

# Modelling environmental antibiotic-resistance gene abundance: A meta-analysis

Daniel Duarte, Rik Oldenkamp, Ad Ragas

Department of Environmental Science, Institute for Water and Wetland Research, Faculty of Science, Radboud University Nijmegen,  
PO Box 9010, 6500 GL Nijmegen, The Netherlands

## INTRODUCTION

- Human and veterinary antibiotics are crucial against disease and infection
- Worldwide antimicrobial resistance crisis is rapidly unfolding
- Environmental emissions due to high consumption and limited treatment
- Unknown effect of antibiotic pollution on antibiotic-resistance genes (ARG)
- Necessary risk assessment of resistance selection due to antibiotic pressure

## QUESTION

Does antibiotic selective pressure **correlate** with ARG abundance?

Does the environmental matrix **influence** ARG abundance?

## DATA & METHODS

### 1 Literature review

### 2 Selection criteria

### 3 Data extraction

### 4 Data structure

$$TARG_{y,j} = \sum_{x \in y} \frac{ARG_x}{16S\ rRNA_j}$$

*Resistance mapping*  
*Antibiotic classification*

$$TASP_{y,j} = \sum_{i \in y} \frac{MEC_{i,j}}{PNEC_i}$$

TARG: Total Antibiotic Resistance Gene  
ARG: Antibiotic resistance gene absolute abundance  
16S rRNA: prokaryote sub-ribosomal RNA gene

TASP: Total Antibiotic Selective Pressure  
MEC: Measured Environmental Concentration  
PNEC: Predicted No-Effect Concentration

