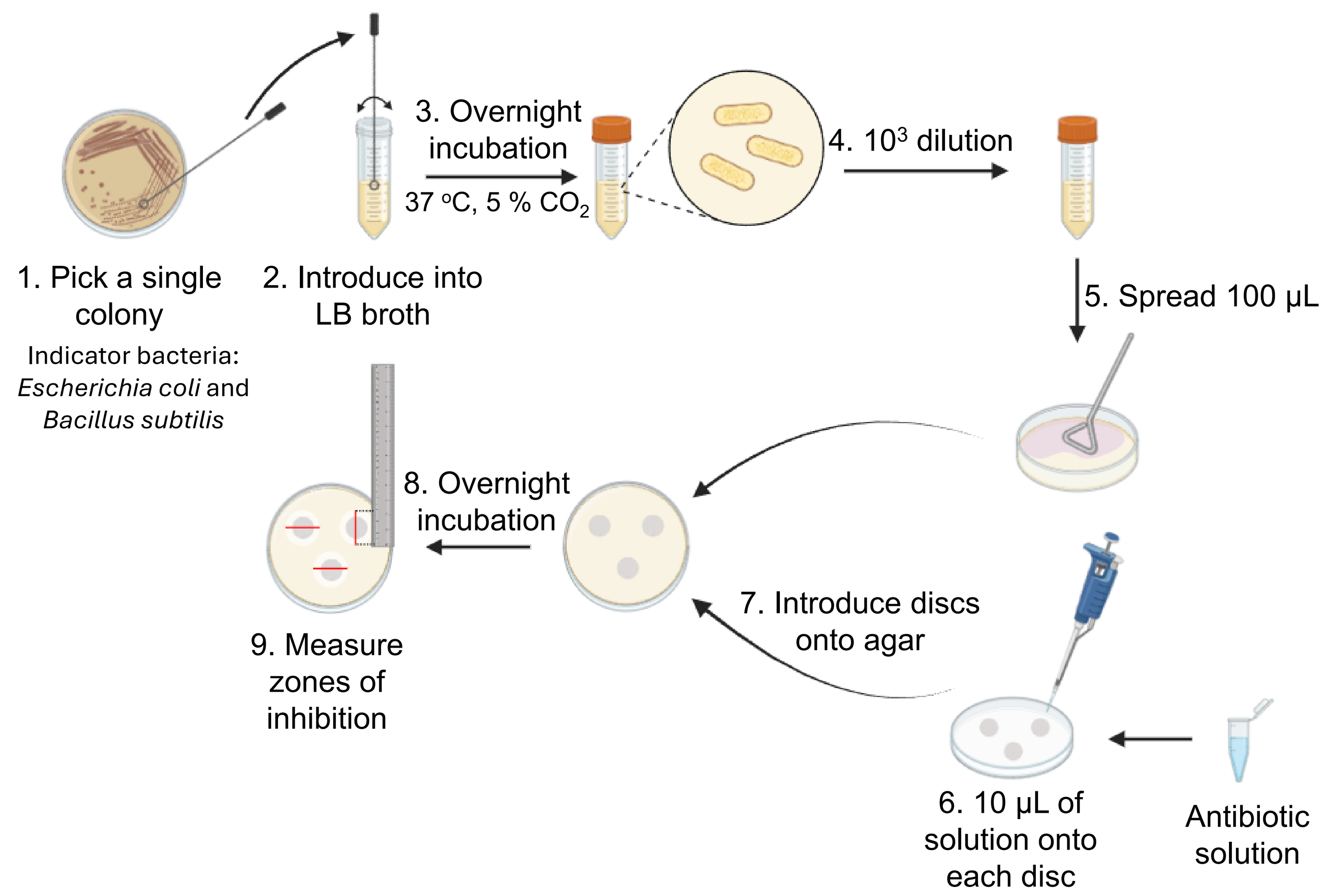
1. Collection and Purification of Water Samples



2. Preparation of Antibiotics



3. Disc Diffusion Assay



Discussion

- **Structural stability:** AMX's beta lactam ring quickly undergoes hydrolysis and is temperature-dependent. CIP's fluoroquinolone core provides thermal stability[4].
- **Environmental persistence:** The temperature of River Thames ranges between <10 °C to 24.4 °C[5], which means the antibiotics, which are usually found in trace concentrations, will degrade slower.
- **AMR implications:** Sub-lethal concentrations creates a selection pressure, driving antimicrobial resistance (AMR).
- **Site variation:** Accelerated kinetics at Site 2 could be due to higher pH and different matrix composition.

References

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[4]Gerecke, J. & Schlink, U. Factors affecting the hydrolysis of the antibiotic amoxicillin in various water types. *Chemosphere* **310**, 136219 (2023).

[5]Bowes, M. J. et al. Predicting river phytoplankton blooms and community succession using ecological niche modeling. *Limnol. Oceanogr.* **69**, 1404–1417 (2024).