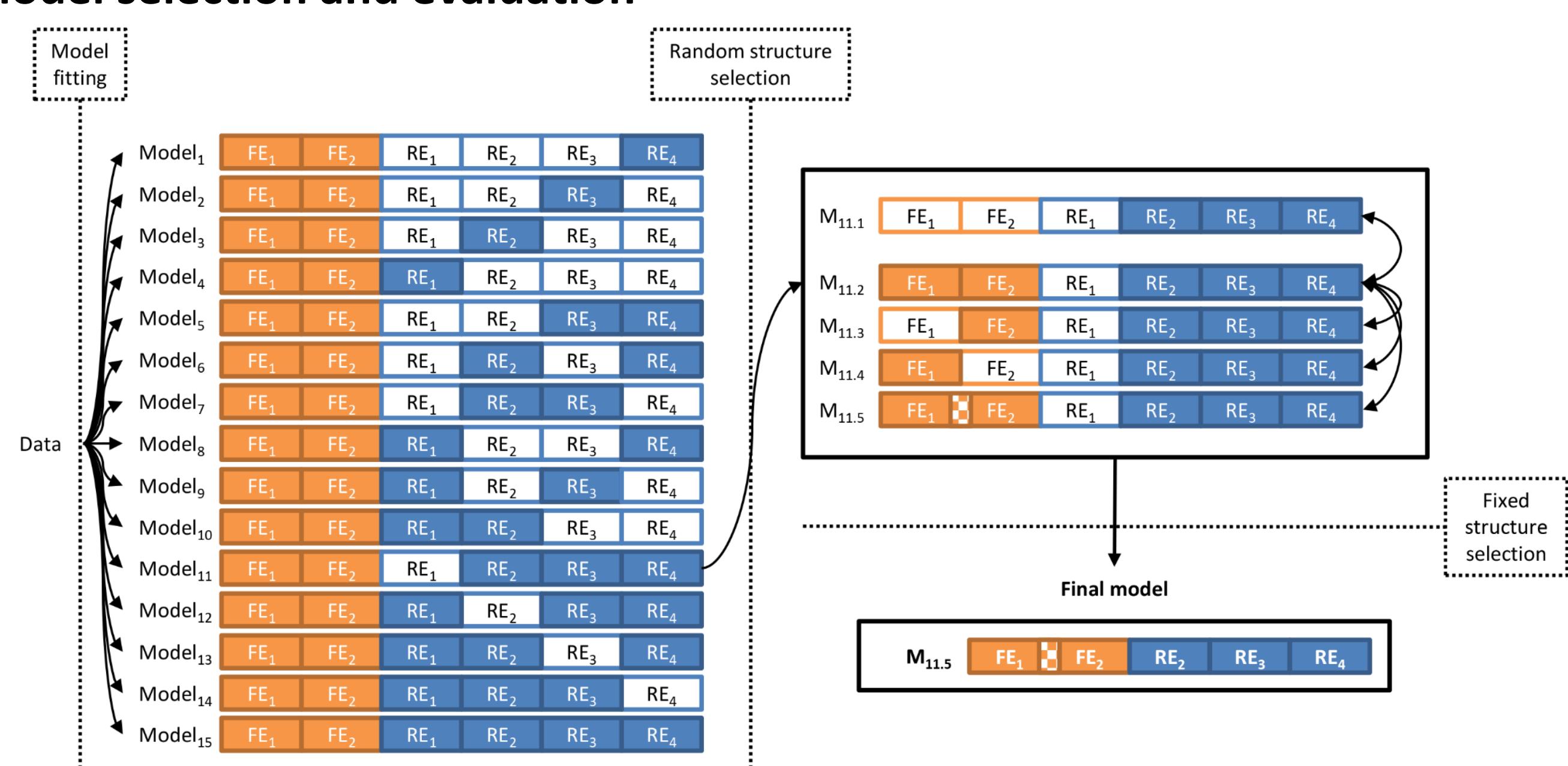
### 5 Database

26 studies (Study) | 11 countries (Country)  
197 samples (Sample) | 10 sampling years (Year)  
3 environmental matrices (Matrix)

### 6 Linear mixed-effects model architecture

$$TARG = TASP + Matrix + (1|Country) + (1|Year) + (Matrix|Class) + (1|Study/Sample) + \varepsilon$$

### 7 Model selection and evaluation



## CONCLUSION

- Antibiotic selective pressure positively correlates with antibiotic-resistance gene abundance
- Interaction effects significantly affect resistance gene abundance
- In sediment, most antibiotic classes exert selective pressure above the risk threshold
- In surface water and wastewater, class-specific gene estimation is less reliable
- Antibiotic pressure and matrix should be considered in resistance risk assessment

## RESULTS & DISCUSSION

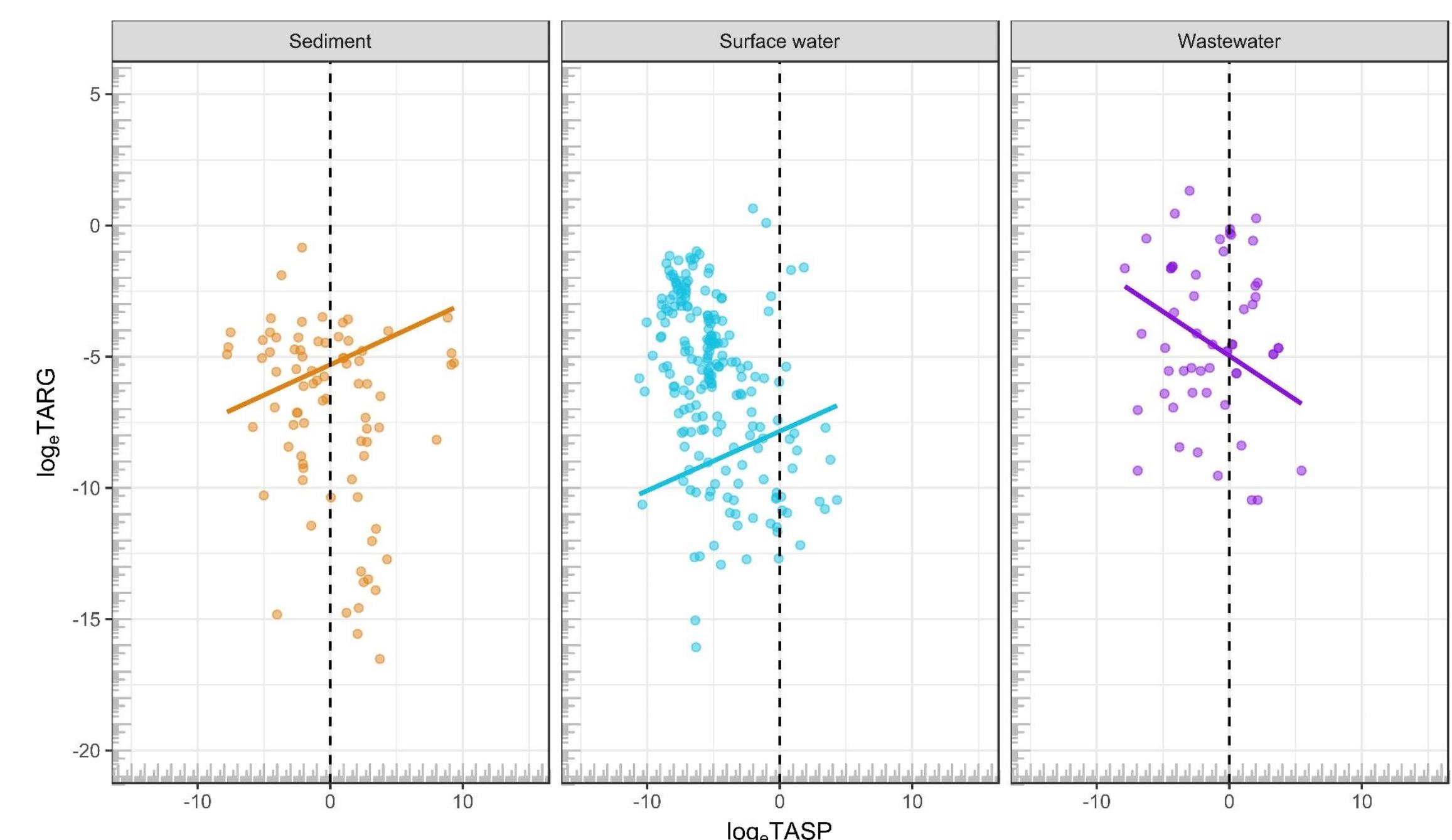


Figure 1. TASP and TARG in sediments, surface water and wastewater. Unique cases are expressed as dots and the model predictions using unconditional (population-level) values are expressed as solid lines. TASP equal to 1 (risk threshold) is indicated by the dashed vertical lines.

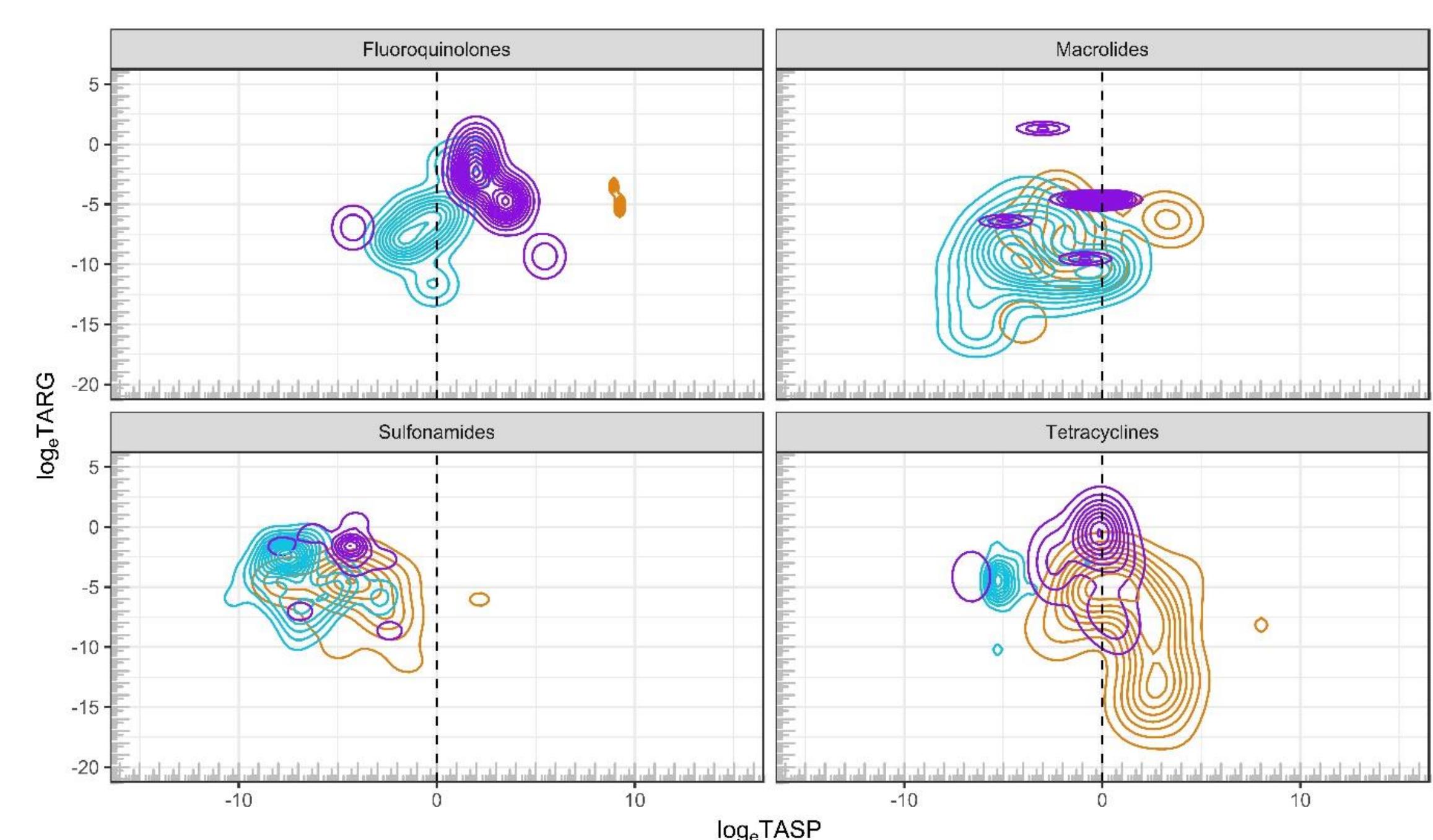


Figure 2. TASP and TARG stratified by therapeutic class and matrix. Sample data is expressed in isocontours after two dimensional Gaussian kernel density estimation. TASP equal to 1 (risk threshold) is indicated by the dashed vertical lines.

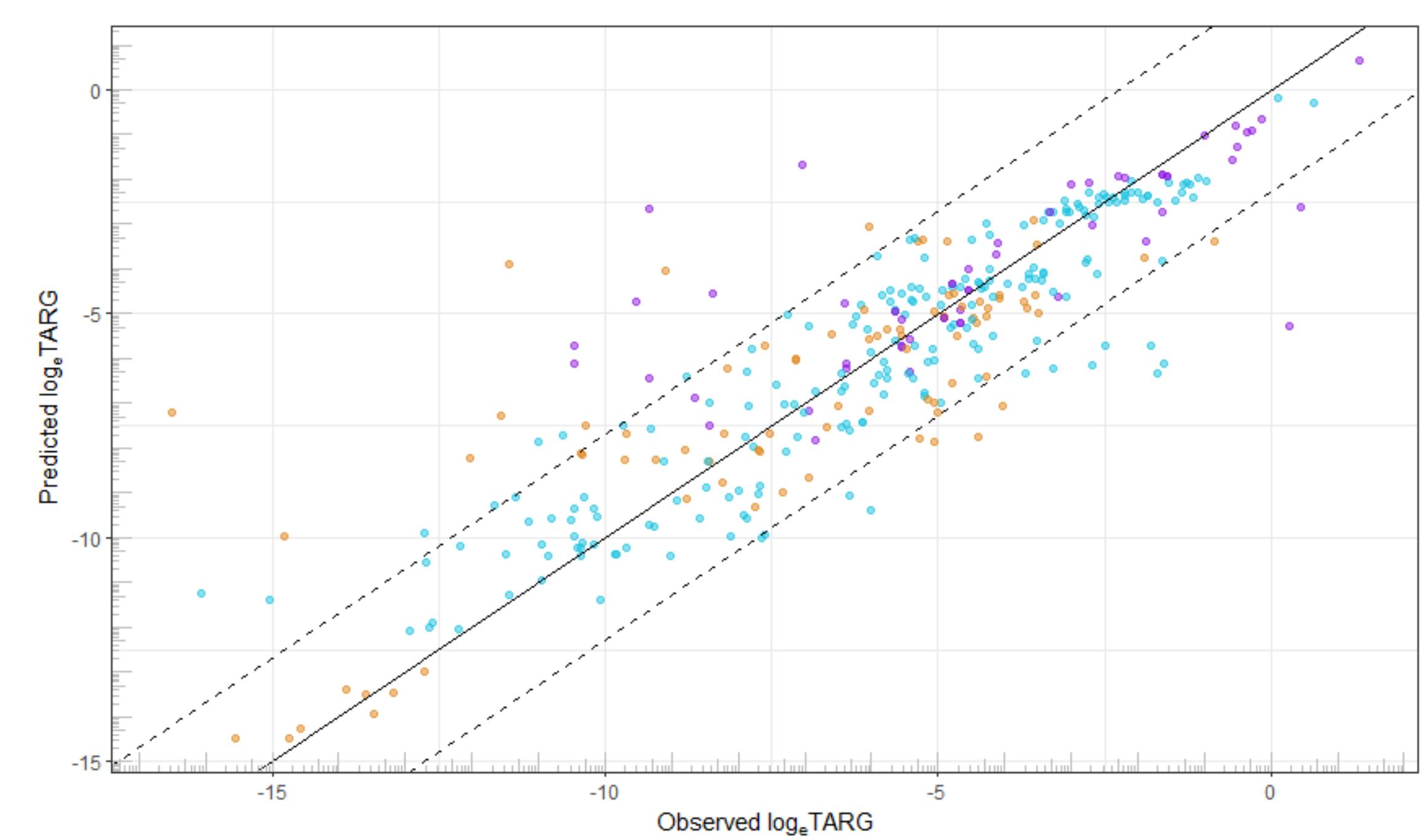


Figure 3. TARG values estimated at group-level, i.e. conditioned on the random effects. Solid line indicates the identity line (adjusted  $R^2 = 0.87$ ) and dashed lines indicate ten-fold margins.